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Supplement to

The Desert Project Soil Monograph

Volume I

SOIL CONSERVATION SERVICE U.S. DEPARTMENT OF AGRICULTURE

Supplement to

THE DESERT PROJECT SOIL MONOGRAPH

Soils and Landscapes of a Desert Region Astride the Rio Grande Valley Near Las Cruces, New Mexico

Volume I

L.H. Gile and R.J. Ahrens, Editors

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FOREWORD

Volume I of the Supplement to the Desert Project Soil Monograph is the first of a number of reports dealing with studies of soils in the Desert Project area. Volume I records a detailed study of soil water in the Jornada Experimental Range, and the relation of soil water to soil morphology, laboratory analyses, landscape position, microrelief, runoff, run-in, vegetation, pipes, and definitions of the soil moisture regimes used in soil classification. In addition to the table of contents, readers who wish to explore the details of these relationships should find two sections particularly helpful: interpretation of the soil water and precipitation graphs, on pages 10-12, and location of information, on pages 22-23.

L. H. Gile and R. J. Ahrens, editors

Volume I. Soil Water and Soils at Soil Water Sites, Jornada Experimental Range[1]

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CONTENTS

INTRODUCTION 1

MATERIALS AND METHODS 2
DESCRIPTION OF THE STUDY AREA 2
Topography 2
Soils and Geomorphology 2
Precipitation 7
Temperature 7
Wind and Evaporation 8
EXPERIMENTAL PROCEDURES 8
Soil Water 8
Interpretation of the Soil Water and Precipitation Graphs 10
Yields 12
Relation of the Soil Water Data to Soil Morphology and Classification 12
The Soil Moisture Control Section and the Soil Moisture Regime 13
The Draft Definition for "Bordering Ustic . . 15

RESULTS AND DISCUSSION 15
EXCHANGE CHEMISTRY, ORGANIC CARBON, AND CARBONATE . . . 15
AVAILABLE WATER CAPACITY 18
LOCATION OF INFORMATION 22
SOILS AND MATRIC POTENTIAL OF SOIL WATER 22
Broad Basin Floor Without Run-in 24
Site Onite, Buried Soil Phase (0) 24
Soils 24
Soil Water, Precipitation, and Yields . . 29
Tests of Definitions of the Soil Moisture Regimes 51
Site Yucca (Y) 51
Soils 51
Soil Water, Precipitation, and Yields . . 58
Tests of Definitions of the Soil Moisture Regimes 76
Site Hueco #1 (H1) 76
Soils 76
Soil Water, Precipitation, and Yields . . 88
Tests of Definitions of the Soil Moisture Regimes 104
Site Hueco #2 (H2) 104
Soils 114
Soil Water and Precipitation 114
Tests of Definitions of the Soil Moisture Regimes 134

CONTENTS

Site Hueco #3 (H3) 141
Soils 141
Soil Water, Precipitation, and Yields . . 141
Tests of Definitions of the Soil Moisture Regimes 158
Site Hueco #4 (H4) 158
Soils 158
Soil Water and Precipitation 169
Tests of Definitions of the Soil Moisture Regimes 182
Site Cruces (C) 182
Soils 194
Soil Water, Precipitation, and Yields . . 194
Tests of Definitions of the Soil Moisture Regimes 200
Site Sonoita (S) 210
Soils 210
Soil Water and Precipitation 210
Tests of Definitions of the Soil Moisture Regimes 236
Site Wink (W) 236
Soils 236
Soil Water and Precipitation 247
Tests of Definitions of the Soil Moisture Regimes 255
Site Turney (T) 267
Soils 267
Soil Water and Precipitation 267
Tests of Definitions of the Soil Moisture Regimes 277
Narrow Basin Floor, with Run-in, and an Adjacent Fan-Piedmont 295

Site Herbel (H) 295
Soils 295
Soil Water and Precipitation 301
Test of Definitions of the Soil Moisture Regimes 313
Site Stellar #1 (S1) 313
Soils 326
Soil Water, Precipitation, and Yields . . 326
Tests of Definitions of the Soil Moisture Regimes 370
Site Reagan (R) 370
Soils 370
Soil Water, Precipitation, and Yields . . 370
Tests of Definitions of the Soil Moisture Regimes 413

CONTENTS

Site Stellar #2 (S2) 413
Soils 413
Soil Water and Precipitation 422
Tests of Definitions of the Soil Moisture Regimes 437
Site Veatch-Stellar 3 (VS3) 437
Soils 437
Veatch 450
Stellar 451
Soil Water, Precipitation, and Yields . . 451
Tests of Definitions of the Soil Moisture Regimes 524
Small Playa with Run-in 533
Site Barcross (B) 533
Soils 533
Soil Water, Precipitation, and Yields . . 537
Tests of Definitions of the Soil Moisture Regimes 579

CONCLUSIONS 579
SOIL TEXTURE AND DEPTH TO PETROCALCIC HORIZON 579
LANDSCAPE POSITION 582
MICRORELIEF 583
PIPES 583
VEGETATIONAL COVER 584
PERCENTAGE OF DAYS DRY AS A TAXONOMIC CRITERION 584
SEASONAL PATTERNS OF SOIL WATER 584
SOIL WATER WITHOUT RUNOFF OR RUN-IN 586
PRECIPITATION, SOIL WATER, AND HERBAGE DYNAMICS 586
TESTS OF DEFINITIONS OF THE SOIL MOISTURE REGIMES . . . 586

LITERATURE CITED 590

INTRODUCTION

Soil water is the major driving force of the rangeland ecosystem of arid and semiarid environs. Soil water in these areas is heavily reliant on the various characteristics of precipitation. However, in southern New Mexico the amount of precipitation is extremely variable, both spatially and temporally.

Soil water and other climatic features are important in soil development and classification. Certain soils occur only in specific climatic zones. The water status of soils continually affect soil properties through its influence on weathering, soil development, friability, permeability, and erodibility of some soils (Herbel and Gile, 1973).

There is a dearth of information in the scientific literature concerning field measurement of soil water on arid and semiarid rangelands. In central Australia, there were six periods of soil water recharge during a two-year period followed by withdrawal to an average soil water potential of -12 MPa (Winkworth, 1970). The r lationship between the amount and intensity of rainfall, and the periodicity of soil water were minor near Tucson, Arizona; however, winter precipitation was more effective than summer precipitation in increasing soil water (Shreve, 1934). Soil water and temperature are not limiting on brushy sites in northeastern Nevada 28 to 70 days per year (Jensen et al., 1989).

Much precipitation is lost by evaporation from the soil surface on sites dominated by creosotebush (*Larrea tridentata* [Sesse and Mocino ex DC.] Coville) near Tucson (Sammis and Gay, 1979). Near Las Cruces, New Mexico, Schlesinger et al. (1987) estimated that most of the precipitation was lost by transpiration on a site dominated by creosotebush. This suggests great variation in loss of soil water through the plant and due to evaporation from the soil. Schlesinger et al. (1987) also suggested that plant uptake of water from the lower soil profile affects the deposition of calcium carbonate (caliche) in desert soils.

Water depletion by grasses was greater than by shrubs at the 15-cm soil depth but it was similar at the 45-cm depth in a study near Tombstone, Arizona (Kincaid et al., 1964). This indicated greater evaporation from surface horizons on sites dominated by grasses.

The information presented in this publication is basic to understanding the functioning of ecosystems of arid rangelands. Summaries of the soil water data are presented by Herbel and Gibbens (1987, 1989) but the information on soil water presented in this publication is in much greater detail than is possible in journal papers. Similarly, some soils information is given by Herbel and Gile (1973) but this publication gives much greater detail for all sites. Landform terminology (e.g., basin floor, piedmont slope) follows Gile et al. (1981, p. 26-30).

MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA

The field part of this study was conducted at selected sites on the Jornada Experimental Range approximately 40 km north of Las Cruces, New Mexico (figs. 1, 2). The abiota and biota are typical of semidesert shrubsteppe in southeastern Arizona, southern New Mexico, western Texas, and northern Mexico. The coarser-textured soils (mostly sands, loamy sands, and sandy loams) primarily support mesa dropseed (*Sporobolus flexuosus* [Thurb.] Rydb.), black grama (*Bouteloua eriopoda* [Torr.] Torr.), honey mesquite (*Prosopis glandulosa* Torr.), and creosotebush. The major plant species on finer textured soils (mostly clay loams, silty clay loams, and clays), commonly in depressions, are tobosa (*Hilaria mutica* [Buckley] Benth.), burrograss (*Scleropogon brevifolius* Philippi), and tarbush (*Flourensia cernua* DC.). Sit s that once supported grassland are now dominated by shrubs (Buffington and Herbel, 1965; Herbel, 1985).

Topography

Most of the Jornada Experimental Range is a broad basin floor with level to gently undulating topography. The San Andres Mountains are on the eastern side of the Range and the Doña Ana Mountains are just off the southwest boundary (figs. 1, 2). The mountain ranges are steep and rocky. Large alluvial fans occur below major canyons that intersect the mountain fronts. Arroyos occur between the alluvial fans and are dry, except when occasional runoff occurs from heavy precipitation upslope. Downslope the fans merge into a broad fan-piedmont with a dominant slope of 2-3%. Slopes gradually decrease to about 0.5% at toeslopes of the fan-piedmont, along margins of the basin floor. Relief in the basin floor ranges from level to gently undulating, and there are scattered depressions. The elevation at Headquarters is 1,317 m. The sites in this study vary only slightly from this elevation.

Soils and Geomorphology

The south end of the Jornada Experimental Range extends into th Desert Soil-Geomorphology Project (fig. 1). The Desert Project part of this study has both the piedmont slope portion of the study and a narrow basin floor that widens northward. Five of the 16 soil water sites are in this area (fig. 2). North of the Desert Project the basin floor widens still further into a broad, undulating plain. The remainder of the soil water sites are in this broad plain (fig. 2).

Table 1 summarizes geomorphic surfaces of the basin floor and piedmont slope in the Desert Project. Table 2 gives soil classification, landscape, geomorphic surface, and soil parent materials at the soil water sites. North of the Desert Project,

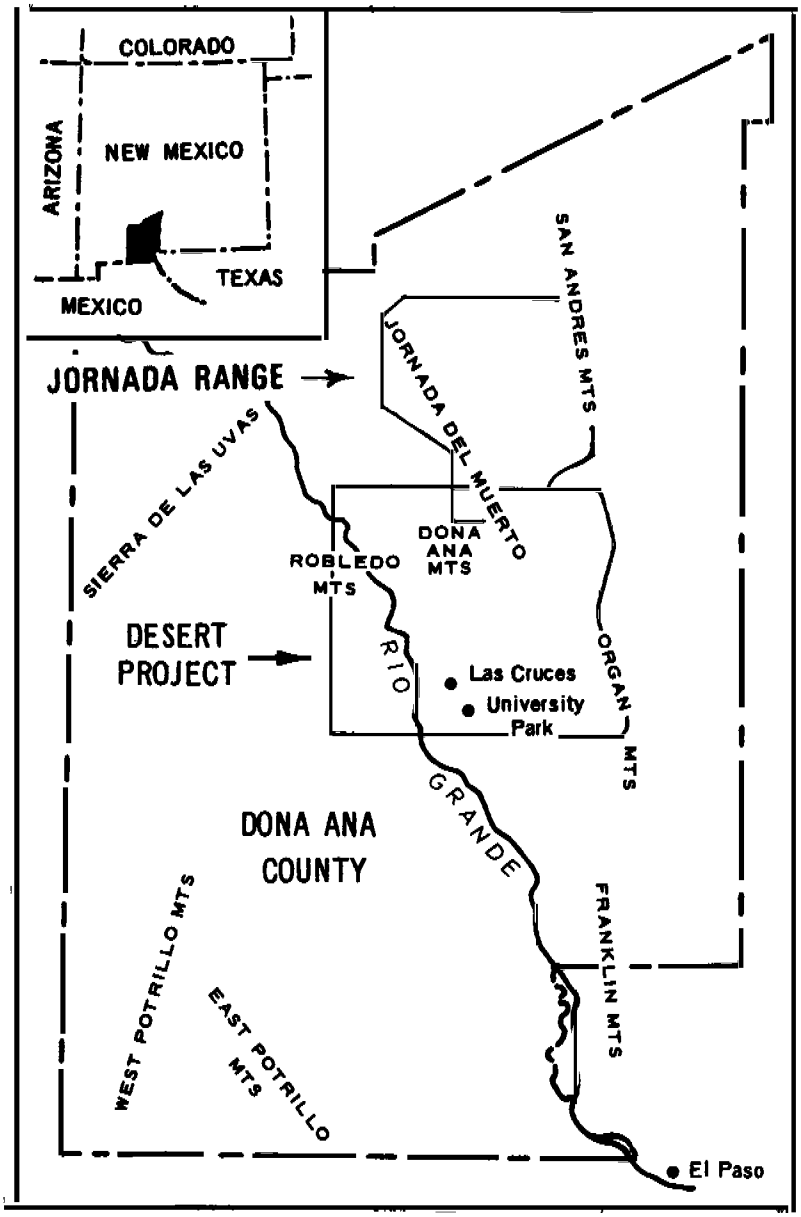


Figure 1. Location of the Jornada Experimental Range and the Desert Soil-Geomorphology Project in Doña Ana County, southern New Mexico.

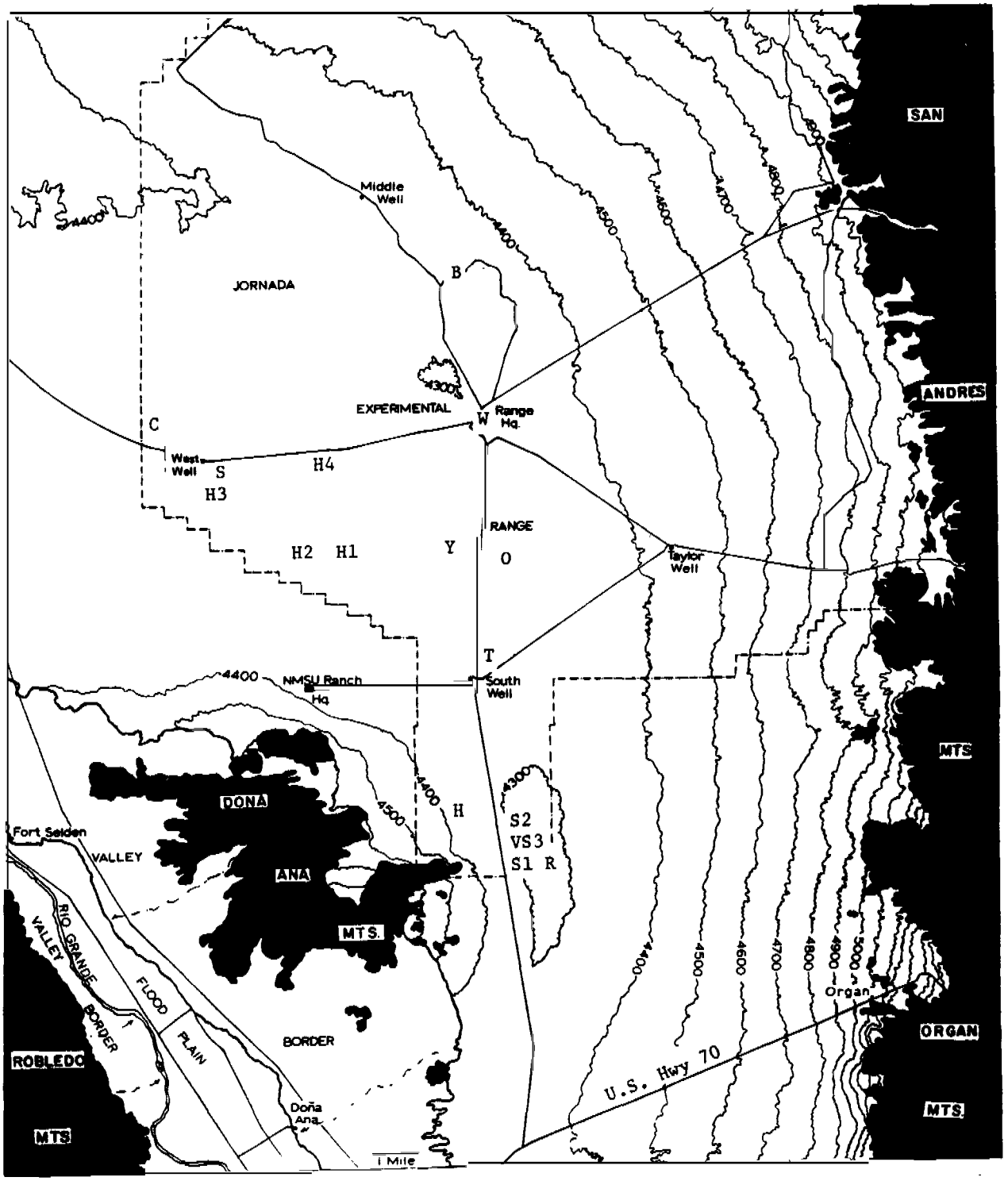


Figure 2. Location of the 16 soil water sites (cf table 2) east of the Doña Ana Mountains and in the broad plain to the north. See figs. 4 and 226 for location at larger scale.

Table 1. Physiographic location and estimated age of geomorphic surfaces and their soils at the soil water sites.

Geomorphic surface[1]	Physiographic location and soil age (yrs B.P. or epoch)
	The basin floor
Lak Tank	Present to late Pleistocene
Petts Tank	Late Pleistocene (25,000-150,000)
Jornada I	Late middle Pleistocene (250,000-400,000)
La Mesa	Middle Pleistocene (greater than 400,000)
Jornada I-La Mesa	(Jornada I or La Mesa, undifferentiated)
	The piedmont slope
Arroyo channels	Historical (1850 A.D. to present)
(Coppice dunes)[2]	Historical
Whitebottom	Historical
Organ	100 to 7,000
III	100 to 1,100
II	1,100 to 2,100
I	2,200 to 7,000
Isaacks' Ranch	Earliest Holocene-latest Pleistocene (8,000-15,000)
Jornada II	Late Pleistocene (25,000-150,000)
Jornada I	Late middle Pleistocene (250,000-400,000)
Jornada	(Jornada I or Jornada II, undifferentiated)
Doña Ana	Middle to early Pleistocene (greater than 400,000)
	Mountain slopes and summits (undifferentiated)

[1]The age of a geomorphic surface and its soils is considered to be the same. On a constructional surface, for example, all would date from the approximate time that sedimentation stopped and soil development started. See Ruhe (1967), Hawley and Kottlowski (1969), and Gile et al. (1981) for more details on geomorphic surfaces.

[2]Coppice dunes have not been formally designated a geomorphic surface but are considered separately here because of their extent and significance to soils of the area.

Table 2. Some characteristics of soils and landscapes at the soil water sites.

Site[1]	Soil series, phase or taxadjunct[2]	Classification[3]	Landscape position and slope	Geomorphic surface[4] and parent materials
Soils of the broad, level or nearly level basin floor. No runoff or run-in except for runoff at Sites S and W, which slope 1% and 2%, respectively. All soils have sandy surface horizons except for the soil at Site O, which has fine sandy loam.				
O	Onite, buried soil phase	Typic Haplargid, coarse-loamy	Basin floor, level	Eolian analogue of Organ alluvium over Jornada-La Mesa; Camp Rice in part (?)
Y	Yucca	Typic Haplargid, coarse-loamy	Basin floor, level	Jornada-La Mesa; Camp Rice, wholly or in part
H1	Hueco	Petrocalcic Paleargid, coarse-loamy	Basin floor, level	La Mesa; Camp Rice
H2	Hueco	Petrocalcic Paleargid, coarse-loamy	Basin floor, level	La Mesa; Camp Rice
H3	Hueco	Petrocalcic Paleargid, coarse-loamy	Basin floor, level	La Mesa; Camp Rice
H4	Hueco	Petrocalcic Paleargid, coarse-loamy	Basin floor, level	La Mesa; Camp Rice
C	Cruces	Petrocalcic Paleargid, loamy, shallow	Basin floor, level	La Mesa; Camp Rice
S	Sonoita	Typic Haplargid, coarse-loamy	Ridge side in undulating basin floor, slope 1%	La Mesa; Camp Rice
W	Wink, deep gypsum phase	Typic Calciorthid, coarse-loamy	Ridge side in undulating basin floor, slope 2%	Eolian analogue of Jornada II (?) over gypsum of geologic (lacustrine?) orgin
T	Turney taxadjunct	Typic Calciorthid, fine-loamy	Basin floor; level	Jornada-La Mesa; Camp Rice, wholly or in part (?)
Soils of a narrow, level basin floor and adjacent fan-piedmont. Site H has runoff. Sites S1 and R occur in the basin floor and receive run-in from adjacent slopes. Although there is some runoff from sites VS3 and S2, which slope 1/2% and 1%, respectively, these soils are also thought to receive some run-in from long, gentle slopes above these sites. All soils have clay loam or loam surface horizons except for the soil at Site H, which has fine sandy loam.				
H	Herbel	Typic Torriorthent, coarse-loamy	Fan-piedmont, slope 2%	Organ alluvium derived from monzonite, andesite, and rhyolite
S1	Stellar	Ustollic Haplargid, fine	Basin floor, level	Jornada I basin-floor alluvium derived from monzonite, andesite, and rhyolite
R	Reagan	Ustollic Calciorthid, fine-silty	Basin floor, level	Petts Tank sediments derived from mixed sedimentary and igneous rocks
S2	Stellar	Ustollic Haplargid, fine	Fan-piedmont, slope 1%	Jornada II alluvium derived from monzonite, andesite, and rhyolite
VS3	Veatch, Stellar	Ustollic Haplargid, fine	Fan-piedmont toeslopes, slope 0.5%	Jornada II alluvium derived from monzonite, andesite, and rhyolite
A soil in a small playa that receives some run-in from long drainageways that head in adjacent mountains. This soil has a fine sandy loam surface horizon.				
B	Barcross	Typic Calciorthid, fine-loamy	Playa, level	Early Organ or Isaacks' Ranch alluvium derived from mixed sedimentary and igneous rocks, over gypsum of geologic (lacustrine?) orgin

[1]See fig. 2. Sites are arranged in order of their presentation in the text.
[2]Onite, Hueco, Cruces, Sonoita, Wink, Turney, Stellar, and Reagan are established series. Yucca and Herbel are proposed series. Barcross and Veatch are informal names for tentative use.
[3]All soils have mixed mineralogy and are in the thermic temperature class.
[4]At the land surface. Some sites have buried surfaces and soils.

less is known about details of the geomorphic surfaces and chronological relations of the soils. Oldest parts of the broad plain mentioned previously comprise the La Mesa geomorphic surface of middle Pleistocene age (table 1). Sediments of this plain (the fluvial facies of the Camp Rice Formation; Strain, 1966; Hawley, 1975) were deposited by the ancestral Rio Grande before the present valley was cut. These sediments have been eroded by wind and water in various places and some parts have been displaced by faulting, but details of this have yet to be worked out. The sediments associated with a given geomorphic surface (the sediments in which the soils have formed) are designated by the geomorphic surface name (e.g., Organ sediments; Hawley and Kottlowski, 1969).

Except for the Barcross soil at site B, all soils have formed in parent materials that contained little or no carbonate, so that virtually most or all of their carbonate was derived from atmospheric additions (Gile et al., 1981).

Soil classification follows the Soil Survey Staff (1975, 1990b). All of the studied soils are Aridisols except for the Torriorthent at site H (fig. 2). Six of the Aridisols are Haplargids, five are Paleargids, and four are Calciorthids (table 2). Horizon designations follow Guthrie and Witty (1982) except for the K horizon nomenclature (Gile et al., 1965), and the designations for buried soils, which are placed at the end of the designation to handle pedons with more than one buried soil. The K horizon is used in the Desert Project and other publications because, as noted by Birkeland (1984), "Most pedologists and geologists working in arid lands find it a very useful term." Carbonate stage terminology follows Gile et al. (1966) and Birkeland et al. (1991).

Precipitation

The precipitation at Headquarters, 1915-89, averaged 241 mm annually and 131 mm for July 1-September 30. Most summer rainfall occurs as localized thunderstorms of high intensity. Warm-season plants make most of their growth when moisture is available during the summer period. Most winter moisture comes from low-intensity rainfall or occasionally as snow. The precipitation is highly variable spatially and temporally. Springs are usually dry and windy. Groundwater in the basin occurs at a depth of 90-140 m in basin-fill deposits (King et al., 1971) and there is a permanent dry zone between the surface layers and groundwater.

Temperature

The frost-free period on the Jornada averages about 200 days. Temperatures are generally moderate with an annual mean of 15° C. The coldest month, January, has an average temperature of 4° C whereas July has an average temperature of 26° C. The diurnal variation is often 20° C.

Wind and Evaporation

The average annual wind movement at Headquarters was 17,346 km. Wind velocities averaged 2.4-3.2 km/hr for March-June but velocities up to 64 km/hr occur. High wind velocities in the spring under droughty conditions result in sandstorms. For July-February, average monthly means of wind velocities ranged from 1.0-1.6 km/hr.

High temperatures, low humidities, and high winds cause large water losses by evaporation, especially during late spring and early summer. Evaporation from a Weather Bureau Pan at Headquarters averaged 2,352 mm a year or about 10 times the average precipitation. The evaporation for June averaged 343 mm.

The components of the climate become collectively favorable for plant growth during July-September when soil water is available. In some years, the growing season may begin in June or even in May (Paulsen and Ares, 1962). Typically, some warm-season plants make some growth in late March and April, and periodically as moisture is available in May through early October.

EXPERIMENTAL PROCEDURES

Soil Water

Twenty-two sets of gypsum electrical resistance blocks were placed at 16 sites. Resource availability dictated location and time of establishment of the sites. Most of the blocks were installed in 1957-59 but one site was established September 1960 and another August 1964. Readings were terminated December 31, 1976 at all sites except one that was terminated December 31, 1973.

At each site, the blocks were placed at soil depths of 10, 25, and 40 cm, and to deeper depths at sites where the depth to carbonate horizons permitted the placement of blocks. The soil water stations were located within a livestock exclosure, and at a few locations all mammals were excluded. The exclosures in which the soil water stations were located had been in existence for variable periods of time (the oldest was established in 1912).

An ohmmeter was used to record resistance measurements 1-3 times per week when the matric potential was $\geq$-1.5 MPa during the summer. Measurements were recorded approximately monthly during the remainder of the year when there were fewer changes in soil water status. The blocks were calibrated in coarse- and medium-textured soils by determining their resistance at different pressures in a pressure plate extractor (Taylor et al., 1961). The blocks give similar readings at the same matric potential for the two groups of soils. All of the blocks were tested and only those with similar response curves were used. No deterioration of the gypsum medium of the blocks occurred in these arid soils. No change in calibration of the gypsum blocks was observed. Blocks were replaced during the study period if readings were inconsistent with other blocks at that location. Blocks used were manufactured and sold by Dr. S. A. Taylor.

The principal forces that contributed to resistance of the soil solution are matric and osmotic potentials (Kramer, 1983). Th soils in this study were nonsaline as determined by a method d veloped by the U.S. Salinity Laboratory (1954). Therefore, the measurements of the soil solution were a measure of the matric potential. The resistance measurements of the matric potential vary with soil temperatures. The soil temperatures were measured at six soil depths at four locations with thermistors at the same time as resistance readings were recorded. Each resistance reading was translated to megapascals (MPa) matric potential corrected to 15.6° C.

For days when the resistance was not measured, matric pot ntial was determined by: 1) previous determinations of matric pot ntial at that depth, 2) matric potential at other depths at that location, 3) current precipitation, and 4) previous pr cipitation events at that location. Precipitation was record d at each location after each storm event in a standard rain gauge modified with a funnel and stoppered plastic bottle to reduce evaporation loss (Gomm, 1961). Thus, daily determinations of matric potential from the date of installation of the gypsum blocks through December 31, 1976 were available except for August 1 through December 31, 1972 when the ohmmeter was inoperative. Resistance readings were terminated December 31, 1973 at one location. All the daily determinations were grouped into matric pot ntials of 0 to -0.1 MPa (category 1, readily available to plants), -0.1 to -1.5 MPa (category 2, also available to plants), and <-1.5 MPa (dry). Some plants use soil water <-1.5 MPa but this is a small volume of the water used by plants.

At four locations receiving run-in water, gypsum resistance blocks were placed inside and outside a sheet-metal cylinder. The cylinder was 3 m in diameter, was buried 15 cm in the soil, and extended 15 cm above the soil surface. The blocks inside the cylinder provided estimates of the matric potential due to precipitation while those placed outside the cylinder provided estimates of the matric potential due to precipitation plus run-in. The readings at the Veatch sites were taken inside a cylinder but a system of small depressions and holes in the soil surface from outside the cylinder gave additional water to the depths below 15 cm. This additional water also affected the readings at 10 cm.

Because winter soil water is generally not dissipated until April (the evaporative demand is greater and transpiration of many plants begins in March), the winter season for soil water is considered as December-April. The driest time of the year is usually May and June, and these months are designated as spring. The summer monsoon generally begins in late June or July, so summer is designated as July-September. Low night temperatures limit growth of the major C4 grasses in late September even though soil water is >-1.5 Mpa. The fall period is considered October and November.

Probabilities were calculated by determining the percentage of days in each month at each study site at each depth that had matric potentials ≥-1.5 Mpa and then averaging these percentages for the entire study period, to obtain the annual probabilities.

Logistic regression (Koch and Edwards, 1985) was used to determine if relationships exist between 1-10 day incremental accumulations of precipitation and categorical estimates of soil matric potential. The data were analyzed within a location and for each depth that a gypsum block was buried within the soil. From the results of these analyses it does not appear that there is a direct relationship ($P>.05$) between precipitation amounts and changes in soil matric potential. This indicates that daily precipitation amount by itself may not be adequate for predicting the soil moisture status of these locations.

Interpretation of the Soil Water and Precipitation Graphs

The precipitation and soil water data are presented in graphs for each site for each year, as illustrated in figure 3. Because both precipitation and soil water status are presented above a monthly scale, the effect of precipitation on soil moisture can be readily seen; each vertical line represents precipitation for a single day.

Figure 3 is interpreted as follows. The "a" shows the soil series part of the soil name (Onite in fig. 3; cf table 2). In a few cases, more than one water site had the same soil series, e.g., Hueco #1, Hueco #2, etc. At some sites, soil water was estimated both within and outside a sheet metal cylinder, e.g., Stellar #1 (inside metal) and Stellar #1 (outside metal). The "b" shows th year studied (1961 in fig. 3). The "c" shows the total annual precipitation at that site (287 mm in fig. 3). The "d" shows estimates of the daily precipitation (e.g., fig. 3 shows 12 mm on January 24, 1961 and 9 mm on January 25, 1961). The "e" shows the daily soil water in megapascals (MPa). The horizontal bar is only at the top when the matric potential of the soil water is >-0.1 MPa (readily available to plants), the horizontal bars are at the top 2 places when the soil water is between -0.1 and -1.5 MPa (also available to plants), and the horizontal bars are at all 3 places when the soil water is <1.5 MPa (dry). The "f" shows the soil depth of the gypsum block(s) (e.g., the matric potential of the soil water at the soil depth of 10 cm in fig. 3 was >-0.1 MPa Jan 1-Apr 23, 1961; between -0.1 and -1.5 MPa, Apr 24-May 7; and <-1.5 MPa, May 8-Jun 17, 1961). The "g" shows the time of the year which can be determined daily (first J = January, F = February.....D = December in fig. 3).

The graphs may be used to determine the approximate days of both cumulative and consecutive moist days, used in testing definitions of soil moisture regimes as discussed later. For example, in figure 3 at 25 cm depth (in the soil moisture control

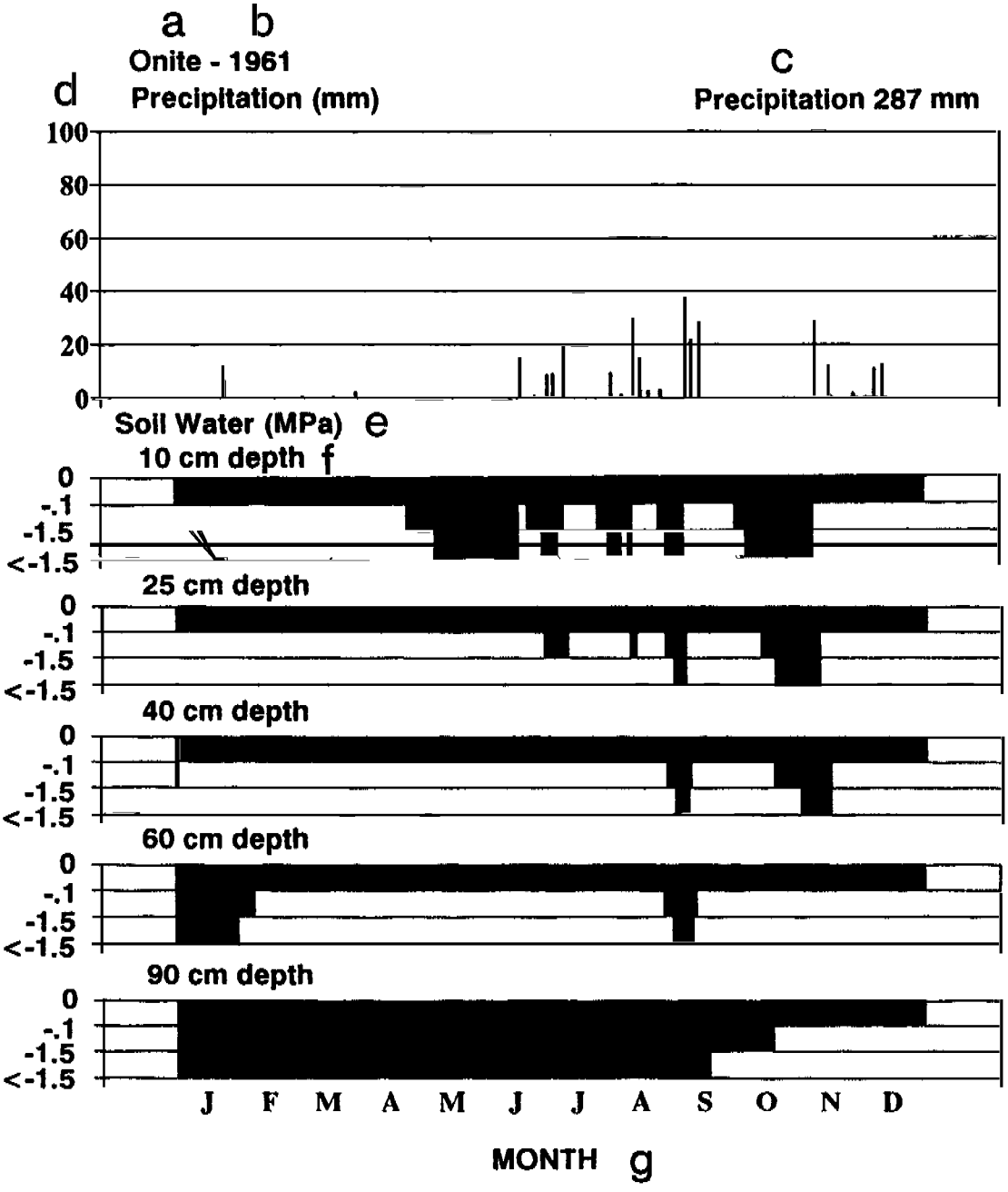


Figure 3. Interpretation of precipitation and soil water graphs. Letters a-g are explained in the text.

section) there were 246 consecutive moist days Jan 1-Sep 3, 42 consecutive moist days Sep 10-Oct 21, and 53 consecutive moist days Nov 9-Dec 31 for a total of 341 cumulative moist days.

There is often a considerable difference in the length of time that horizons are at >-0.1 MPa as compared to between >-0.1 and >-1.5 MPa, the former usually being much greater, as illustrated by figure 3. This is because the volume of soil water between 0 and -0.03 is greater than that between -0.03 and -0.1 MPa, and between -0.1 and -1.5 MPa. Thus, the length of time any soil has water >-0.1 MPa is greater than the length of time the soil water is between -0.1 and -1.5 MPa. When the soil is in a drying mode, changing to a wetting mode requires more precipitation than when the soil is in a wetting mode.

Yields

Vegetation data were collected at end of the summer growing season in October or early November. The samples were taken near the soil water station at some sites. Perennial grasses were clipped at ground level; growth from previous years was separated from the production of the current year and the old growth was discarded; and the herbage was air-dried and weighed. Each sampling plot was 5 cm x 30.5 m on sandy soils and 30.5 cm x 1.5 m on clay loams. Means and standard errors of the mean (s.e.) were calculated for each year when the data were available.

Relation of the Soil Water Data to Soil Morphology and Classification

To relate soil morphology and classification to the soil water data, the soils selected for study must be very similar to the soils in which the gypsum blocks are set. For this reason the soils around the blocks were examined in considerable detail with an auger before the study trench was dug. Even though the soil water readings were discontinued in 1976, the blocks could still be precisely located in 1990 (except for sites W and S2) by the wires leading to them. At sites W and S2, the approximate former location of the gypsum blocks was provided by ARS personnel who were familiar with them at the time the readings were taken. In the text, location of the studied pedon with respect to the gypsum blocks is indicated by reference to one or more of these markers: the wires leading to the blocks, the low stakes on which the wires were placed, the recording rain gauge, the nonrecording rain gauge, and/or the exclosure fence. See "Location of Information" section and table 6a for location of information on soil morphology.

Because soil water data are extremely scarce for soils of arid regions, the data obtained in this study are useful for testing definitions involving soil classification and soil moisture. Definitions tested in this manuscript are those presented by the Soil Survey Staff (1975, 1990a) and by the International Committee

on Aridisols (1987). Proposed definitions involving soil moisture have also been presented by the International Committee on Soil Moisture and Temperature Regimes (ICOMMOTR) (1992). These definitions were not tested with these data.

The Soil Moisture Control Section and the Soil Moisture Regime

Because definitions concerning soil water (Soil Survey Staff, 1975, 1990b) are basic to discussions of soil water and soil classification presented later, the definitions concerned (Soil Survey Staff, 1990a) are quoted below.

> SOIL MOISTURE REGIMES
>
> The soil moisture regime, as the term is used here, refers to the presence or absence either of ground water or of water held at a tension less than 1500 kPa (>-1.5 MPa in this chapter) in the soil or in specific horizons by periods of the year. Water held at a tension of 1500 kPa or more is not available to keep most mesophytic plants alive. The availability of water also is affected by dissolved salts. A soil may be saturated with water that is too salty to be available to most plants, but it would seem better to call such a soil salty rather than dry. Consequently, we consider a horizon to be dry when the moisture tension is 1500 kPa or more. If water is held at a tension of less than 1500 kPa but more than zero, we consider the horizon to be moist. A soil may be continuously moist in some or all horizons throughout the year or for some part of the year. It may be moist in winter and dry in summer or the reverse. In the northern hemisphere, summer refers to the months of June, July, and August, and winter means December, January, and February. A soil or a horizon is considered to be saturated with water when water stands in an unlined borehole close enough to the soil surface or to the horizon in question that the capillary fringe reaches the surface or the top of the horizon.
>
> Soil moisture control section
>
> The intent in defining the soil moisture control section is to facilitate estimation of soil moisture regimes from the climatic data. The upper boundary of this control section is the depth to which a dry (tension of more than 1500 kPa but not air dry) soil will be moistened by 2.5 cm (1 in.) of water within 24 hours. The lower boundary is the depth of which a dry soil will be moistened by 7.5 cm (3 in.) of water within 48 hours. These depths are exclusive of the depth of moistening along any cracks or animal burrows that are open to the surface.

If 7.5 cm of water moistens the soil to a lithic, petroferric, or paralithic contact or to a petrocalcic horizon or a duripan, the upper boundary of the rock or of the cemented horizon is the lower boundary of the soil moisture control section. If 2.5 cm of water moistens the soil to one of these contacts or horizons, the soil moisture control section is the lithic contact itself, the paralithic contact, or the upper boundary of the cemented horizon. The control section of the latter soil is moist if the upper boundary of the rock or the cemented horizon has a thin film or water. If the upper boundary is dry, the control section is dry.

As a rough guide to the limits, the soil moisture control section lies approximately between 10 and 30 cm (4 and 12 in.) if the particle-size class is fine-loamy, coarse-silty, fine-silty, or clayey. The control section extends approximately from a depth of 20 cm to a depth of 60 cm (8 to 24 in.) if the particle-size class is coarse-loamy, and from 30 to 90 cm (12 to 35 in.) if the particle-size class is sandy.

Classes of soil moisture regimes

The moisture regimes are defined in terms of the ground-water level and in terms of the presence or absence of water held at a tension less than 1500 kPa in the moisture control section by periods of the year. It is assumed in the definitions that the soil supports whatever vegetation it is capable of supporting. In other words, it is in crops, grass, or native vegetation; it is not being fallowed to increase the amount of stored moisture, nor is it being irrigated by man. These cultural practices affect the soil moisture condition as long as they are continued.

Aridic and torric (L. *aridus*, dry and L. *torridus*, hot and dry) moisture regimes. --These terms are used for the same moisture regime but in different categories of the taxonomy.

In the aridic (torric) moisture regime, the moisture control section in most years is

1. Dry in all parts more than half the time (cumulative) that the soil temperature at a depth of 50 cm is above 5° C; **and**

2. Never moist in some or all parts for as long as 90 consecutive days when the soil temperature at a depth of 50 cm is above 8°C.

According to the particle-size classes cited in the previous section on the soil moisture control section, soil water data from the most appropriate depths in soils of this study have been selected to test the definitions of the soil moisture regimes. For all sites soil water data at 25 cm depth have been used because this depth lies within the soil moisture control section of all soils of the study. For convenience, soil water data for other depths are also presented.

The Draft Definition for "Bordering Ustic"

A "Bordering Ustic" criterion has been proposed to distinguish some subgroups (e.g., the Ustollic Haplargids). The draft definition is quoted below (International Committee on Aridisols, 1987).

> In the non-iso soil temperature regime, the soil moisture control section is moist in some part for 60 to 90 consecutive days per year when the soil temperature at 50 cm is more than 8°C but not moist in any part for more than 30 consecutive days in the 4 months following the summer solstice.

RESULTS AND DISCUSSION

EXCHANGE CHEMISTRY, ORGANIC CARBON, AND CARBONATE

Tables 3 and 4 present some of the data for the eight soils analyzed in the laboratory; other data are in the data sheets for each site. Soluble salts and extractable sodium (Na) are very low for all soils, reflecting movement of water through the sampled horizons at the present time. Extractable potassium (K) and organic carbon values are all very low except for the Ustollic Haplargid, Stellar, which is finer-textured, has a much denser vegetative cover than the other soils, and receives some run-in (table 2).

A characteristic feature termed the noncalcareous zone has formed above many horizons of carbonate accumulation in the area (Gile, 1977). The close relation of the formation and thickness of this zone to soil water was demonstrated in transects from the arid basin to the semiarid mountains (Gile, 1977). In Holocene soils with sandy loam textures and at stable sites, thickness of the noncalcareous zone gradually increases mountainward, reflecting the increase in precipitation. Holocene soils were used because infiltration and depth of moisture penetration in these soils are not confounded by prominent horizons that developed in the Pleistocene.

As noted previously, calcium carbonate in dustfall and in precipitation has been a major source of carbonate in most soils of this study. The soils shown in tables 3 and 4 have all formed in

Table 3. Particle size, organic C, carbonate, and soil water data for soils at sites Y, H1, H2, and H4.

Horizon	Depth cm	Tex-tural class	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	Organic C	$CaCO_3$	Water content -0.03 MPa	Water content -1.5 MPa	AWC (WRD)[1]	Bulk density -0.03 MPa	AWC	AWC in horizon
			%						%		g/cc	cm/cm	
Typic Haplargid, Yucca (S90NM-013-001)[2], at site Y													
C	0-8	s	89	5	6	0.19			2.8				
Eb	8-15	ls	85	5	10	0.26		10.9	3.8	7.1	1.62	0.12	0.84
BEtb	15-25	ls	85	4	11	0.29	1		4.1				
Btklb	25-37	ls	83	4	12	0.22	1		4.7				
Btk2b	37-51	fsl	81	6	13	0.20	1	8.7	5.0	2.7	1.47	0.05	0.70
Btk3b	51-62	fsl	78	7	16	0.22	2		6.1				
Btk4b	62-71	sl	74	7	19	0.26	4	10.0	7.8	2.2	1.53	0.03	0.27
Btk5b	71-85	scl	71	7	22	0.24	6		7.8				
Klb	85-104	scl	66	10	24	0.18	18		8.3				
K2b	101-112	scl	64	12	23	0.12	25	13.5	7.2	6.3	1.69	0.10	1.10
Total AWC in measured horizons: 2.9 cm													
AWC from 0-112 cm using the same rate as for the measured horizons (0.071 cm water/cm soil): 8.0 cm													
Petrocalcic Paleargid, Hueco #1 (S90NM-013-002), at site H1													
C	0-11	s	89	5	7	0.17			2.3				
Ab	11-18	ls	86	7	7	0.21			2.7				
BAt	18-26	ls	85	5	11	0.27			3.6				
Btl	26-35	ls	82	5	12	0.22		6.5	4.5	2.0	1.60	0.03	0.27
Bt2	35-50	ls	82	6	12	0.19		5.6	4.4	1.2	1.63	0.02	0.30
Bt3	50-71	fsl	81	7	12	0.16		6.9	4.5	2.4	1.65	0.04	0.84
Btkb	71-84	fsl	78	8	14	0.20	1		5.3				
K21mb	84-88	(Carbonate-cemented upper subhorizon of the petrocalcic horizon)				0.23	65		11.1				
Total AWC in measured horizons: 1.4 cm													
AWC from 0-84 cm using the same rate as for the measured horizons (0.031 cm water/cm soil): 2.6 cm													
Petrocalcic Paleargid, Hueco #2 (S90NM-013-003), at site H2													
C	0-11	s	89	4	7	0.15	TR		2.2				
Ab	11-18	ls	82	8	10	0.26	TR	10.5	4.0	6.5	1.51	0.10	0.70
Btlb	18-29	ls	83	5	12	0.19	TR	6.8	4.5	2.3	1.81	0.04	0.44
Bt2b	29-41	ls	83	5	12	0.17	TR		4.5				
Btklb	41-53	fsl	81	4	15	0.17	1	7.5	5.4	2.1	1.58	0.03	0.36
Btk2b	53-66	fsl	77	7	15	0.24	4	9.7	6.6	3.1	1.51	0.05	0.65
Klb	66-76	vgsl	76	15	9	0.21	80		10.8				
K2lmb	76-80	(Carbonate-cemented upper subhorizon of the petrocalcic horizon)				0.26	82		8.1				
Total AWC in measured horizons: 2.2 cm													
AWC from 0-76 cm using the same rate as for the measured horizons (0.065 cm water/cm soil): 4.9 cm													
Petrocalcic Paleargid, Hueco #4 (S90NM-013-005), at site H4													
A	0-5	ls	89	2	9	0.28	TR		2.8				
C	5-12	ls	89	2	9	0.11	TR		2.8				
BAtkb	12-23	fsl	81	4	15	0.18	2	6.5	4.6	1.9	1.56	0.02	0.22
Btklb	23-34	fsl	76	5	19	0.21	4		6.0				
Btk2b	34-44	fsl	76	4	20	0.16	4	10.8	7.6	3.2	1.55	0.05	0.50
Btk3b	44-57	fsl	77	7	16	0.16	4		6.4				
Kltb	57-67	fsl	70	11	20	0.21	12	12.7	6.8	5.9	1.69	0.10	1.00
K2lmb	67-69	(Carbonate-cemented upper subhorizon of the petrocalcic horizon)											
Total AWC in measured horizons: 1.7 cm													
AWC from 0-67 cm using the same rate as for the measured horizons (0.55 cm water/cm soil): 3.7 cm													

[1]WRD = Water Retention Difference, the weight (g) of the water retained in 1 cm^3 of whole soil between -0.03 and -1.5 MPa (Soil Conservation Service, 1984), reported as cm of water per cm of soil. This figure is an estimate of the available water capacity (AWC).

$$WRD = \frac{W(-0.03MPa) - W(-1.5MPa)\ (Db\text{-}0.03MPa)\ cm}{100}$$

[2]National Soil Survey Laboratory (NSSL) number.

Table 4. Particle size, organic C, carbonate, and soil water data for soils at sites S, W, T, and S2.

Horizon	Depth cm	Tex-tural class	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	Organic C	$CaCO_3$	Water content -0.03 MPa	Water content -1.5 MPa	AWC (WRD)[1]	Bulk density -0.03 MPa	AWC	AWC in horizon
			%						%		g/cc	cm/cm	
Typic Haplargid, Sonoita (S90NM-013-006), at site S													
C1	0-8	s	91	4	5	0.28			2.2				
C2	8-16	s	92	3	5	0.14	TR		2.2				
C3	16-33	s	91	4	5	0.12	TR		2.1				
Ab	33-39	ls	86	7	7	0.18	TR	5.2	2.8	2.4	1.66	0.04	0.24
BAtb	39-44	ls	83	6	11	0.22	TR		3.6				
Bt1b	44-55	ls	84	5	11	0.20	TR	6.2	4.5	1.7	1.62	0.03	0.33
Bt2b	55-70	fsl	81	7	12	0.20	TR	6.9	4.9	2.0	1.64	0.03	0.45
Bt3b	70-91	fsl	77	10	13	0.18	TR		5.2				
Btk1b	91-109	fsl	77	7	16	0.17	3	8.4	6.3	2.1	1.60	0.03	0.54
Btk2b	109-129	fsl	80	6	14	0.10	2	9.2	5.7	3.5	1.62	0.06	1.20
Btk3b	129-143	fsl	82	6	12	0.08	2	9.1	5.4	3.7	1.68	0.06	0.84
Total AWC in measured horizons: 3.6 cm													
AWC from 0-143 cm using the same rate as for the measured horizons (0.043 cm water/cm soil): 6.2 cm													
Typic Calciorthid, Wink phase (S90NM-013-004), at site W													
C	0-9	ls	87	5	8	0.26	1		2.9				
A1b	9-18	ls	84	7	9	0.26	1	4.5	3.2	1.3	1.69	0.02	0.18
A2b	18-30	ls	86	4	11	0.23	2		3.5				
Bb	30-42	fsl	81	6	13	0.23	5	5.3	4.4	0.9	1.59	0.01	0.12
Bk1b	42-58	fsl	79	7	13	0.21	7		4.5				
Bk2b	58-78	fsl	77	8	14	0.18	6		4.8				
K2b	78-101	scl	64	14	22	0.22	17	11.2	6.7	4.5	1.52	0.07	1.61
K3b	101-117	scl	60	17	23	0.18	12	13.2	7.7	5.5	1.53	0.08	1.28
Bkb	117-127	scl	65	14	21	0.19	10		7.7				
Cb	127-136	sl	61	31	8	0.08	2	19.7	6.0	13.7	1.30	0.18	1.62
Total AWC in measured horizons: 4.8 cm													
AWC from 0-136 cm using the same rate as for the measured horizons (0.070 cm water/cm soil): 9.5 cm													
Typic Calciorthid, Turney taxadiunct (S90NM-013-007), at site T													
A	0-5	ls	83	9	8	0.18	3		3.6				
C	5-19	ls	85	7	8	0.19	3	6.5	3.5	3.0	1.58	0.05	0.70
Bk1	19-34	fsl	69	15	16	0.30	6	10.2	6.5	3.7	1.54	0.06	0.90
Bk2	34-46	sl	65	16	19	0.32	11	10.7	7.1	3.6	1.48	0.05	0.60
Bk3	46-57	scl	62	18	21	0.26	12	8.7	7.1	1.6	1.54	0.02	0.22
Bk4	57-67	scl	53	19	28	0.33	18	15.6	8.8	6.8	1.42	0.10	1.00
K21	67-77	cl	40	27	33	0.30	34	18.0	8.6	9.4	1.40	0.13	1.30
K22	77-92	cl	37	30	33	0.20	38	15.8	8.5	7.3	1.68	0.12	1.80
Btk	91-111	cl	43	27	30	0.14	31	13.2	8.4	4.8	1.76	0.08	1.52
Total AWC in measured horizons: 8.0 cm													
AWC from 0-111 cm using the same rate as for the measured horizons (0.076 cm water/cm soil): 8.4 cm													
Ustollic Haplargid, Stellar (S90NM-013-008), at site S2													
A	0-4	l	50	29	21	2.21	1		11.0				
EA	4-14	vfsl	57	26	17	0.96	1	17.5	9.2	8.3	1.46	0.12	1.20
E	14-22	l	30	44	26	1.03	TR	21.9	13.1	8.8	1.42	0.13	1.04
EB	22-29	cl	27	37	36	0.66			15.0				
Bt1	29-39	cl	35	30	35	0.48	1	18.9	14.1	4.8	1.56	0.07	0.70
Bt2	39-54	cl	32	33	35	0.43	1	19.4	13.7	5.7	1.57	0.09	1.35
Btk1	54-68	cl	33	36	32	0.30	2		12.9				
Btk2	68-78	cl	32	35	33	0.26	4	18.3	12.6	5.7	1.46	0.08	0.80
Btk3	78-97	cl	36	26	38	0.22	6	19.9	14.1	5.8	1.52	0.09	1.7
K1t	97-105	c	28	30	42	0.20	21		13.9				
K2l	105-118	c	23	36	41	0.19	30	21.1	11.9	9.2	1.48	0.13	1.69
Total AWC in measured horizons: 8.5 cm													
AWC from 0-118 cm using the same rate as for the measured horizons (0.100 cm water/cm soil): 11.8 cm													

[1]See footnote 1, table 3.

parent materials with little or no carbonate. In sandy textures and at stable sites, these parent materials sensitively reflect movement of water into the soil; enough water enters it to move carbonate from the soil surface downward and to form a noncalcareous zone with a carbonate horizon beneath it.

The illustrative soils (tables 3 and 4) all date from the Pleistocene, have prominent horizons, differ considerably in texture, and occur at roughly the same elevation, thus differing from the orographic study cited earlier. Due to the foregoing variables, formation and thickness of the noncalcareous zone can differ greatly in soils at the same elevation. Five of the eight soils in tables 3 and 4 have noncalcareous zones that range in thickness from 12 to 91 cm; the latter is a huge pipe (see site S). Soil texture is important; all but one of the soils with noncalcareous zones have sand upper horizons underlain by loamy sand horizons, that in turn are underlain by fine sandy loam horizons. These noncalcareous zones are significant indicators of soil water because they reflect a zone of common water movement and leaching under the present climate.

A variation of the general tendency to form a surficial noncalcareous zone is shown by Stellar soils of the fan-piedmont toeslopes. In these soils, the upper few cm of the soils are commonly calcareous above an underlying noncalcareous zone; so much carbonate has accumulated from dustfall and run-in that the present moisture is unable to move all of it down into the soil.

A noncalcareous zone has not formed at all in high-carbonate parent materials, nor in soils with prominent carbonate horizons so near the surface that materials from them have been brought to or near the surface by soil biota, by erosion, or, in very old soils, by long-continued accumulation in the soil itself. The Wink soils are calcareous throughout, but contain only 1% carbonate in upper horizons (table 4).

AVAILABLE WATER CAPACITY

This section considers the volume of water in soils as determined in the laboratory. The water content at -0.03 MPa is closely related to field capacity, and the water content at -1.5 MPa is closely related to the wilting point in many soils. The difference between -0.03 MPa and -1.5 MPa has been used to represent the amount of water that is available to plants, commonly termed available water capacity (AWC; e.g., Peters and Bartelli, 1958; Longwell et al., 1963; and Cassel and Nielsen, 1986).

Longwell et al. (1963) studied the AWC of many soils in Tennessee. The loam, silty clay loam, and silt loam textures had the highest AWC; means ranged from 0.191 to 0.234 cm of available water per cm (in/in) of soil. Silty clays, clay loams, and clays were medium in AWC, with means ranging from 0.156 to 0.180 cm/cm (in/in) of soil. Fine sandy loams, sandy loams, and loamy sands had means ranging from 0.015 to 0.171 cm of available water per cm of soil.

Detailed studies of soil water were carried out by Bartelli and Peters (1959). Because the amount of water in any soil at a specific tension is largely controlled by particle size and organic matter, Bartelli and Peters (1959) studied the relations between silt, clay, organic matter, and soil water at -0.03 MPa and -1.5 MPa. Their studies showed AWC to be controlled primarily by the silt fraction. They found a significant positive correlation between silt content and AWC, and a lack of any correlation between clay content and AWC. Bartelli and Peters (1959) found that organic matter influences AWC most strongly in coarse-textured soils, and much less so in soils high in silt and clay.

As noted by the NSSL (unpublished training materials, NSSL, SCS), the amount of silt is important because water held between -0.03 and -1.5 MPa is retained by silt-sized pores (pores with diameters of 0.02-10 micrometers).

The difference between -0.03 MPa and -1.5 MPa has limitations for use as AWC (Russell, 1962; Bartelli and Peters, 1959). In addition, differences have been found between field and laboratory estimates of AWC (Franzmeier et al., 1973). Nevertheless, the difference between -0.03 and -1.5 MPa tensions continues to be used as a guide for estimating the approximate AWC for many soils, at the same time recognizing the limitations. Table 5 shows the NSSL guides for estimating AWC (unpublished training materials, NSSL-SCS). The table also shows the profound effect of rock fragments in decreasing AWC.

In sampling soils of this study for laboratory measurements of soil water, clods of representative horizons were taken for determination of bulk density and soil water at -0.03 MPa and -1.5 MPa. To convert from a percentage to a volume basis, the difference between -0.03 and -1.5 MPa water contents is multiplied by the -0.03 MPa bulk density (and corrected for content of rock fragments, if present). This is termed Water Retention Difference (Soil Conservation Service, 1984; table 3). Tables 3 and 4 present bulk density and soil water determinations, with laboratory determinations of properties that commonly influence AWC. Current reporting methods present WRD (AWC of this study) as cm/cm instead of in/in of the earlier work. However, the two values are numerically equal. In a number of cases the WRD values are very low (<0.05), suggesting the possibility that Saran used in the WRD procedure may have infiltrated the clods. This possibility has not been explored.

As shown in tables 3 and 4, in most soils only representative horizons were sampled for bulk density and soil water determinations. Thus, there are gaps in the AWC picture.

Table 6 summarizes the AWC data by soil texture. None of the AWC values for loamy sand fall within the 0.06-0.08 range in table 5; two of the values are above it and the remainder are below it. For the sandy loams, fine sandy loams, and very fine sandy loam, all values are well below the ranges of 0.11-0.13, 0.13-0.15, and 0.15-0.17, respectively, except for the 0.18 value for the Wink sandy loam. Although this horizon was not analyzed for gypsum in the

Table 5. Guides for estimating available water capacity (AWC)[1]

Soil Texture	% COARSE FRAGMENTS (BY VOLUME)														
	0	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	AVAILABLE WATER CAPACITY (cm/cm or in/in)														
clay	.14-.16	.12-.14	.12-.14	.11-.13	.11-.12	.10-.11	.09-.10	.08-.10	.08-.09	.07-.08	.06-.07	.05-.06	.05-.06	.04-.05	.03-04
silty clay	.15-.17	.13-.15	.13-.14	.12-.14	.11-.13	.10-.12	.10-.11	.09-.10	.08-.09	.07-.09	.07-.08	.06-.07	.05-.07	.04-.05	.04
sandy clay	.15-.17	.13-.15	.13-.14	.12-.14	.11-.13	.10-.12	.10-.11	.09-.10	.08-.09	.07-.09	.07-.08	.06-.07	.05-.06	.04-.05	.04
silty clay loam	.19-.21	.17-.19	.16-.18	.15-.17	.14-.16	.13-.15	.12-.14	.11-.13	.10-.12	.09-.11	.08-.09	.07-.08	.06-.07	.06	.05
clay loam	.19-.21	.17-.19	.16-.18	.15-.17	.14-.16	.13-.15	.12-.14	.11-.13	.10-.12	.09-.11	.08-.09	.07-.08	.06-.07	.06	.05
sandy clay loam	.14-.16	.12-.14	.12-.14	.11-.13	.11-.12	.10-.11	.09-.10	.08-.10	.08-.09	.07-.08	.06-.07	.05-.06	.05-.06	.04-.05	.03-.04
silt loam	.19-.21	.17-.19	.16-.18	.15-.17	.14-.16	.13-.15	.12-.14	.11-.13	.10-.12	.09-.11	.08-.09	.07-.08	.06-.07	.06	.05
loam	.16-.18	.14-.16	.14-.15	.13-.14	.12-.14	.11-.13	.10-.12	.10-.11	.09-.10	.08-.09	.07-.08	.05-.07	.05-.06	.05	.04-.05
very fine sandy loam	.15-.17	.13-.15	.13-.14	.12-.14	.11-.13	.10-.12	.10-.11	.09-.10	.08-.09	.07-.09	.07-.08	.06-.07	.05-.06	.04-.05	.04
fine sandy loam	.13-.15	.12-.14	.11-.13	.10-.12	.10-.11	.09-.11	.08-.10	.08-.09	.07-.08	.06-.08	.06-.07	.05-.06	.04-.05	.04-.05	.03-.04
sandy loam	.11-.13	.10-.12	.09-.11	.09-.10	.08-.10	.07-.09	.07-.08	.07-.08	.06-.07	.05-.07	.05-.06	.04-.05	.04-.05	.03-.04	.03
loamy very fine sand	.10-.12	.09-.11	.08-.10	.08-.10	.08-.09	.07-.08	.06-.08	.06-.07	.05-.07	.05-.06	.04-.05	.04-.05	.03-.04	.03-.04	.02-.03
loamy fine sand	.09-.11	.08-.10	.08-.09	.07-.09	.07-.08	.06-.07	.06-.07	.05-.07	.05-.06	.04-.06	.04-.05	.03-.04	.03-.04	.03	.02-.03
loamy sand	.06-.08	.05-.07	.05-.07	.05-.06	.04-.06	.04-.06	.04-.05	.04-.05	.03-.04	.03-.04	.03-.04	.02-.03	.02-.03	.02	.01-.02
fine sand	.05-.07	.04-.06	.04-.06	.04-.06	.04-.05	.03-.05	.03-.05	.03-.04	.03-.04	.03-.04	.02-.03	.02-.03	.02-.03	.01-.02	.01-.02

[1]From unpublished training materials, NSSL, SCS.

Table 6. Available water capacity (AWC)[1] and texture for eight soils.

Soil and NSSL no.	Texture: loamy sand	sandy loam	fine sandy loam	very fine sandy loam	loam	sandy clay loam	clay loam	clay
	Available water capacity (cm/cm, or in/in)							
Yucca S90NM-013-001	0.12	0.03	0.05					
Hueco #1 S90NM-013-002	0.03 0.02		0.04					
Hueco #2 S90NM-013-003	0.10 0.04		0.03 0.05					
Hueco #4 S90NM-013-005			0.02 0.05 0.10					
Sonoita S90NM-013-006	0.04 0.03		0.03 0.03 0.06 0.06					
Wink S90NM-013-004	0.02	0.18	0.01			0.07 0.08		
Turney S90NM-013-007	0.05		0.06 0.05			0.02 0.10	0.13 0.12 0.08	
Stellar #2 S90NM-013-008				0.12	0.13		0.07 0.09 0.08 0.09	0.13

[1]Estimates from WRD values (see footnote 1, table 3).

laboratory, field morphology indicates that the horizon consists primarily of gypsum, and this may be partly responsible for the high AWC.

The single value of 0.13 for loam is well below the suggested range of 0.16-0.18 (table 5). The sandy clay loam and clay loam values are well below the ranges of 0.14-0.16 and 0.19-0.21, respectively. The single value for clay (0.13) is close to the range of 0.14-0.16 in table 5. Reasons for the low values are not known, but may be related to the relatively low silt values and/or low values of organic carbon for most of the horizons studied. In one respect the values as a whole are similar to the Tennessee work and to the guides in table 5: the coarser textures (loamy sand, sandy loam, and fine sandy loam) generally have lower values than the finer textures (very fine sandy loam, loam, sandy clay loam, clay loam, and clay).

Carbonates may also have a role in increasing AWC (compare deeper horizons that have higher percentages of carbonate with upper horizons that have little or no carbonate, tables 3 and 4). The higher percentages of organic carbon for Stellar #2 may be partly responsible for the higher AWC in the horizons from 4 to 22 cm depth (table 4). The highest value obtained for AWC was the 0.18 cm/cm for the Wink sandy loam discussed previously.

LOCATION OF INFORMATION

This report presents a substantial amount of information about the 16 soil water sites in the Jornada Experimental Range. To facilitate use of this information by readers who wish to study the detailed interrelationships of the laboratory data, soil morphology, and soil water at different depths and at different sites, all material pertinent to a given site is located at one place instead of putting some of it in an appendix. To aid locating the specific information at each site, table 6a locates the text discussion, photographs, summary tables of selected data, complete data, narrative soil descriptions, tables of soil morphology, and soil water and precipitation graphs for each site.

SOILS AND MATRIC POTENTIAL OF SOIL WATER

Data are presented for soils at 16 sites that occur in three general landscape positions (fig. 2, table 2): (1) a broad, nearly level basin floor with generally good infiltration, only localized runoff, and usually no run-in from adjacent slopes, (2) a narrow basin floor and an adjacent fan-piedmont that contributes water to the basin floor, and (3) a small playa that receives some run-in water from long drainageways leading to adjacent mountains.

Table 6a. Location of information for the 16 soil water sites.

Site	Soil	Page: Start of text discussion	Photographs	Summary tables of data	Complete laboratory data	Narrative soil descriptions	Tables of soil morphology	Soil water and precipitation graphs
O	Onite, buried soil phase	24	27, 28	—	—	[1]	26	30-52
Y	Yucca	51	53, 54	26	57	55, 56	26	60-81
H1	Hueco	76	83, 84	82	87	85, 86	82	89-111
H2	Hueco	104	112, 113	82	117	115, 116	82	118-140
H3	Hueco	141	142, 143	—	—	[1]	82	144-163
H4	Hueco	158	164, 165	82	168	166, 167	82	170-191
C	Cruces	182	192, 193	—	—	—	82	195-209
S	Sonoita	210	212-214	211	217	215, 216	211	219-241
W	Wink, deep gypsum phase	236	242, 243	211	246	244, 245	211	248-266
T	Turney taxadjunct	267	268, 269	211	272	270, 271	211	273-294
H	Herbel	295	299, 300	—	—	[1]	298	302-322
S1	Stellar	313	324, 325	—	—	[1]	323	328-369
R	Reagan	370	371, 372	—	—	[1]	323	374-415
S2	Stellar	413	417, 418	416	421	419, 420	416	423-444
VS3	Veatch	437	446, 447	—	—	[1]	445	453-532
	Stellar	437	448, 449	—	—	—	445	453-532
B	Barcross	533	535, 536	—	—	[1]	534	538-580

[1]In Herbel and Gile, 1973.

Broad Basin Floor Without Run-in

Ten of the soil water sites occur in a broad basin floor and have no run-in from adjacent slopes (fig. 4). Table 2 lists the soils, landscapes, and geomorphic surfaces.

Site Onite, Buried Soil Phase (O)

Site O (figs. 4-6, table 7) is in Exclosure A on the Jornada Experimental Range. The west edge of the study trench was about 2 m east of the nonrecording rain gauge, which has now been removed from the exclosure. The area had a good cover of black grama prior to the great drought of 1951-56 (Herbel et al., 1972). By the end of the drought, black grama cover was reduced to 1% of the predrought average and it has not increased since that time. The present perennial vegetation is a relatively sparse stand of mesa dropseed.

Soils. The soil water blocks are in the Typic Haplargid, Onite, buried soil phase (fig. 6, table 7). Diagnostic horizons are an ochric epipedon and an argillic horizon. Soil morphology (table 7) indicates a buried soil from 44 to 126 cm depth. In horizons above 44 cm, silicate clay decreases below the Bt horizon, then abruptly increases in the buried horizons below 44 cm. To the 44-cm depth the horizons are similar to those of Organ soils (table 1), and the deposit from 0-44 cm depth is considered to be an eolian analogue of Organ alluvium. Age of the buried horizons is not known, and they are tentatively designated Jornada-La Mesa, a broad designation ranging from late to middle Pleistocene in age (table 1).

There is abundant evidence of recent wind erosion; a belt of sand about 7 m wide is piled along the fence on the southwest side of the exclosure, and is nearly 1 m high at the fence. Smaller eolian accumulations occur around the other sides of the exclosure and around shrubs. There are no large coppice dunes. Because the sand belt along the fence was recorded in 1970, it must have accumulated during the period 1958-1970. Severe drought years occurred from 1951-56 (Herbel et al., 1972), and this may have initiated or accelerated erosion in some areas.

Although there is substantial evidence of recent erosion, horizon arrangement suggests a net effect of long-term stability at this site. The noncalcareous upper horizons and the gradual increase in stage of carbonate accumulation with depth (from stage I carbonate filaments in the BAtkb horizon, to the stage II carbonate nodules in the Btkb horizon, and to stage III carbonate in the K2b horizon) all indicate long-term stability, with sediments in place to record the effect of pedogenesis.

The Onite phase is noncalcareous to a depth of 44 cm (except for weak effervescence in a few spots in the BCt2 horizon) and reflects a zone of relatively frequent wetting. The substantial depth of wetting is attributed to the moderately coarse texture of upper horizons, to the sandy BCt2 horizon, and to the substantial

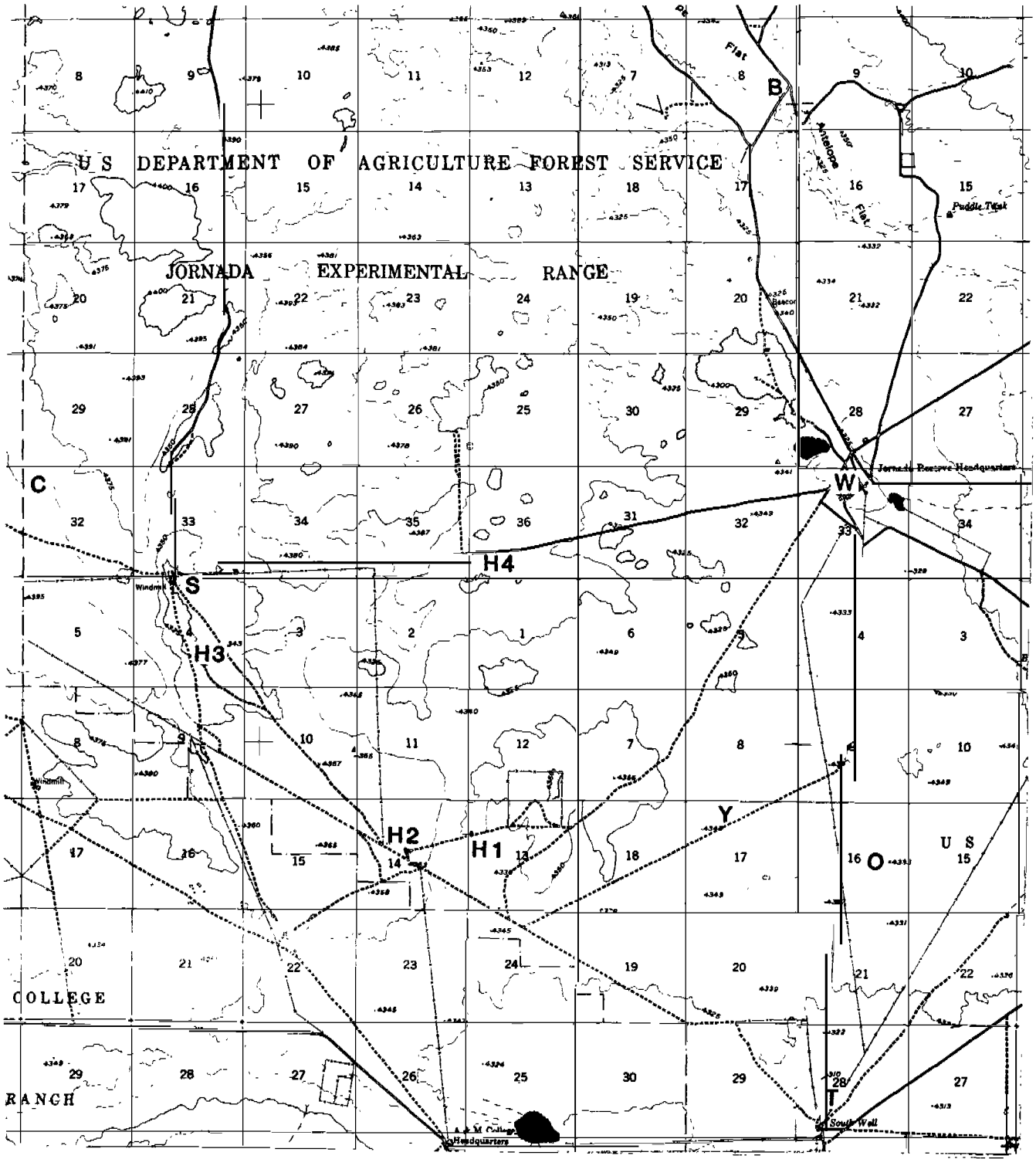


Figure 4. Topography and elevations in the vicinity of sites B, C, H1, H2, H3, H4, O, S, T, W, and Y, from the San Diego and Bear Peak 15' Quadrangles.

Table 7. Characteristics of Typic Haplargids at sites O and Y[1].

Horizon	Depth cm	Hue	Value/chroma Dry	Value/chroma Moist	Structure	Consistence Dry	Consistence Moist	Eff. with HCl	Textural class	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay < 0.002 mm	Organic C	$CaCO_3$
										%				
Onite phase at site O														
Bt	0-18	5YR	5/5	4/5	lmsbk	sh	vfr	nc	fsl					
BCt1	18-34	5YR	5/5	4/5	m	sh	vfr	nc	fsl					
BCt2	34-44	5YR	5.5/4	4.5/4	m, sg	s,sh	vfr	nc,e	ls					
BAtkb	44-60	5YR	5.5/4	4.5/4	lcpr-lmsbk	h	fr	es,e	sl					
Btk1b	60-76	6YR	6/4	4.5/4	lcpr	h	fr	es,e	scl					
		5YR	5/6	4/6	lm,csbk									
Btk2b	76-90	7.5YR	6/5	5/5	lcpr-lmsbk	h,vh	fr,fi	es,e	scl					
		10YR	9/2	8/4										
		5YR	5/6	4/6										
Btk3b	90-103	5YR	5.5/5	4.5/5	lcpr-lmsbk	h,vh	fr,fi	e,c	scl					
		7.5YR	6/5	4/5										
		7.5YR	9/2	8/2										
K2b	103-126	7.5YR	8/2	7/4	lm,csbk	vh	fi	es	scl					
		7.5YR	6.5/4	5.5/4										
		5YR	5/4	4/4										
Yucca (S90NM-013-001), at site Y														
C	0-8	5YR	5/4	3.5/4	ms,lfgr,sg	s,l	vfr	nc	s	89	5	6	0.19	
Eb	8-15	5YR	5/4	3.5/4	lf,msbk	sh	vfr	nc	ls	85	5	10	0.26	
BEtb	15-25	5YR	5/4	3.5/4	lf,sbk	sh	fr	e	ls	85	4	11	0.29	1
Btk1b	25-37	5YR	5/4	4/4	lf,msbk	sh	fr	e	ls	83	4	12	0.22	1
Btk2b	37-51	5YR	5/4	4/4	lf,msbk	sh	fr	es	fsl	81	6	13	0.20	1
Btk3b	51-62	5YR	6/4	5/4	lf,msbk	sh	fr	es	fsl	78	7	16	0.22	2
Btk4b	62-71	5YR	6/4	5/4	lf,msbk	sh	fr	es	sl	74	7	19	0.26	4
Btk5b	71-85	5YR	6.5/4	5/4	lf,msbk	sh	fr	es	scl	71	7	22	0.24	6
K1b	85-104	7.5YR	8/2	7/3	2msbk	vh	fi	es	scl	66	10	24	0.18	18
K2b	101-112	7.5YR	8/2	7/3	lcsbk	vh,eh	fi	es	scl	64	12	23	0.12	25

[1]Abbreviations follow the Soil Survey Staff (1951) except for massive materials that are stratified and lack structure formed by pedogenesis. Such materials, which commonly have horizontal cleavage, are abbreviated ms. See soil descriptions for details on soil morphology.

Figure 5. Landscape at Site O (fig. 4) and the Typic Haplargid Onite, buried soil phase, in Exclosure A in the Jornada Experimental Range. The San Andres Mountains are on the skyline. The nonrecording rain gauge is at right, next to the study trench. Photographed December 1970.

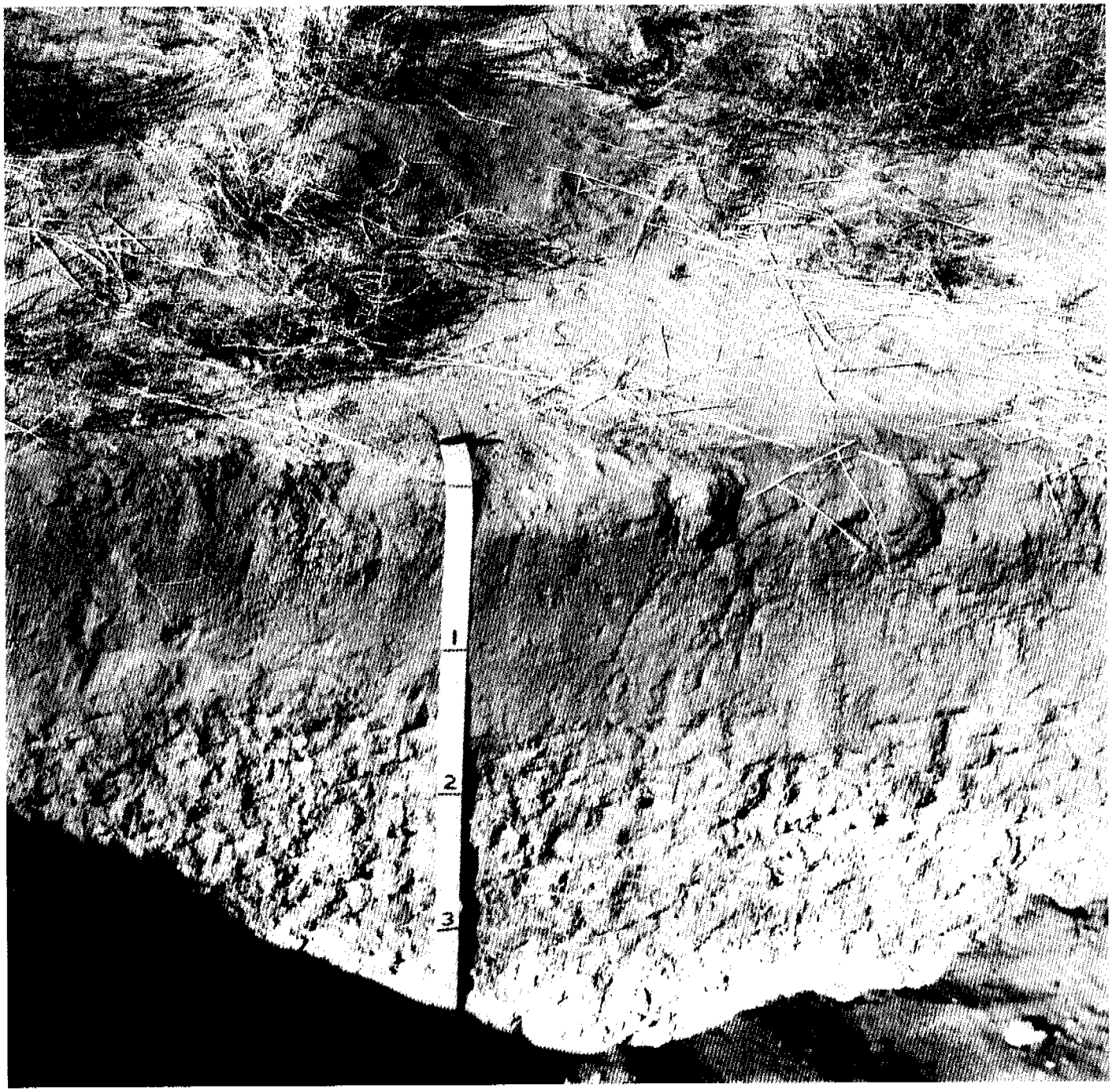


Figure 6. Profile of upper horizons of the Typic Haplargid Onite, buried soil phase. A buried Haplargid occurs at 44 cm depth. Note youthful appearing sand at the surface beyond the study trench. Scale is in feet.

depth to finer horizons that would slow the wetting front. Morphological similarity to dated soils in the Desert Project indicates that accumulation of silicate clay in the Bt horizon and formation of the stage I carbonate filaments in the BAtkb horizon are features of pedogenesis during the late Holocene.

Soil Water, Precipitation, and Yields. The gypsum impregnated resistance blocks were installed in three replications within a rodent exclosure at Exclosure A at soil depths of 10, 25, and 40 cm on August 14, 1957 and at the 60- and 90-cm depths on July 29, 1959. The standard rain gauge was established July 15, 1958. Estimates of precipitation prior to this date can be obtained from Yucca which is about 2.3 km from Onite. The rodent exclosure was 38 x 46 m. The perennial grasses on 15, 5-cm x 30.8-m transects were clipped to ground level each fall beginning in 1959. The grass stand in this area was dominated by mesa dropseed.

The matric potential of the soil water at 10 cm was >-1.5 MPa August 14-27, 1957; August 30-September 11; and October 9, 1957-April 29, 1958 (figs. 7, 8). The moisture control section, 25-cm depth, had soil water >-1.5 MPa August 23-27, 1957; September 1-11; and October 10, 1957-April 30, 1958. There was soil water >-1.5 MPa at 40 cm September 2-11, 1957 and October 10, 1957-April 30, 1958.

The 1958 precipitation for this location for July 15-December 31 was 202 mm. Rainfall of 37 mm on August 21 and 36 mm on September 13 were the largest daily amounts. The 25-cm depth had soil water >-1.5 MPa August 25-November 30, 1958 in addition to the winter-spring (fig. 8).

The annual precipitation for 1959 was 228 mm with 82 mm on August 8 (fig. 9). The winter-spring was very dry. The 25-cm depth had soil water >-1.5 MPa July 23-September 15. The production of perennial grasses was 78 kg/ha (s.e.=13 kg/ha).

The precipitation in 1960 was 171 mm, 34 mm occurred on December 11 (fig. 10). Soil water at 25 cm was >-1.5 MPa February 15-May 4; July 18-31; and December 28, 1960-August 30, 1961. Soil water at the 60- and 90-cm depths remained <-1.5 MPa throughout 1960. Perennial grasses yielded 12 kg/ha (s.e.=3 kg/ha) in 1960.

Contrary to 1960, the annual precipitation in 1961 was considerably above average and the soil water at 25 cm was >-1.5 MPa most of the year (fig. 11). Perennial grasses yielded only 48 kg/ha (s.e.=15 kg/ha) in 1961.

Annual precipitation for 1962 at 294 mm (fig. 12) was considerably above average for the second consecutive year. Soil water at 25 cm was >-1.5 MPa continuously from November 10, 1961-June 13, 1962. Summer soil water >-1.5 MPa at the 25-cm depth occurred July 3-August 19, 1962. Yields of perennial grasses averaged 31 kg/ha (s.e.=11 kg/ha) in 1962. Soil water at 25 cm was also >-1.5 MPa September 25, 1962-March 21, 1963 (figs. 12, 13).

Annual precipitation was below average 1963-67. Soil water was >-1.5 MPa at 25 cm August 10-September 21, 1963 (fig. 13); October 21, 1963-March 15, 1964 (figs. 13, 14); July 13-28, 1964; August 15-30, 1964; February 11-May 18, 1965 (fig. 15); September 12-29, 1965; January 21, 1966-May 3 (fig. 16); September 13-28,

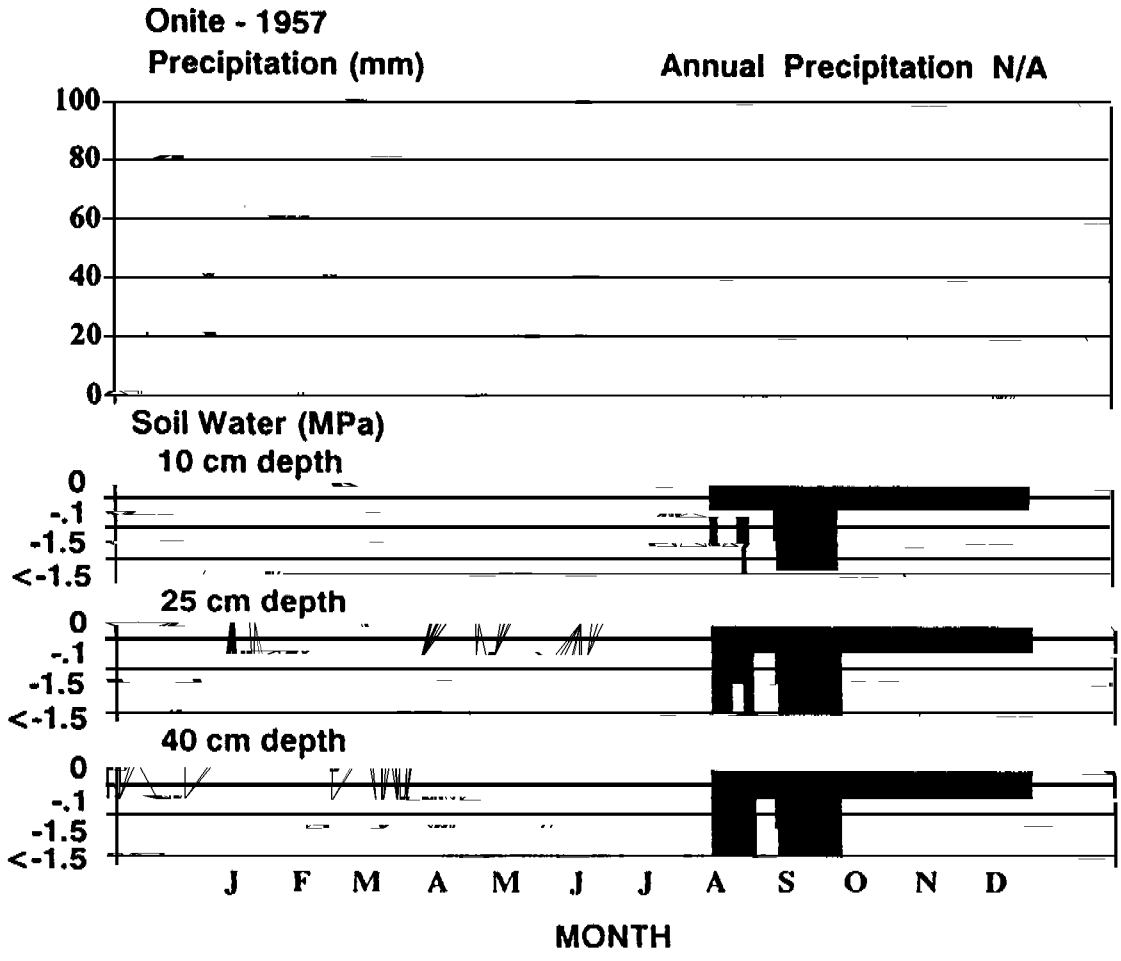


Figure 7. The matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for the Onite site for August 14-December 31, 1957. No estimates of precipitation were available.

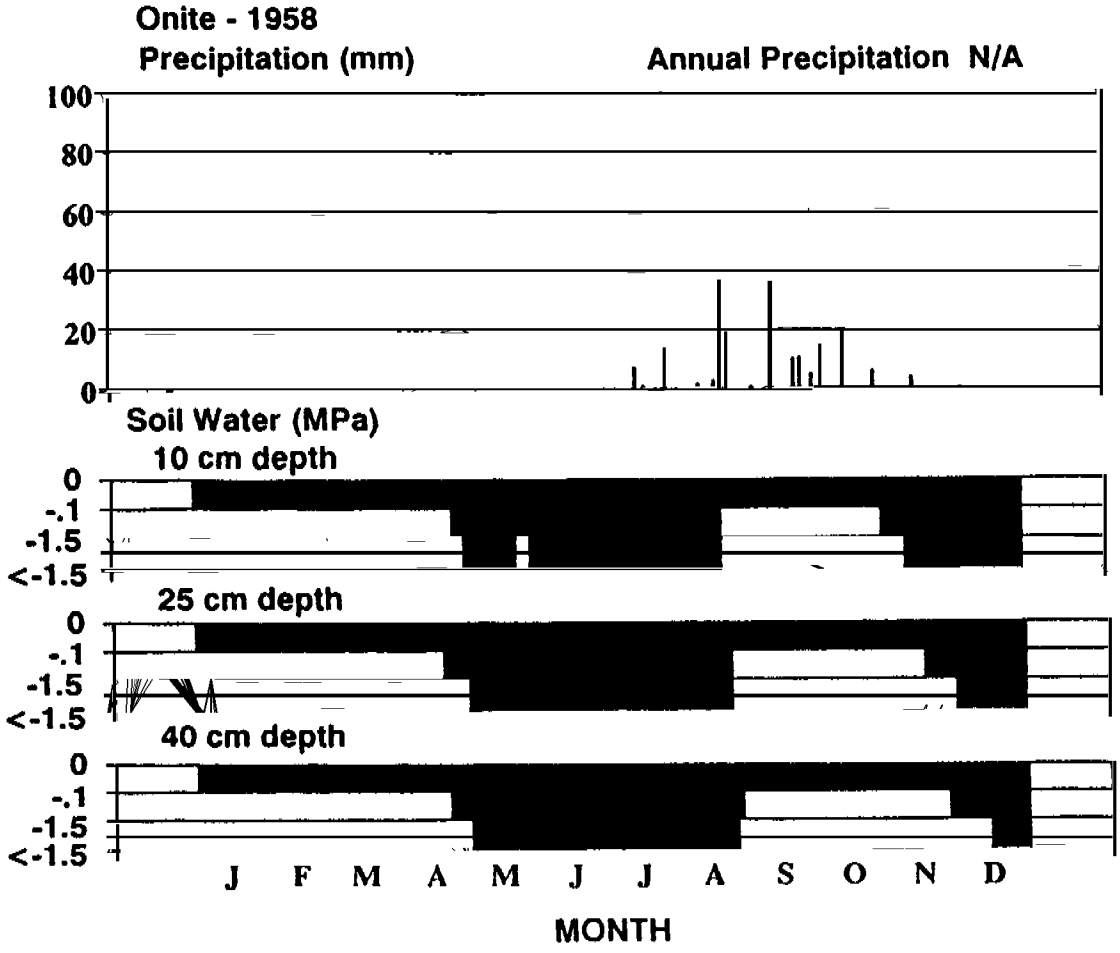


Figure 8. Daily precipitation (mm) at the Onite site for July 15-December 31, 1958 and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for 1958.

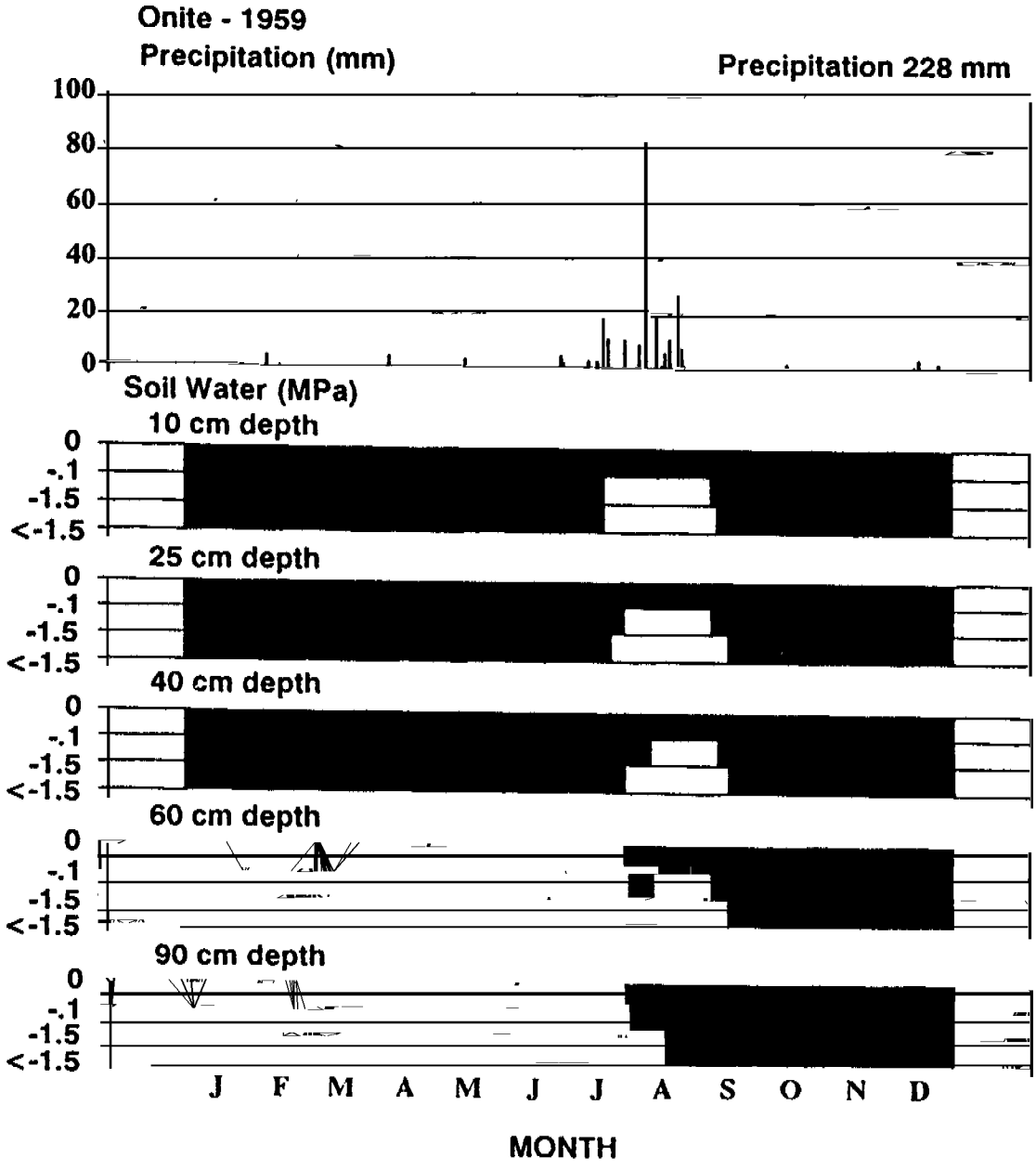


Figure 9. Annual precipitation (228 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Onite site for 1959. Also shown is the soil water at depths of 60 and 90 cm July 29-December 31, 1959.

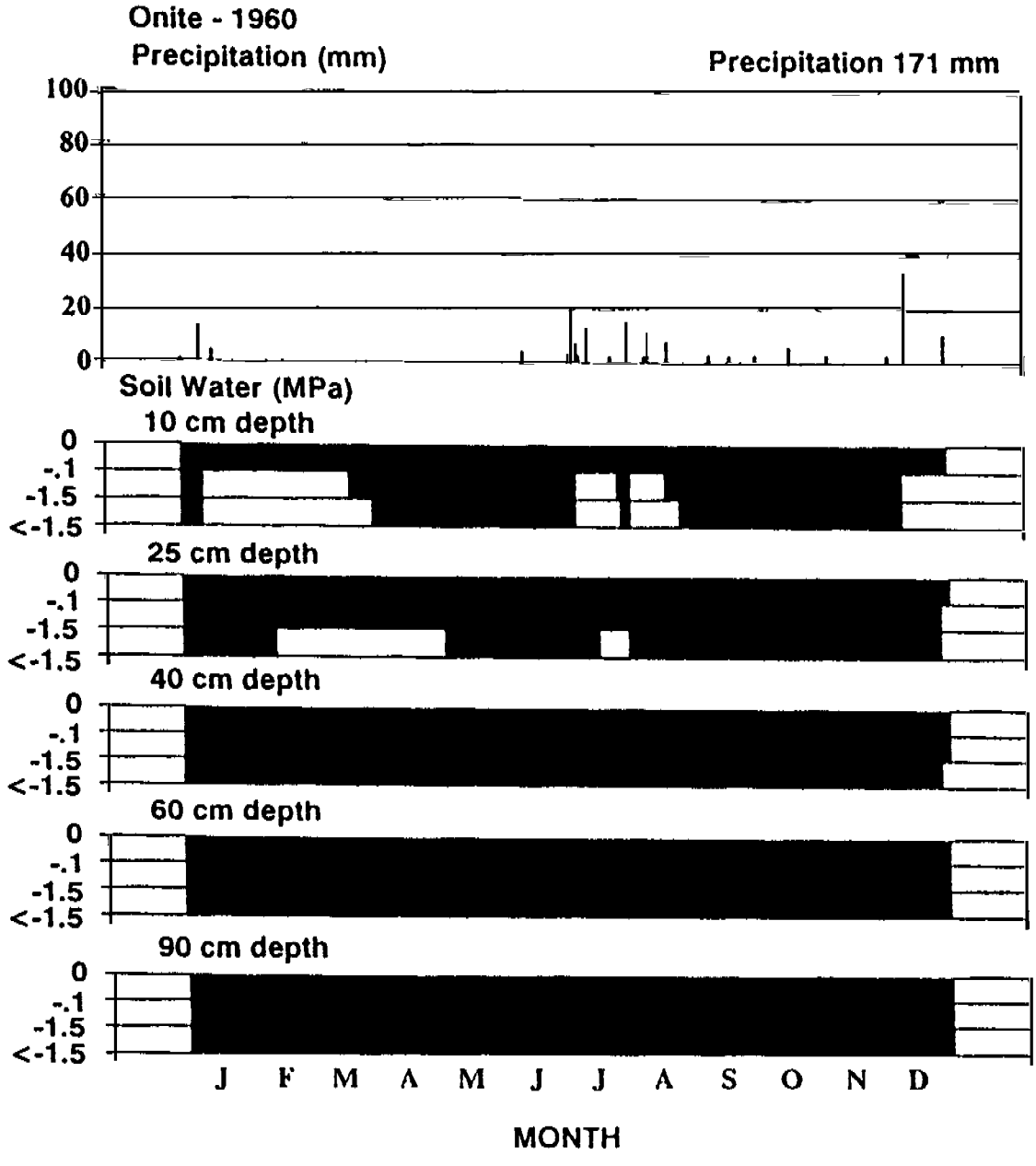


Figure 10. Annual precipitation (171 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1960.

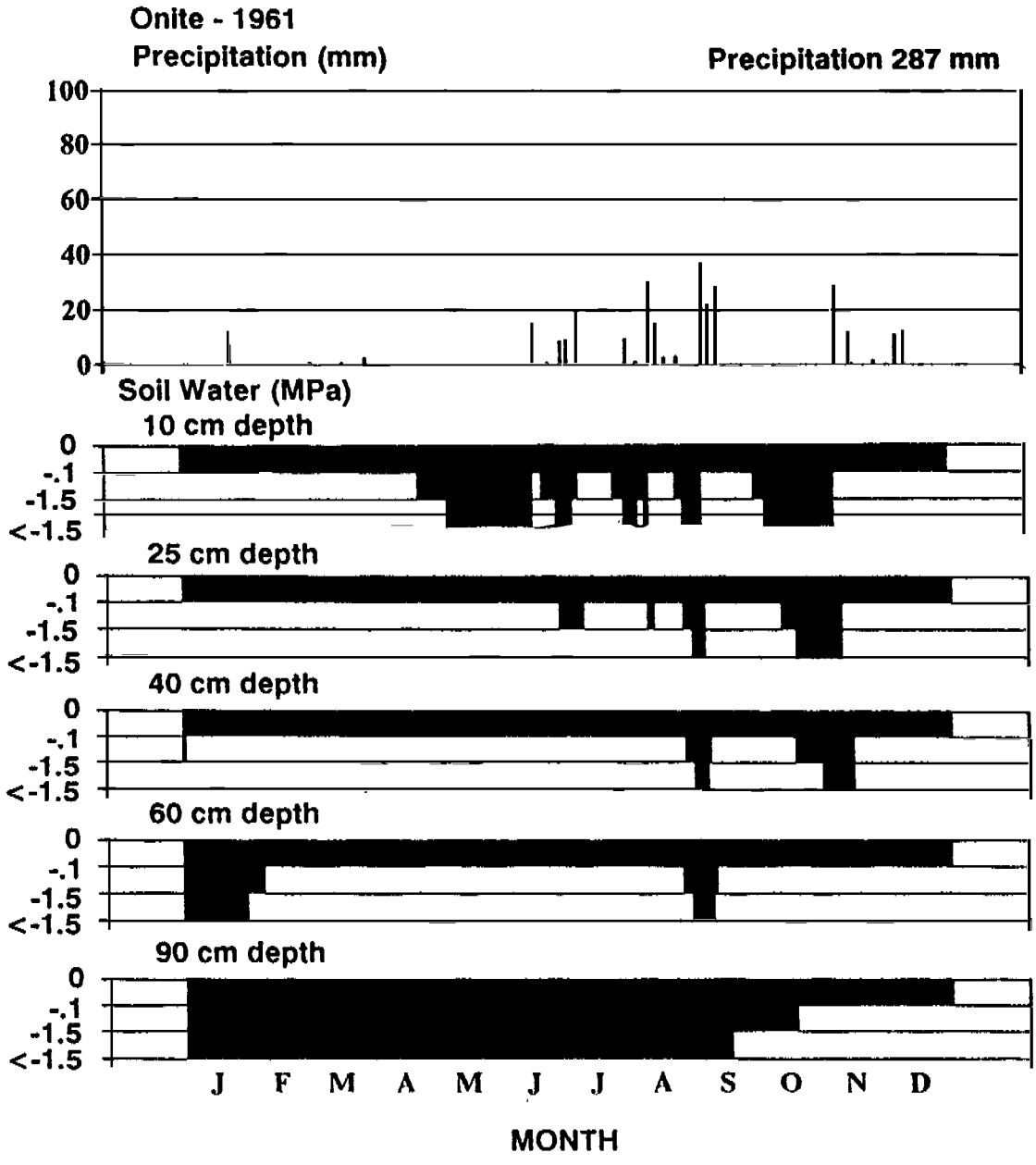


Figure 11. Annual precipitation (287 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1961.

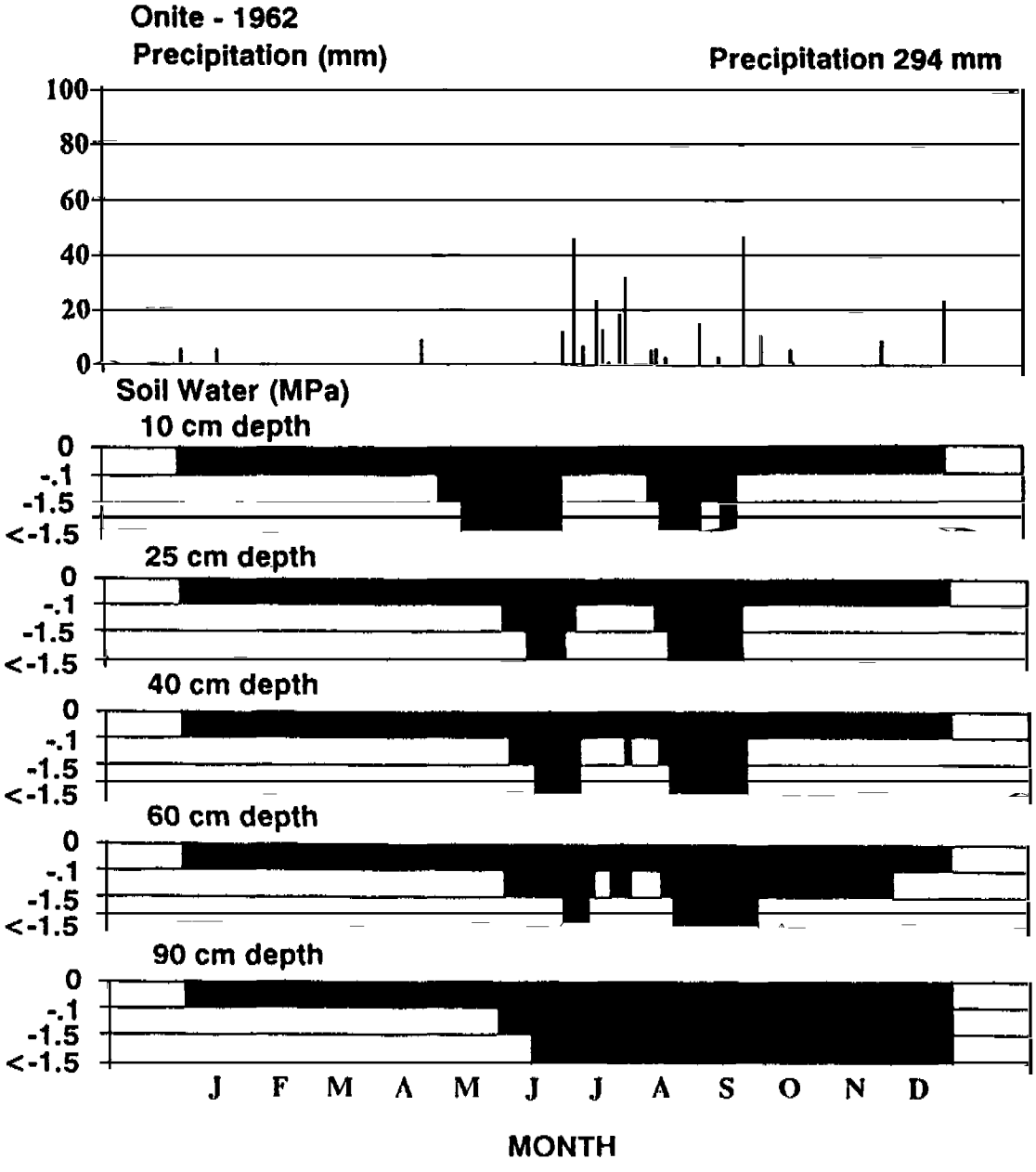


Figure 12. Annual precipitation (294 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1962.

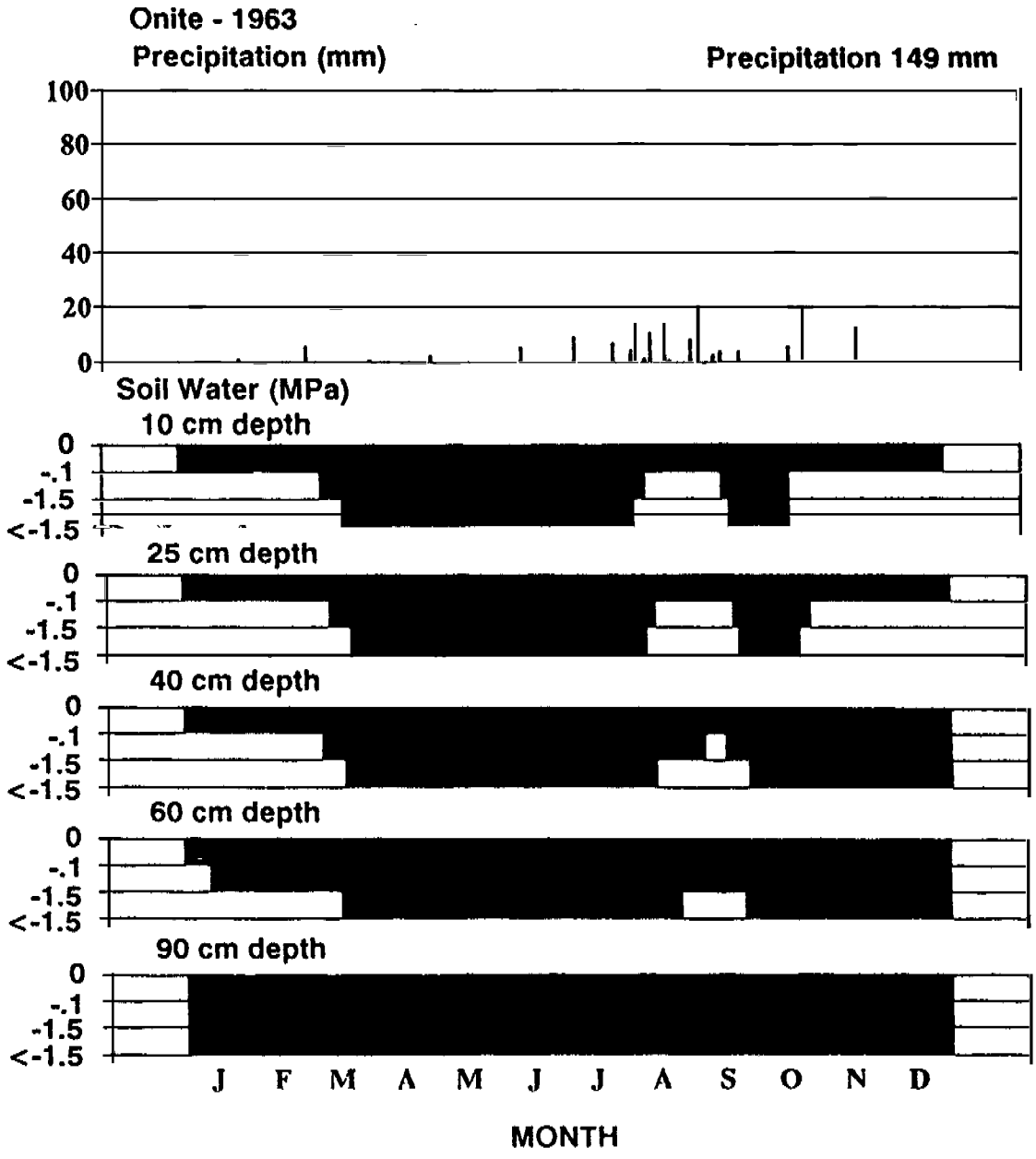


Figure 13. Annual precipitation (149 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1963.

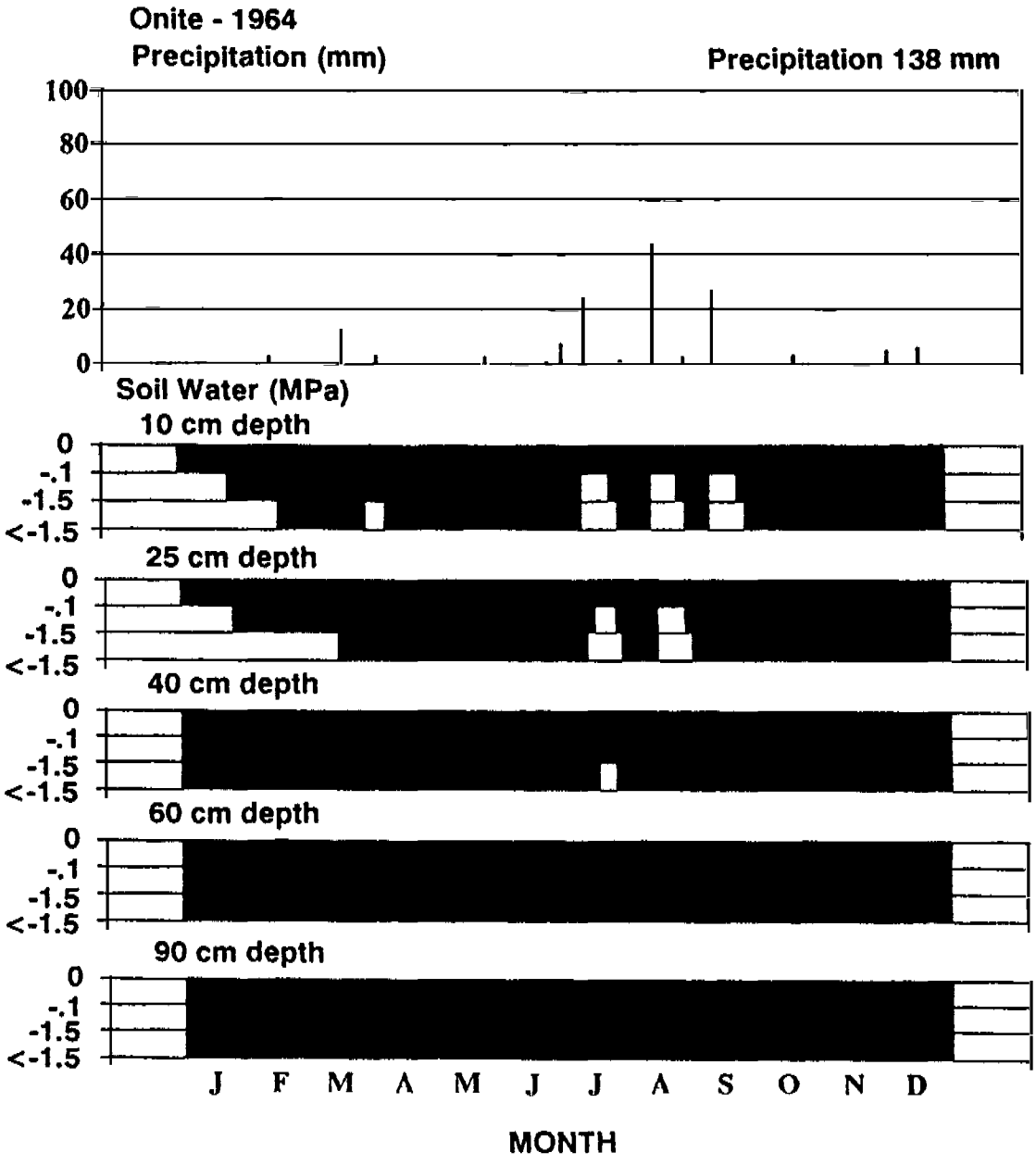


Figure 14. Annual precipitation (138 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1964.

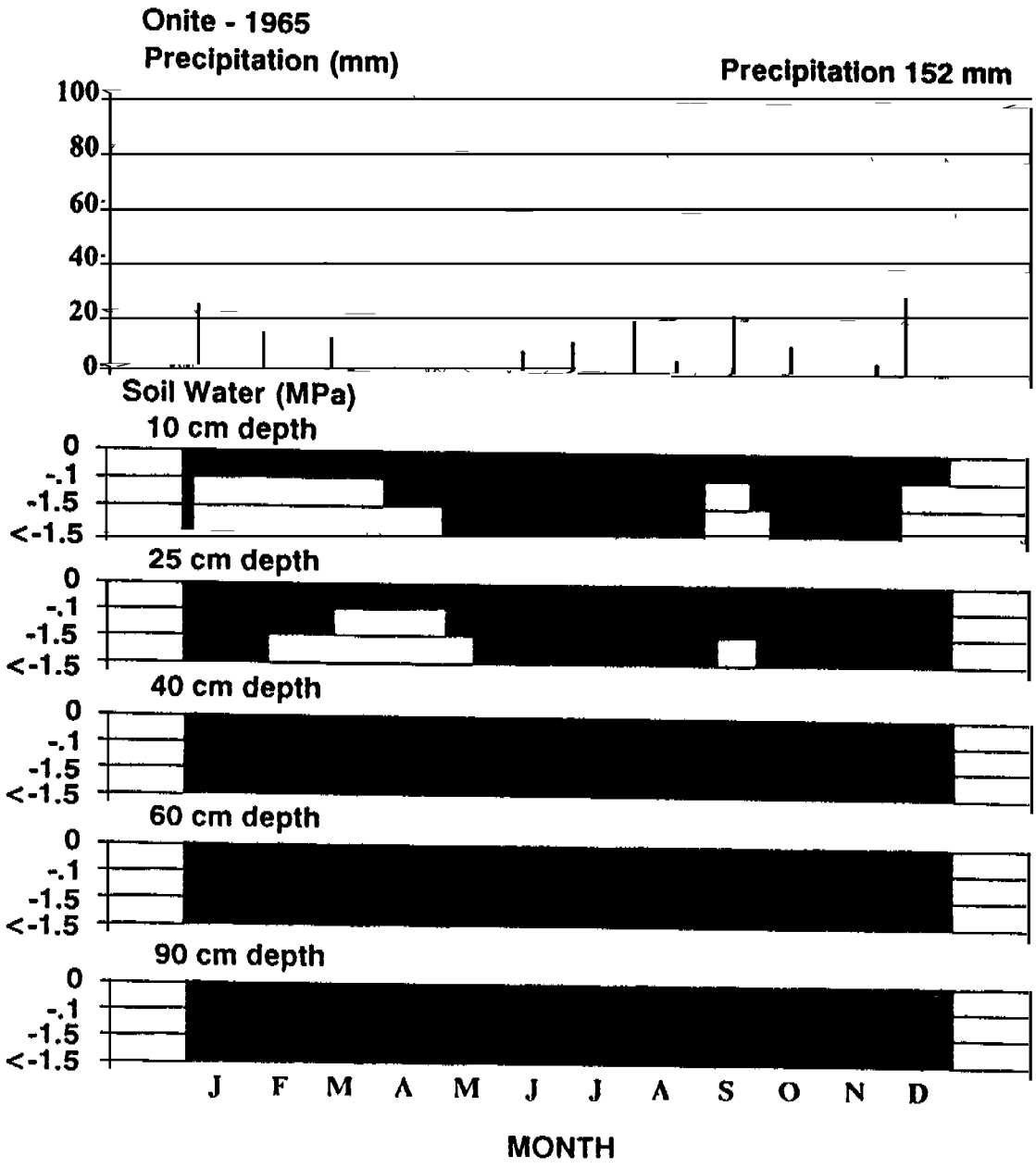


Figure 15. Annual precipitation (152 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1965.

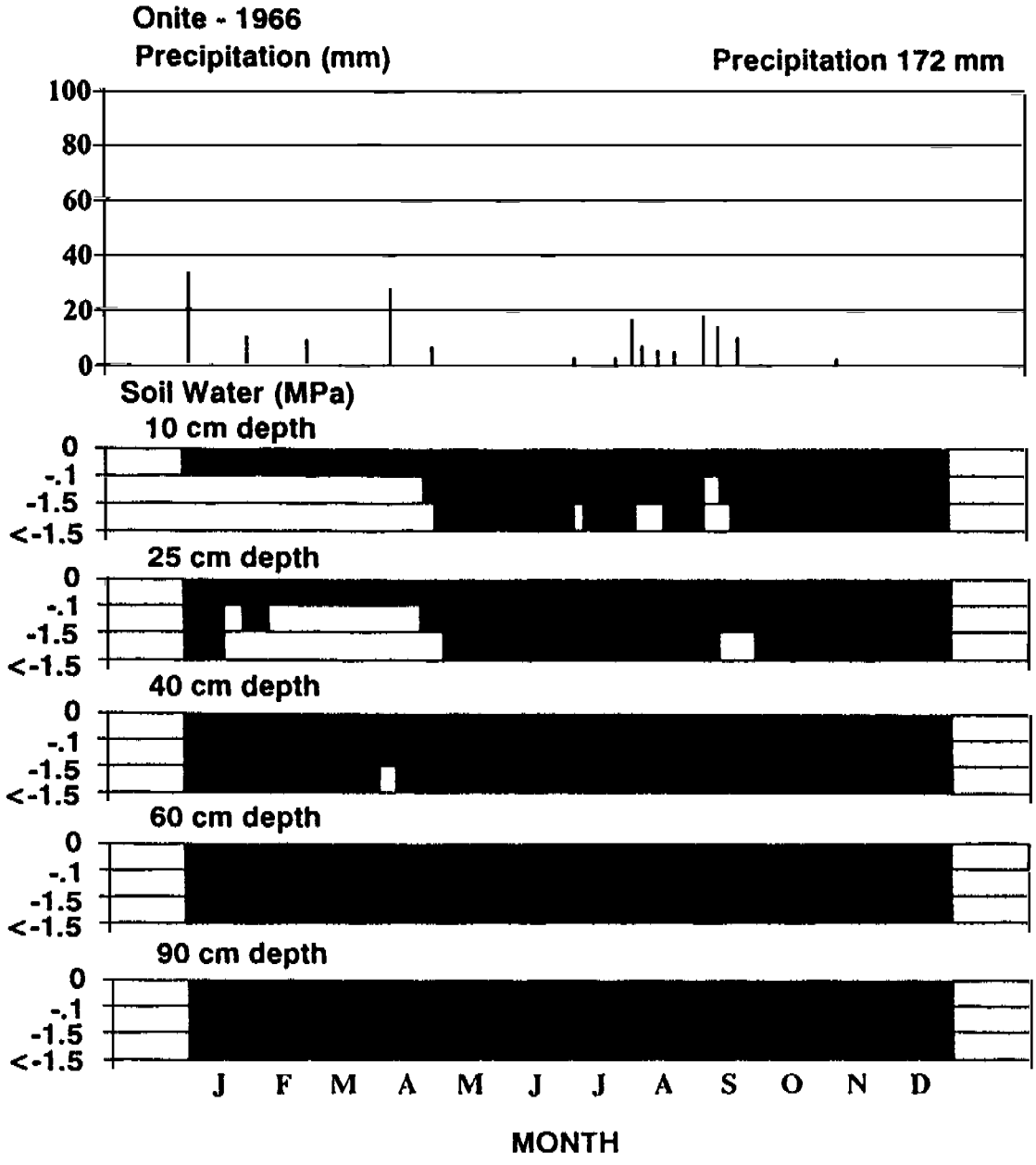


Figure 16. Annual precipitation (172 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1966.

1966; July 1-30, 1967 (fig. 17); August 18-23; and September 26-October 23, 1967. There were only a few days when the soil water was >-1.5 MPa at 40, 60, and 90 cm, particularly in 1964-67. Perennial grasses yielded 18 kg/ha (s.e.=7 kg/ha), 17 kg/ha (s.e.=7 kg/ha), 3 kg/ha (s.e.=2 kg/ha), 5 kg/ha (s.e.=2 kg/ha), and 12 kg/ha (s.e.=4 kg/ha) for 1963-67, respectively.

The 1968 precipitation was 304 mm. There was soil water >-1.5 MPa at the 25-cm depth December 22, 1967-May 3, 1968 (figs. 17, 18); July 7-August 19; and September 6-10, 1968. The yield of perennial grasses averaged 16 kg/ha (s.e.=10 kg/ha).

Annual precipitation for 1969 was 234 mm, about average. Soil water at 25 cm was >-1.5 MPa December 28, 1968-May 18, 1969; July 11-August 2; and September 5-17 (figs. 18, 19). Perennial grasses yielded 41 kg/ha (s.e.=17 kg/ha).

Precipitation for 1970 was 220 mm. Besides the soil water >-1.5 MPa in winter-spring, soil water >-1.5 MPa at the 25-cm depth was also recorded July 26-August 26, 1970 (fig. 20). The yield of perennial grasses averaged 46 kg/ha (s.e.=14 kg/ha).

Annual precipitation for 1971 was 238 mm but single events were small so that there was no soil water >-1.5 MPa at 60 and 90 cm. The 25-cm depth had water >-1.5 MPa only briefly August 18-September 2, 1971 before fall (fig. 21). Perennial grasses yielded 31 kg/ha (s.e.=11 kg/ha).

Precipitation for 1972 was well above average at 370 mm but no soil water was recorded August 1-December 31. Continuous soil water >-1.5 MPa at 25 cm occurred October 26, 1971-July 31, 1972 (figs. 21, 22). The high precipitation in 1972 and a 12-fold increase in the cover of mesa dropseed resulted in a yield of perennial grasses of 1509 kg/ha (s.e.=409 kg/ha), a dramatic increase from previous estimates.

Annual precipitation for 1973 was 229 mm. The water at the 25-cm soil depth was >-1.5 MPa continuously from January 1-September 3, 1973 (fig. 23). Perennial grasses averaged 369 kg/ha (s.e.=105 kg/ha).

Precipitation was 418 mm in 1974 (fig. 24), higher than 1972 (fig. 22), but perennial grasses yielded only 374 kg/ha (s.e.=106 kg/ha) in 1974. An examination of the soil water shows the winter-spring of 1974 was much drier than the same period in 1972. The moisture control section (25-cm depth) had soil water >-1.5 MPa March 1-31, 1974 (fig. 24); July 14-August 31; and again September 23, 1974-May 17, 1975 (figs. 24, 25).

Annual precipitation for 1975 was 200 mm (fig. 25). In addition to the soil water >-1.5 MPa in the winter and early spring, the matric potential of the water at the 25-cm soil depth was >-1.5 MPa September 9-October 24 (fig. 25). Estimates of perennial grasses in fall 1975 were 691 kg/ha (s.e.=75 kg/ha).

Precipitation in 1976 was above average at 263 mm (fig. 26). The soil water at 25 cm was >-1.5 MPa December 2, 1975-March 3, 1976 (figs. 25, 26); June 9-20; September 2-November 1; and November 30-December 31, 1976. Perennial grasses yielded an estimated 456 kg/ha (s.e.=47 kg/ha) in 1976.

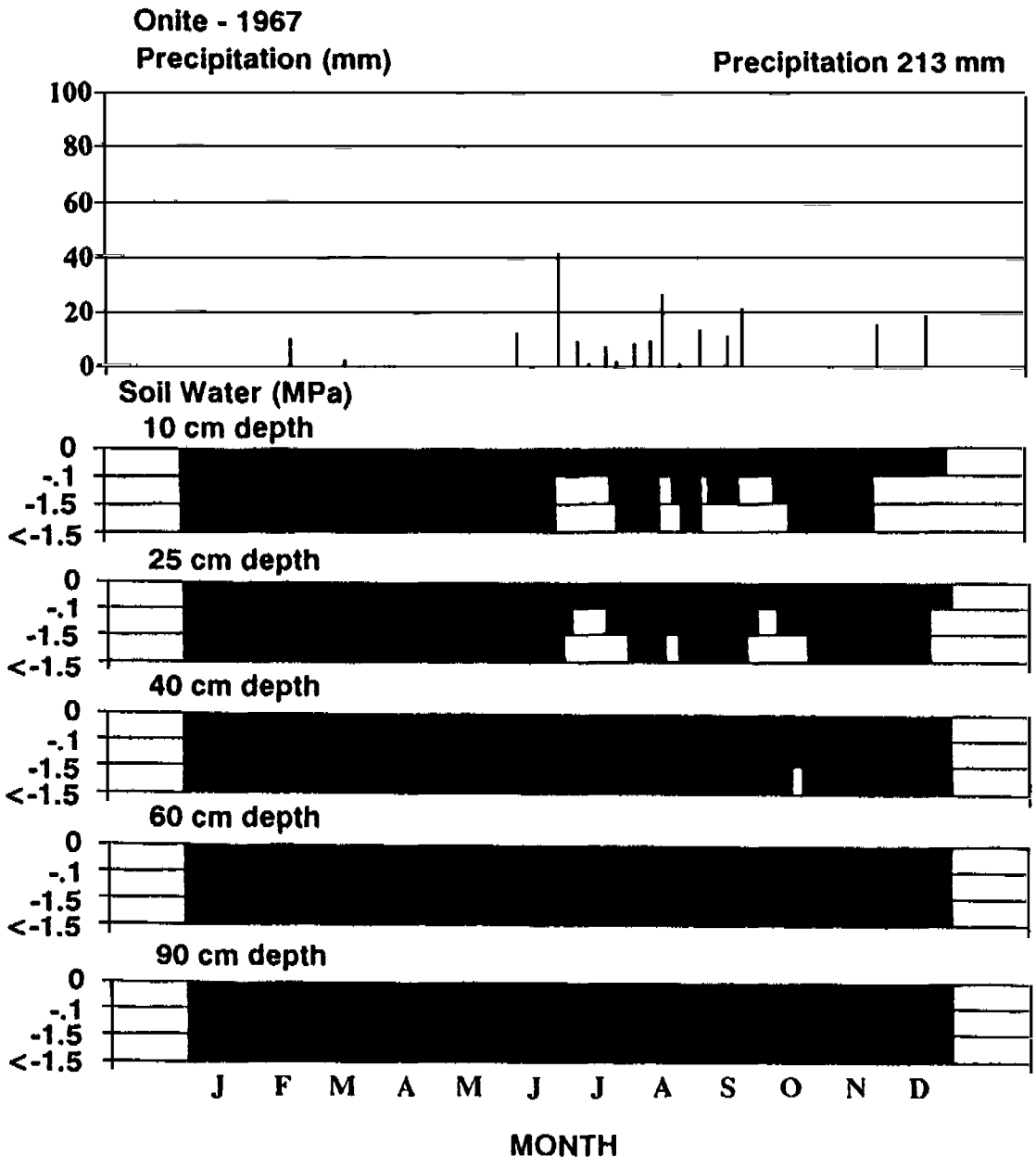


Figure 17. Annual precipitation (213 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1967.

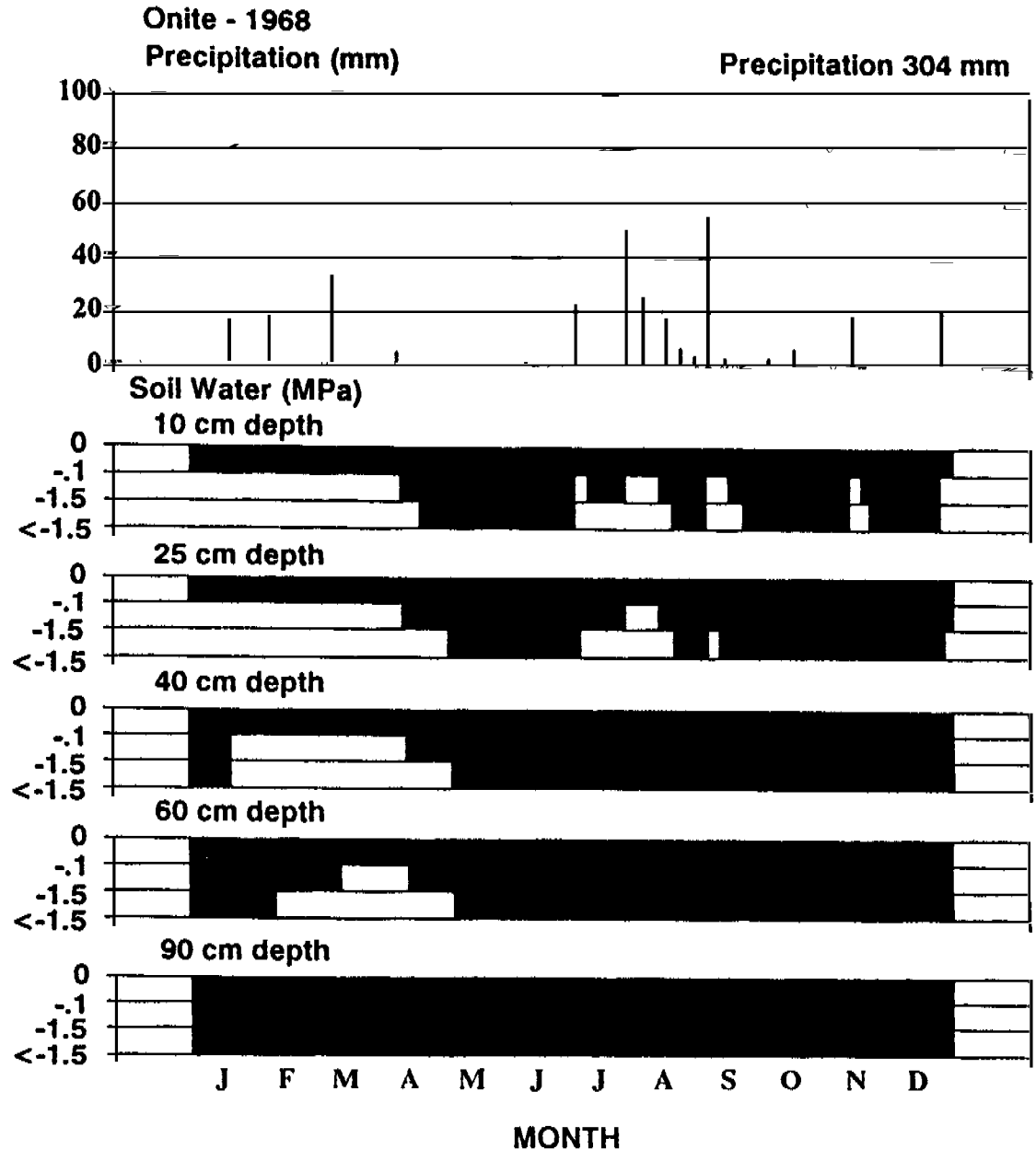


Figure 18. Annual precipitation (304 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1968.

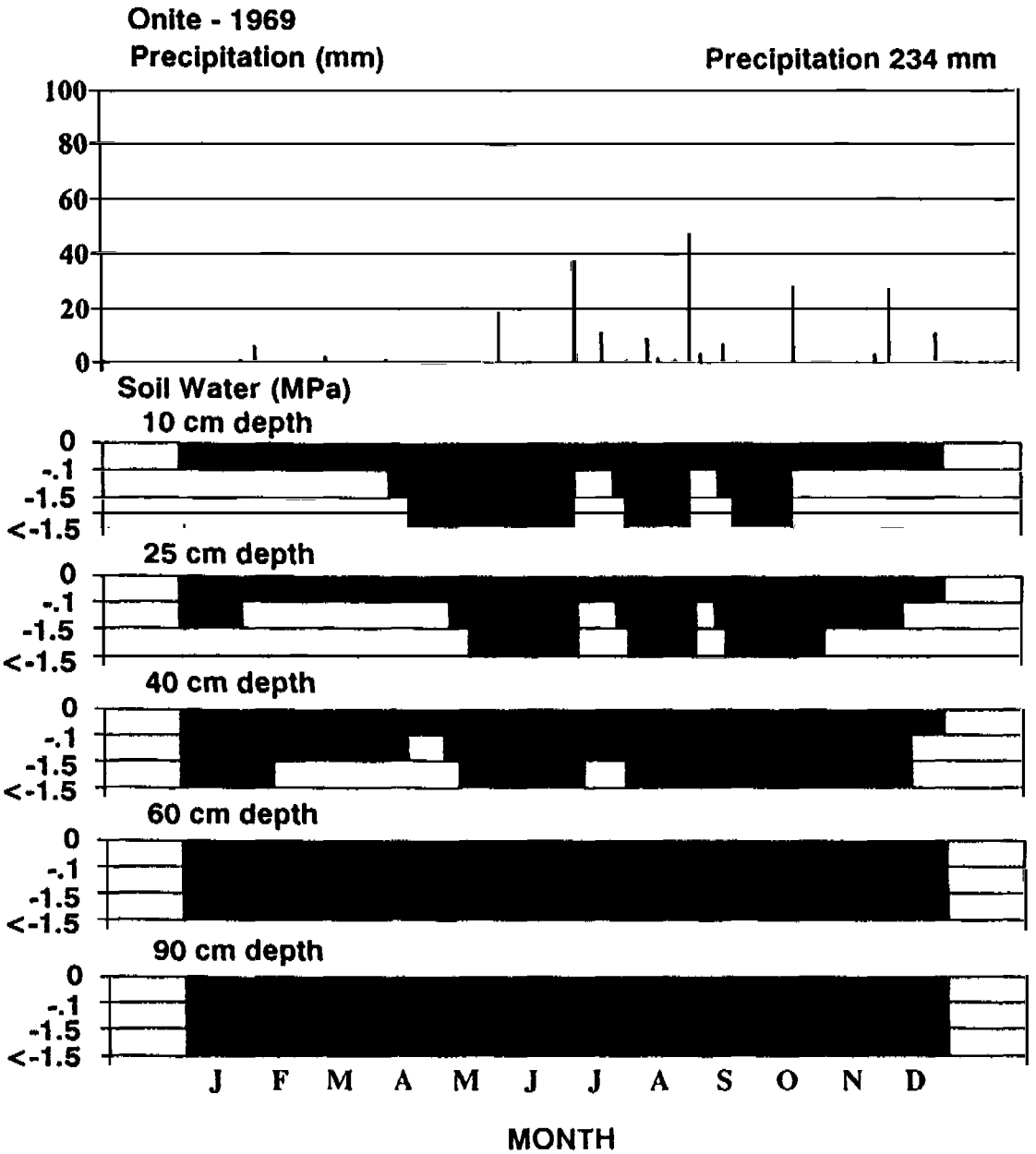


Figure 19. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1969.

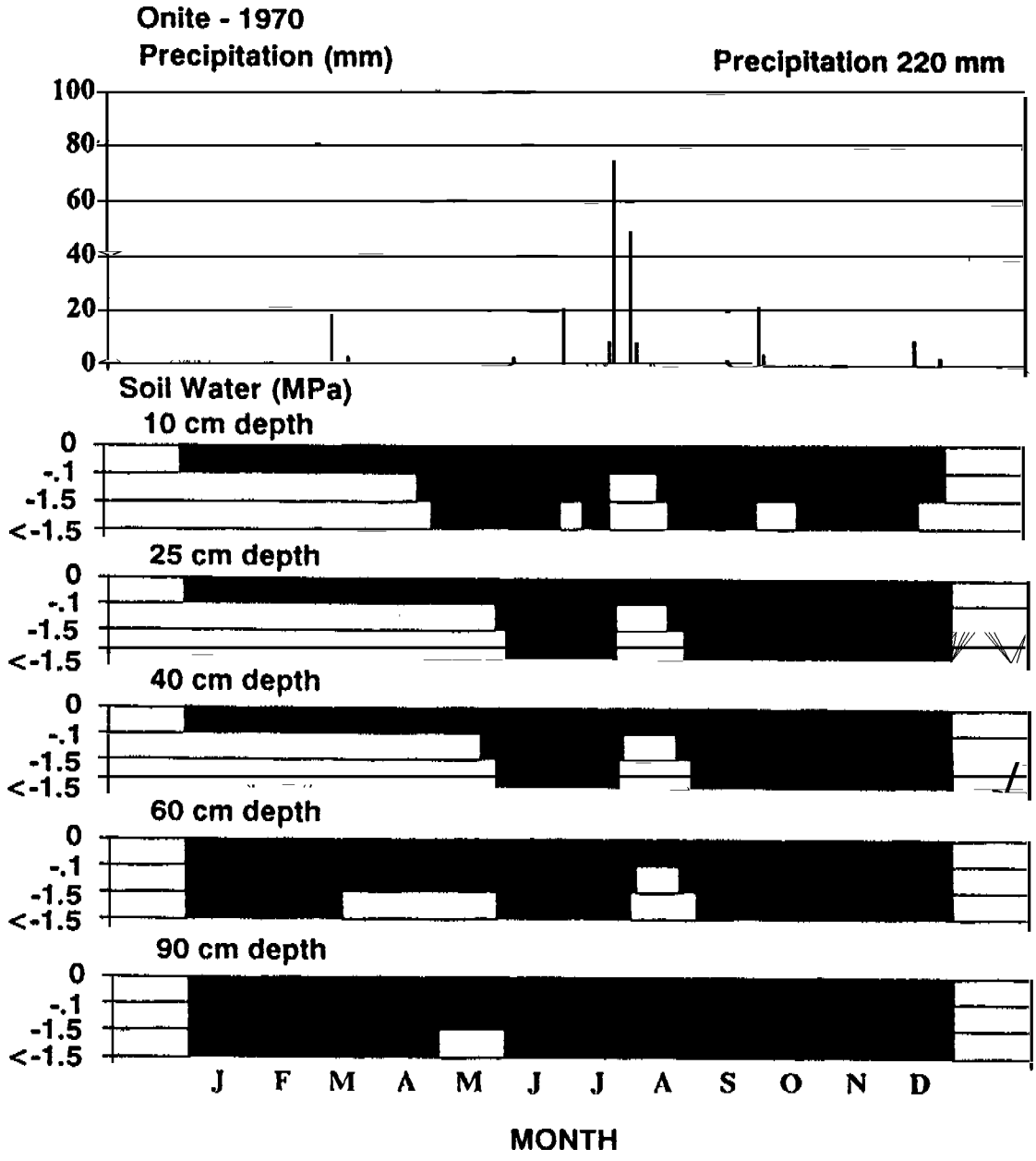


Figure 20. Annual precipitation (220 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1970.

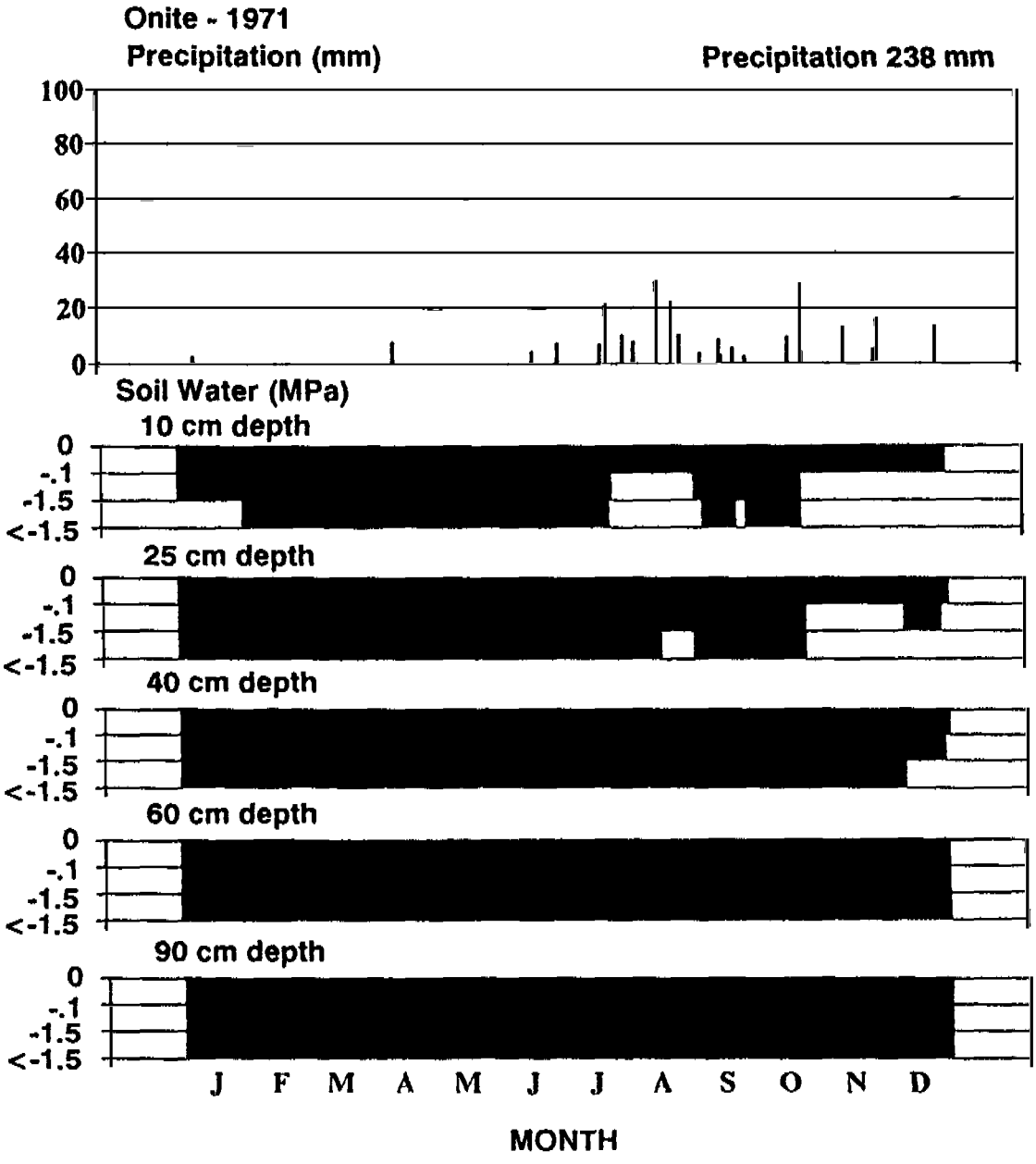


Figure 21. Annual precipitation (238 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1971.

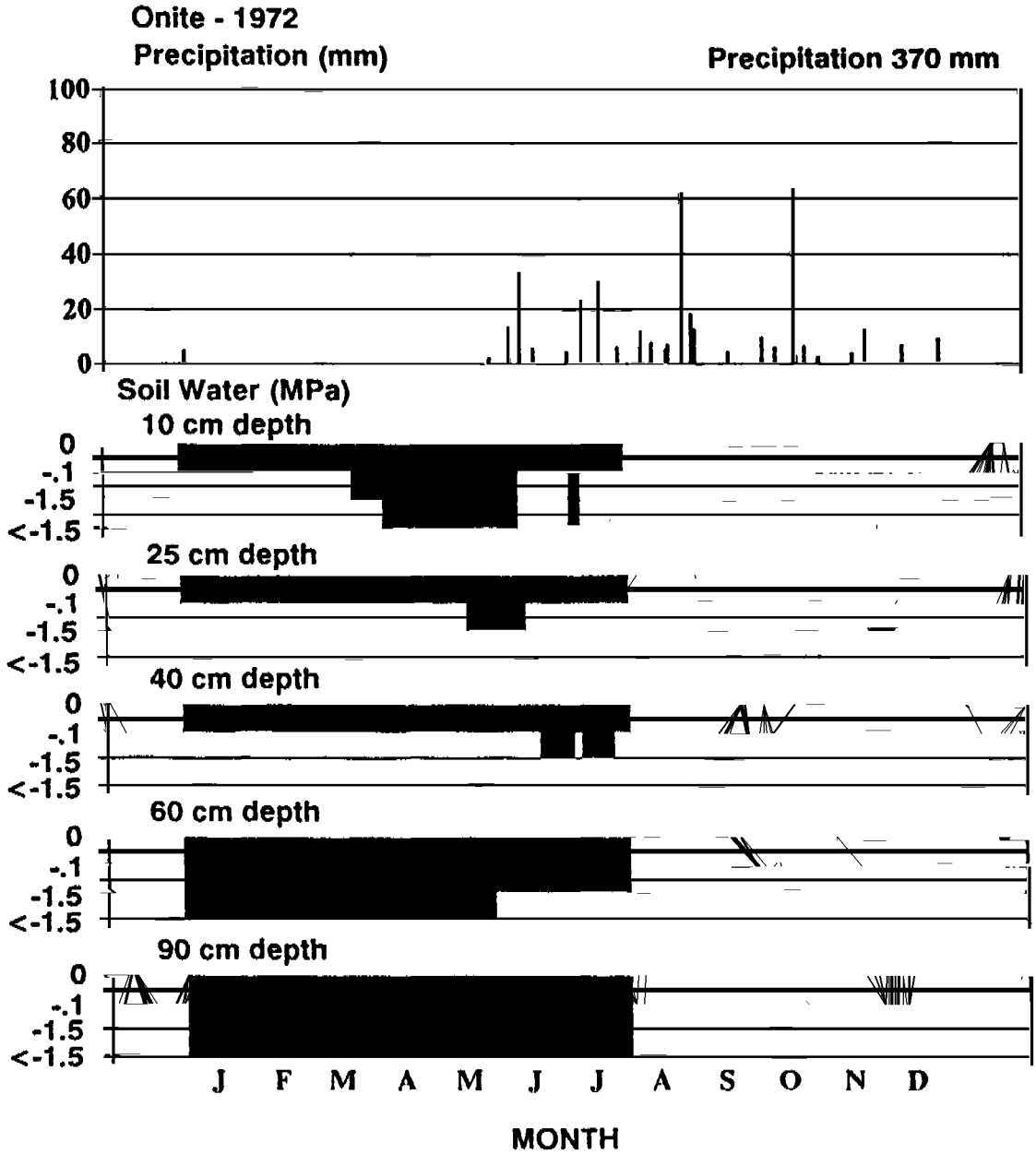


Figure 22. Annual (370 mm) and daily precipitation (mm) for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm January 1-August 1, 1972 at the Onite site.

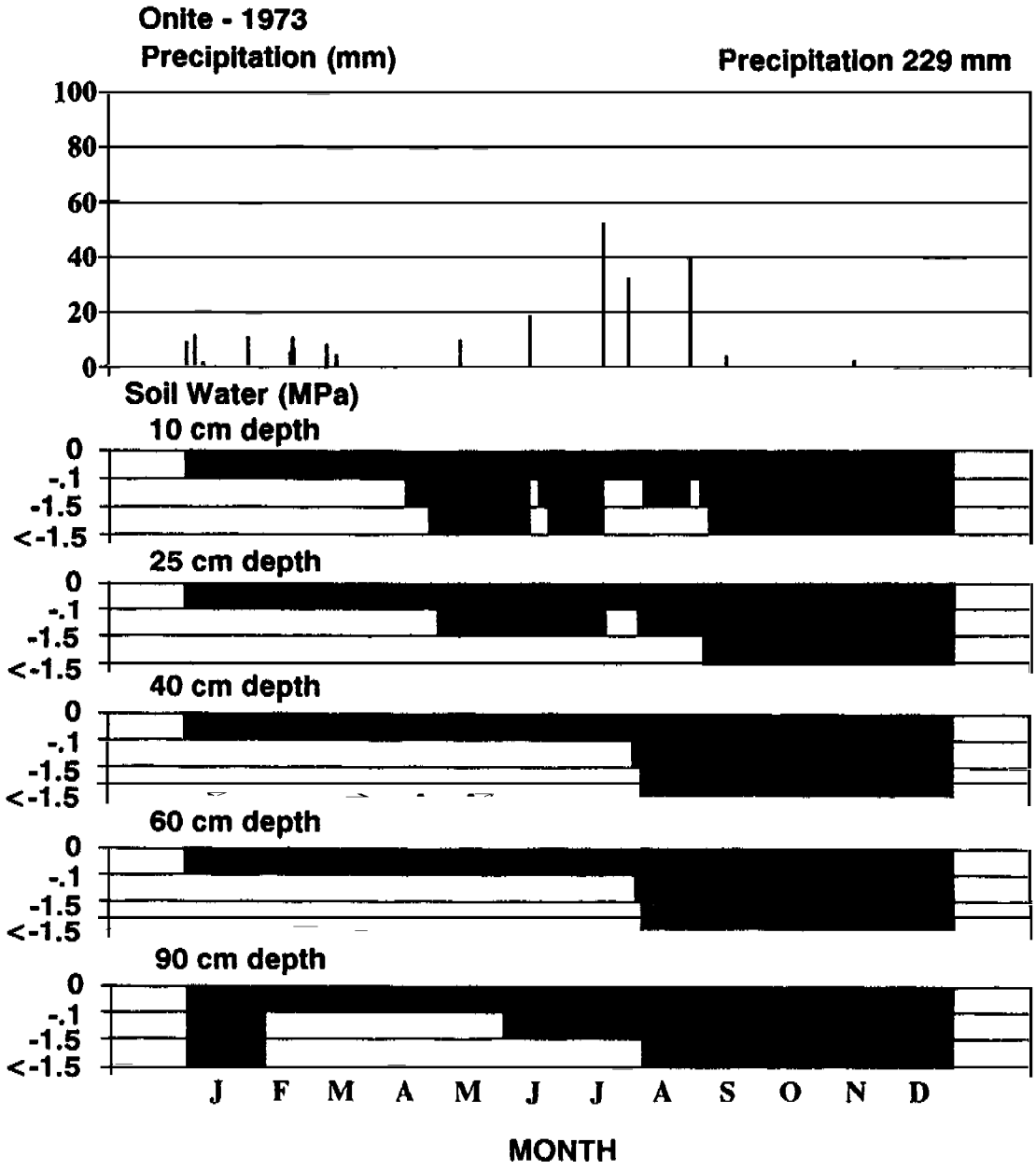


Figure 23. Annual precipitation (229 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1973.

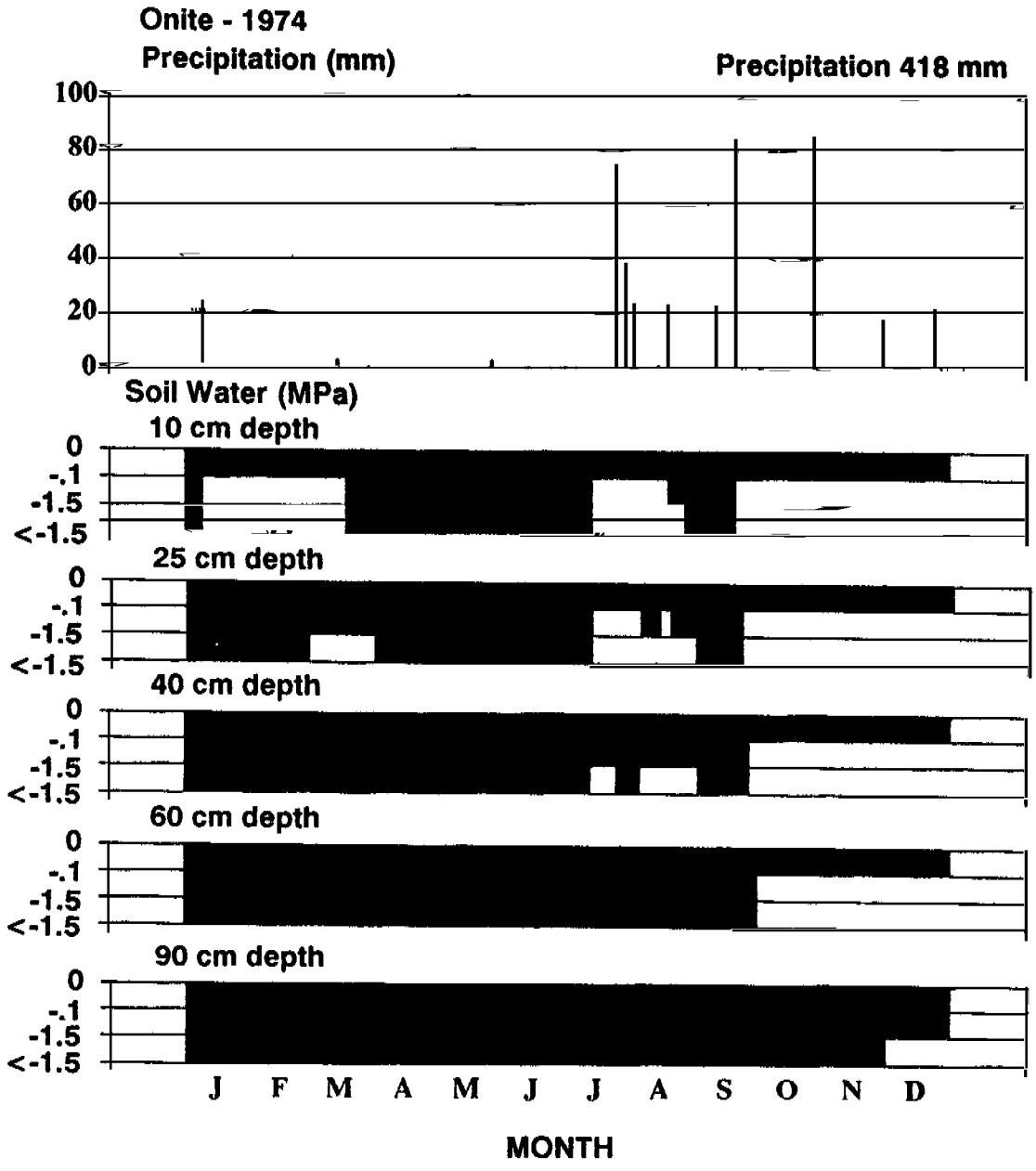


Figure 24. Annual precipitation (418 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1974.

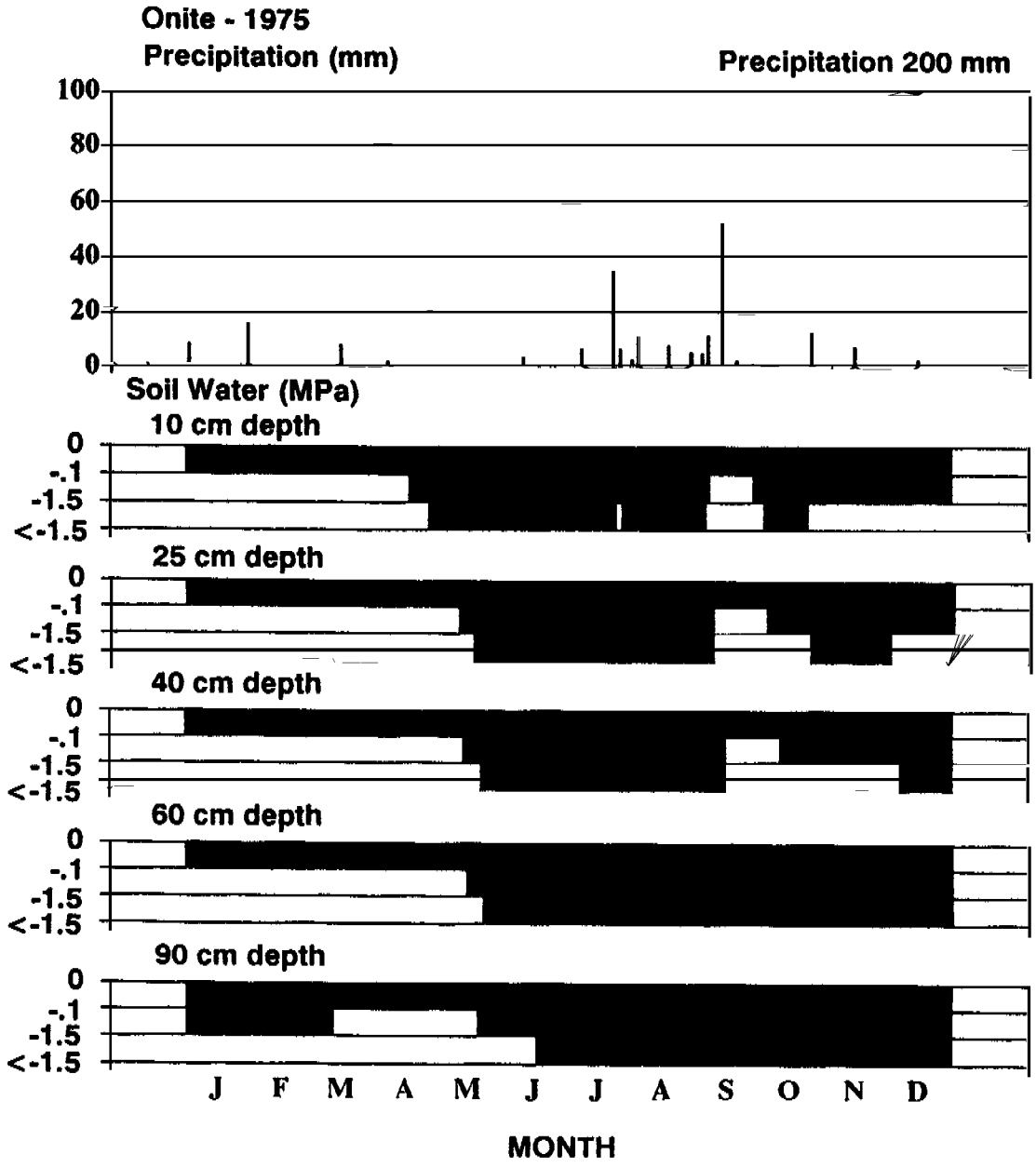


Figure 25. Annual precipitation (200 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1975.

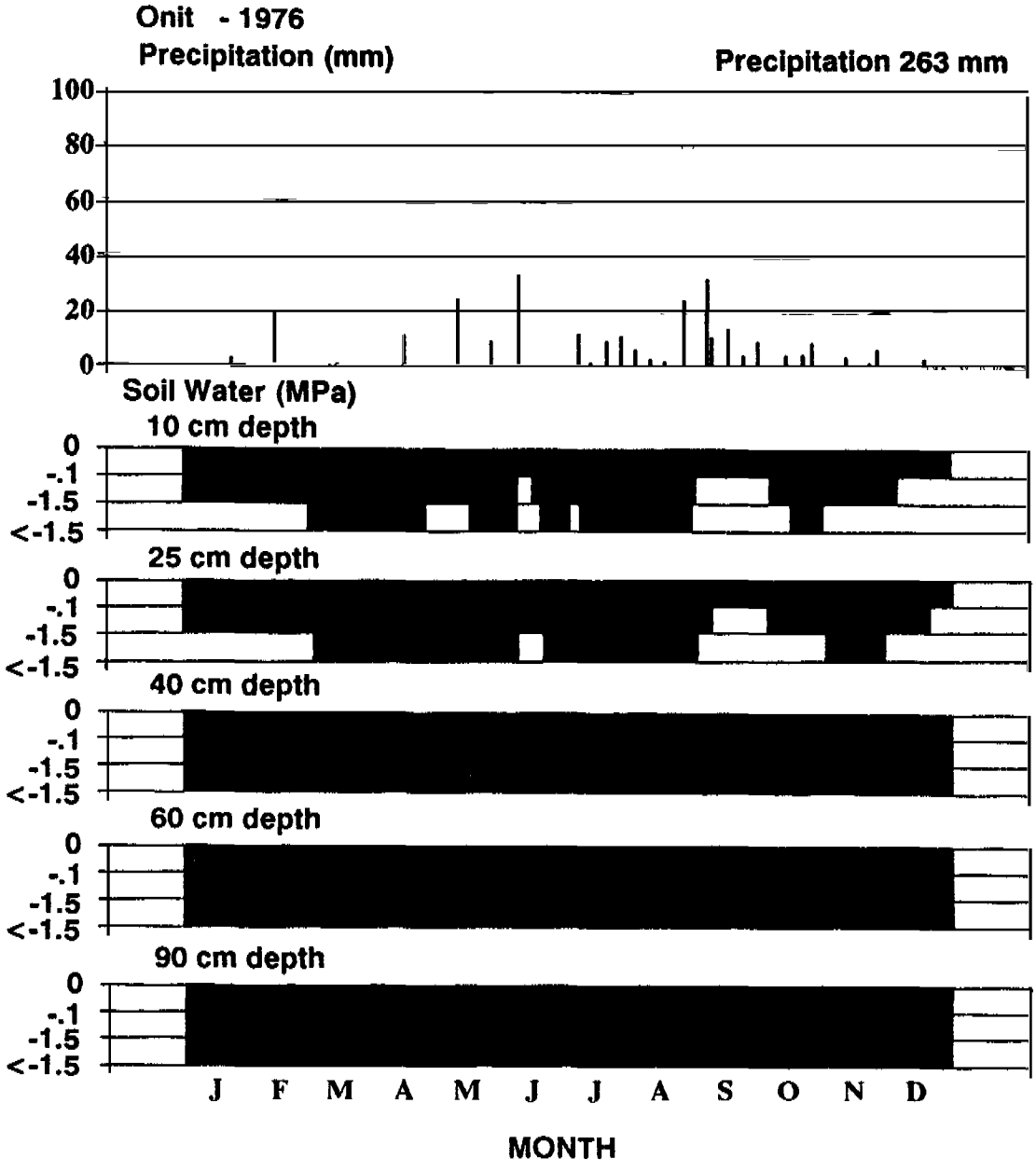


Figure 26. Annual precipitation (263 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Onite site for 1976.

Annual precipitation at this location for 1959-76 averaged 238 mm. It was below average eight years, about average four years, and above average for six years. The probability of the matric potential of the water >-1.5 MPa at the 25-cm soil depth was 65.6% for December-April, 28.9% for May-June, 43.2% for July-September, and 39.4% for October-November (see fig. 27). The average yield of perennial grasses was 209 kg/ha for 1959-76.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, ten of 20 years had soil wat r <-1.5 MPa at 25 cm more than half the time; 13 of 20 years at 40 cm; 15 of 18 years at 60 cm; and every year had soil water <-1.5 MPa more than half the time at a depth of 90 cm. Seven of 20 years had soil water <-1.5 MPa at 25 cm for 90+ consecutive days; 10 of 20 years at 40 cm; 13 of 18 years at 60 cm; and 14 of 18 years at a soil depth of 90 cm.

For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 16 of 18 years and >30 consecutive days in the four months after June 21, 12 of 18 years when the soil water data were complete for the entire year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was observed both years and the 30-day criterion was met in 1972.

Site Yucca (Y)

Site Y (figs. 4, 28, 29, table 7) is in the Yucca exclosure on the Jornada Experimental Range. The sampled pedon is 2.3 m southwest of the nonrecording rain gauge and 1.3 m southwest of the wires to the soil water blocks. Perennial vegetation is mainly mesa dropseed, with a few plants of broom snakeweed (*Gutierrezia sarothrae* [Pursh] Britton & Rusby), mesquite, and soaptree yucca (*Yucca elata* Engelm.).

Soils. The soil water blocks are in the Typic Haplargid Yucca (fig. 29, table 7; Yucca description and primary data). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a calcic horizon. Silicate clay, carbonate, and organic carbon data (table 7) confirm the presence of these horizons. Beneath a thin Historical deposit are Bt and K horizons similar to those buried by Organ sediments at site O (table 7). Also similarly, these buried sediments at site Y are designated Jornada-La Mesa.

In contrast to site O, previously discussed, only slight evidence of recent eolian sedimentation was found at site Y. The thin layer of stratified C horizon material at the surface attests to fairly recent deposition. This youthful deposit (which was also found at other stable-appearing sites discussed later) is thought to be due to regional wind erosion caused by the introduction of large numbers of cattle early in Historical time (table 1). The number of cattle greatly increased on the Jornada plain in the 1880's (Buffington and Herbel, 1965).

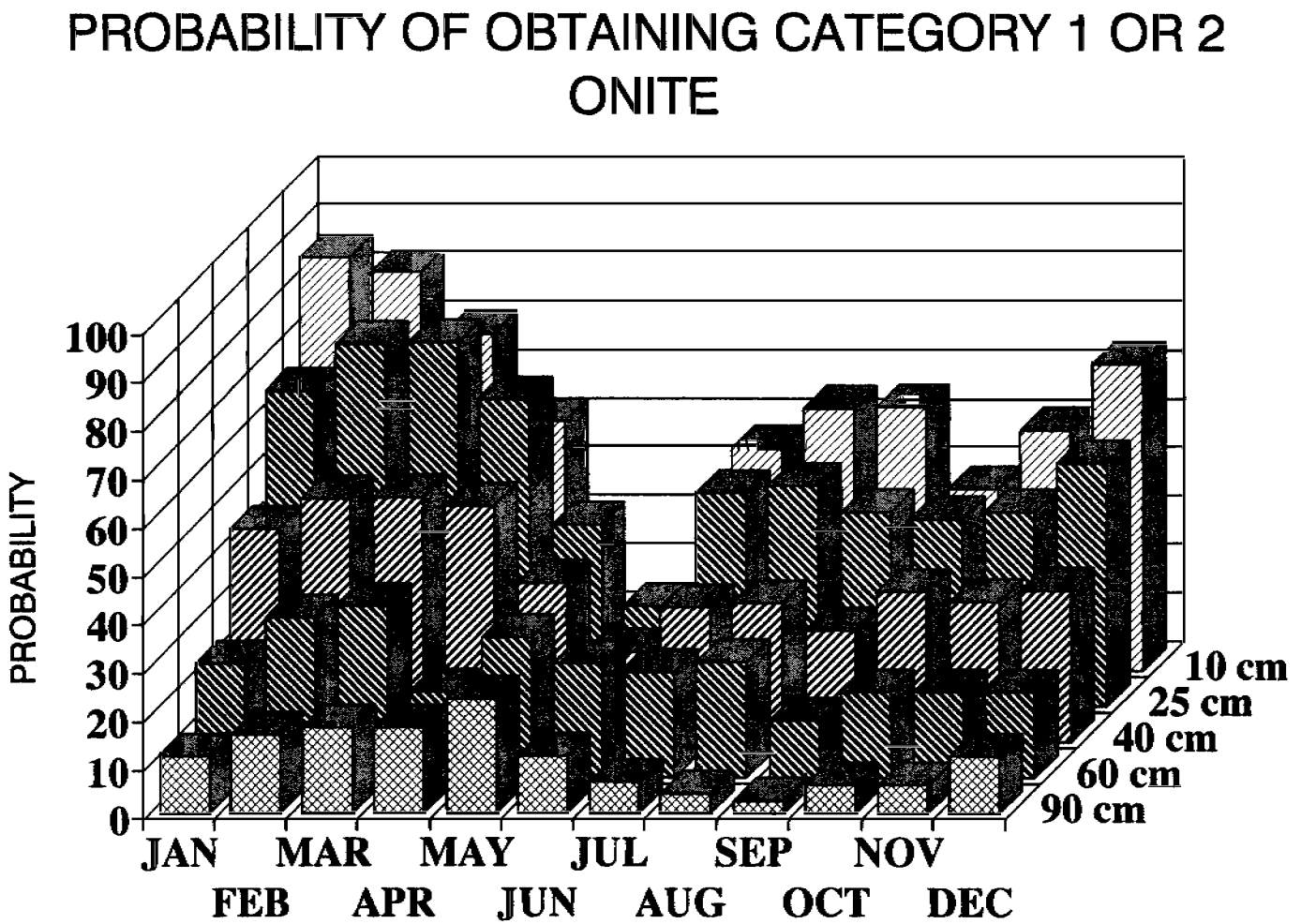


Figure 27. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 60, and 90 cm at the Onite site.

Figure 28. Landscape at Site Y (fig. 4) and the Typic Haplargid Yucca, in the Yucca exclosure on the Jornada Experimental Range. The Caballo Mountains are on the skyline. The recording rain gauge may be seen at left. Photographed February 1990.

Figure 29. Profile of upper horizons on the Typic Haplargid Yucca. Note the stable-appearing surface as compared to Site O. Scale is in feet.

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Yucca
Classification: Coarse-loamy, mixed, thermic Typic Haplargid
NSSL ID#: 90P0492
Soil Survey #: S90NM-013-001
Location: The SE1/4NE1/4NW1/4 section 17, T.20S., R.2E., in the Yucca exclosure on the Jornada Experimental Range. The south edge of the exclosure is on the north edge of the road. The sampled pedon is 2.3 m southwest of the nonrecording rain gauge, and 1.3 m southwest of the wires to the gypsum blocks.
Elevation: 4335 ft, 1321 m
Landform: Level basin floor
Geomorphic Surface: Jornada-La Mesa
Parent Material: Upper Camp Rice Formation
Vegetation: Mainly dropseed, with a few snakeweed, mesquite, and soaptree yucca
Described By: L.H. Gile
Date: Feb. 1, 1990
Soil surface: alternating areas of thin, loose sand and smooth crust.

C--0 to 8 cm; stratified reddish brown (5YR 5/4) sand; dark reddish brown (5YR 3.5/4) moist; massive but with horizontal cleavage to thin lenses; generally soft, with some lenses separated by soft fine granules or by loose, single-grain material; generally few fine roots, except that many and common, fine and very fine roots occur below grass clumps; stratified; 90P2702; noncalcareous; abrupt smooth boundary.

Eb--8 to 15 cm; reddish brown (5YR 5/4) loamy sand; dark reddish brown (5YR 3.5/4) moist; weak fine and medium subangular blocky structure; slightly hard, very friable; generally few fine roots, except that many and common, fine and very fine roots occur below grass clumps; 90P2703; noncalcareous; abrupt wavy boundary.

BEtb--15 to 25 cm; reddish brown (5YR 5/4) loamy sand; dark reddish brown (5YR 3.5/4) moist; weak fine subangular blocky structure; slightly hard, friable; generally few fine roots, except that many and common, fine and very fine roots occur below grass clumps; 90P2704; sand and grains coated with oriented clay; slightly effervescent; clear wavy boundary.

Btk1b--25 to 37 cm; reddish brown (5YR 5/4) loamy sand; reddish brown (5YR 4/4) moist; weak fine and medium subangular blocky structure; slightly hard, friable; generally few fine roots, except that many and common, fine and very fine roots occur below grass clumps; 90P2705; few carbonate filaments; sand grains coated with oriented clay; slightly effervescent; clear wavy boundary.

Btk2b--37 to 51 cm; reddish brown (5YR 5/4) fine sandy loam; reddish brown (5yr 4/4) moist; weak fine and medium coarse subangular blocky structure; slightly hard, friable; very few fine roots; 90P2706; few carbonate filaments; sand grains coated with oriented clay; strongly effervescent; clear wavy boundary.

Btk3b--51 to 62 cm; light reddish brown (5YR 6/4) fine sandy loam; reddish brown (5YR 5/4) moist; lesser amount of reddish brown (5YR 5/4, dry) weak fine and medium subangular blocky structure; slightly hard, friable; very few fine roots; 90P2707; few dark insect burrow fillings, commonly 1-5mm in diameter; some are horizontally elliptical and up to 2 cm in length; common carbonate filaments; sand grains in 5YR 5/4 material coated with oriented clay; strongly effervescent; clear wavy boundary.

Btk4b--62 to 71 cm; light reddish brown (5YR 6/4) sandy loam; reddish brown (5YR 5/4) moist; 10-20% of reddish brown 5YR 5/4; weak fine and medium subangular blocky structure; slightly hard, friable; very few fine roots; 90P2708; few dark insect burrow fillings, commonly 1-5 mm in diameter; some are horizontally elliptical and up to 2 cm in length; common carbonate filaments; sand grains in 5YR 5/4 material coated with oriented clay; strongly effervescent; clear wavy boundary.

Btk5b--71 to 85 cm; light reddish brown (5YR 6/4) sandy clay loam; reddish brown (5YR 5/4) moist; 30% of reddish brown 5YR 5/4; weak fine and medium subangular blocky structure; slightly hard, friable; very few fine roots; 90P2709; few dark insect burrow fillings, commonly 1-5 mm in diameter; some are horizontally elliptical and up to 2 cm in length; common carbonate filaments; sand grains in 5YR 5/4 material coated with oriented clay; strongly effervescent; abrupt wavy boundary.

K1b--85 to 101 cm; pinkish white (7.5YR 8/2) sandy clay loam; pinkish gray to pink (7.5YR 7/3) moist; lesser amount of pinkish gray to light brown 7.5YR 6/3; moderate medium subangular block structure; very hard, friable; very few fine roots; 90P2710; parts between some carbonate nodules are massive and soft; strongly effervescent; clear wavy boundary.

K2b--101 to 112 cm; pinkish white (7.5YR 8/2) sandy clay loam; pinkish gray to pink (7.5YR 7/3) moist; some parts pinkish gray to pink 7.5YR 7/3, dry; weak coarse subangular blocky structure; very hard and extremely hard, friable; no roots; 90P2711; strongly effervescent.

*** P R I M A R Y C H A R A C T E R I Z A T I O N D A T A ***

S90NM-013-001

PRINT DATE 11/29/91

Soil series: Yucca

COARSE-LOAMY, MIXED, THERMIC TYPIC HAPLARGID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 492, SAMPLES 90P2702-2715
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
				(- - -TOTAL - - -)			(- -CLAY- -)		(- -SILT- -)			(- - - - - -SAND- - - - - -)				(-COARSE FRACTIONS(MM)-)				(>2MM)
SAMPLE NO.	DEPTH (CM)	HORIZON	CLAY LT .002	SILT .002 -.05	SAND .05 -2	FINE LT .0002	CO3 LT .002	FINE .002 -.02	COARSE .02 -.05	VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2		2 -5	5 -20	20 -75	WEIGHT - - - - .1- 75	WT PCT OF WHOLE SOIL
			<- - - - - - - - - - - - PCT OF <2MM						(3A1) - - - - - - - - - - - - - - - ->							<- PCT OF <75MM(3B1)->		
90P2702S	0- 8	C	6.3	4.8	88.9			0.8	4.0	9.5	35.9	36.1	7.1	0.3		--	--	--	79	--
90P2703S	8- 15	EB	10.0	4.6	85.4			1.7	2.9	14.5	39.1	27.5	3.9	0.4		--	--	--	71	--
90P2704S	15- 25	BETB	11.3	4.2	84.5			1.2	3.0	11.4	39.2	29.3	4.4	0.2		--	--	--	73	--
90P2705S	25- 37	BTK1B	12.3	4.4	83.3			1.6	2.8	11.3	37.6	29.7	4.3	0.4		TR	--	--	72	TR
90P2706S	37- 51	BTK2B	13.1	6.0	80.9			1.7	4.3	12.7	35.5	27.1	4.8	0.8		TR	TR	--	68	TR
90P2707S	51- 62	BTK3B	15.7	6.7	77.6		0.8	2.9	3.9	12.6	32.4	26.2	5.7	0.7		1	TR	--	65	1
90P2708S	62- 71	BTK4B	19.1	7.2	73.7		1.7	5.2	4.0	10.5	29.4	25.6	7.0	1.2		2	TR	--	64	2
90P2709S	71- 85	BTK5B	22.0	7.3	70.7		3.1	5.6	3.7	11.0	29.3	23.5	5.5	1.4		2	TR	--	61	2
90P2710S	85-101	K1B	23.8	10.4	65.8		7.9	7.0	3.4	9.8	28.3	21.8	4.5	1.4		3	2	--	58	5
90P2711S	101-112	K2B	23.3	12.4	64.3		10.7	10.0	2.4	9.8	27.0	20.9	4.8	1.8		1	2	--	56	3
																--	--	--		--
																--0	--	--		--

	ORGN	TOTAL	EXTR TOTAL	(- - DITH-CIT - -)				(RATIO/CLAY)		(ATTERBERG)		(- BULK DENSITY -)			COLE	(- - -WATER CONTENT - - -)				WRD
	C	N	P	S	FE	AL	MN	CEC	15 BAR	LL	PI	FIELD MOIST	1/3 BAR	OVEN DRY	WHOLE SOIL	FIELD MOIST	1/10 BAR	1/3 BAR	15 BAR	WHOLE SOIL
DEPTH (CM)	6A1c	6B3a	6S3	6R3a	6C2b	6G7a	6D2a	8D1	8D1	4F1	4F	4A3a	4A1d	4A1h	4D1	4B4	4B1c	4B1c	4B2a	4C1
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM	-->			PCT	<0.4MM	<- - G/CC - - ->			CM/CM	<- - -PCT OF	<2MM - ->			CM/CM
0- 8	0.19							0.84	0.44										2.8	
8- 15	0.26							0.77	0.38				1.62	1.65	0.006			10.9	3.8	0.12
15- 25	0.29							0.75	0.36										4.1	
25- 37	0.22							0.74	0.38										4.7	
37- 51	0.20							0.72	0.38				1.47	1.52	0.011			8.7	5.0	0.05
51- 62	0.22							0.60	0.39										6.1	
62- 71	0.26							0.61	0.41				1.53	1.61	0.017			10.0	7.8	0.03
71- 85	0.24							0.55	0.35										7.8	
85-101	0.18							0.36	0.35										8.3	
101-112	0.12							0.29	0.31				1.69	1.80	0.021			13.5	7.2	0.10

AVERAGES, DEPTH 15- 65: PCT CLAY 13 PCT .1-75MM 69

	(- NH4OAC EXTRACTABLE BASES -)					ACID-	(- -CEC- -)		EXCH	SAR	BASE SATURATION		CO3 AS CACO3	RES. OHMS	CASO4 AS GYPSUM		(- - - -PH - - - -)		
	CA	MG	NA	K	SUM BASES	ITY	SUM CATS	NH4-OAC	NA		SUM	NH4OAC	<2MM	/CM	<2MM	<20MM	SAT PASTE	CACL2 .01M	H2O
DEPTH (CM)	5B5a 6N2a	5B5a 6O2d	5B5a 6P2b	5B5a 6Q2b		6H5a	5A3a	5A8b	5B5b PCT	5E	5C3 <- -PCT- >	5C1	6E1g PCT	8E1	6F1a <- -PCT ->	6F4	8C1b	8C1f 1:2	8C1f 1:1
	<- - - - - - - - - - -MEQ / 100 G - - - - - - - - - ->																		
0- 8	4.9	1.0	0.1	0.5	6.5	--	6.5	5.3	1		100	100						6.6	7.4
8- 15	11.2	1.2	0.1	0.7	13.2	--	13.2	7.7	1		100	100						7.0	7.8
15- 25		1.3	TR	0.8		--		8.5	TR		100	100	1					7.5	8.1
25- 37		1.5	TR	0.6		--		9.1	1		100	100	1					7.6	8.3
37- 51		1.8	TR	0.5		--		9.4	1		100	100	1					7.6	8.0
51- 62		2.3	0.1	0.5				9.4	2		100	100	2					7.6	8.2
62- 71		3.3	0.1	0.5				11.7	1		100	100	4					7.6	8.2
71- 85		4.0	0.2	0.5				12.2	2		100	100	6					7.7	8.3
85-101		3.9	0.3	0.3				8.6	3		100	100	18					7.8	8.2
101-112		3.6	0.3	0.2				6.7	3	2	100	100	25	3100			8.0	7.9	8.4

	(- - - - - - - -WATER EXTRACTED FROM SATURATED PASTE- - - - - - - - -)											
	CA	MG	NA	K	CO3	HCO3	CL	SO4	NO3	H2O	TOTAL SALTS EST.	ELEC. COND. 8A3a
DEPTH (CM)	6N1b	6O1b	6P1b	6Q1b	6I1b	6J1b	6K1c	6L1c	6N1c	8A	8D5	MMHOS /CM
	<- - - - - - - - - - -MEQ / LITER - - - - - - - - - ->									<- -PCT ->		
0- 8												0.23
8- 15												0.15
15- 25												0.16
25- 37												0.14
37- 51												0.15
51- 62												0.16
62- 71												0.17
71- 85												0.18
85-101												0.21
101-112	2.3	1.4	2.2	0.1	--	1.8	0.8	2.9	--	41.1	TR	0.62

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 1, 2, 3, 4, 5, 6, 7, 8, 9,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

At one place in the study trench (just to the right of the tape, fig. 29) a tongue of dark fine earth, about 15 cm wide, extends from about 17 to 26 cm depth. This dark tongue may be a remnant of an A horizon that formed during an interval more moist than now. This dark fine earth is not evident elsewhere along the study trench; any evidence of such a former horizon may hav been obliterated during the present climate.

Site Y appears to have been stable for a very long period of time, as attested by the continuous E horizon and the prominent soil horizons below it. The noncalcareous upper horizons, the increase in stage of carbonate accumulation with depth (from the stage I carbonate filaments in the Btkb horizon, to the stage II nodular carbonate in the upper part of the K1b horizon, and to the stage III carbonate in the K2b horizon), the gradual increase in analytical carbonate with depth (table 7); all indicate stable, in-place sediments recording the effects of pedogenesis over a long period of time.

The stage I carbonate filaments from 25 to 85 cm depth are morphologically the same as in soils known to be of late and middle Holocene age by C-14 dating in the Desert Project, and are in the same horizon position, beneath a surficial noncalcareous zone. Laboratory analyses add supporting evidence. The percentages of carbonate for the filamentary zone are mostly between 1 and 4 percent, with one horizon having 6 percent carbonate (table 7). Analytically, this zone of stage I carbonate from 25 to 85 cm depth is also found in soils of early or middle Holocene age (see page 868-869 in Gile and Grossman, 1979, for laboratory analyses of a soil thought to date from the middle Holocene).

The foregoing chronomorphological relations indicate that during the full-glacial pluvial from 17,000 to 23,000 yr B.P. (Martin and Mehringer, 1965), the thick zone above the K horizon must have been virtually carbonate-free. From this it is clear that the prominent K horizon must have formed almost wholly in the Pleistocene. The K1b horizon has more than 50 percent of K-fabric (Gile et al. 1965) and enough carbonate to qualify as a calcic horizon (table 7). Although the K2b horizon is very and extremely hard when dry, it softens markedly when moistened (Yucca description).

Presently, the surficial noncalcareous zone is 15 cm thick and the zone from 15-37 cm has only weak effervescence. This 0-37 cm zone is frequently wetted (figs. 4, 30-49), demonstrating that it is kept nearly carbonate-free under the present climate.

Soil Water, Precipitation, and Yields. The gypsum resistance blocks were installed at soil depths of 10, 25, and 40 cm on August 5, 1957 and at the 60- and 90-cm depths on July 29, 1959 within a livestock exclosure at Yucca Rain Gauge. This rain gauge was established in 1926. Yields of perennial grasses were obtained each fall beginning in 1958 by clipping 14-19, 5-cm x 30.5-m transects. These transects were 1.0-2.6 km from the rain gauge. An average of 66% of the perennial grass cover was mesa dropseed.

The moisture control section, 25-cm soil depth, had water >-1.5 MPa August 9-October 1, 1957 (fig. 30); October 11, 1957-May 23, 1958 (figs. 30, 31); and August 22, 1958-March 15, 1959 (figs. 31, 32). The production of perennial grasses in 1958 was 180 kg/ha (n=14, s.e.=31 kg/ha).

Precipitation in 1959 was below average and most of it occurred in July and August. The 25-cm depth had soil water >-1.5 MPa July 21-September 30 (fig. 32). Perennial grasses yielded 244 kg/ha (n=19, s.e.=38 kg/ha) in 1959.

The 1960 precipitation was below average and perennial grasses yielded only 92 kg/ha (n=18, s.e.=14 kg/ha). Soil water at the 25-cm depth was >-1.5 MPa January 13, 1960-April 21; July 8-August 3; and briefly August 12-14 (fig. 33).

Precipitation for 1961 and 1962 was above average. There was soil water >-1.5 MPa at 25 cm December 12, 1960-May 26, 1961 (figs. 33, 34); June 19-July 25; August 14-October 30; November 13, 1961-May 16, 1962 (figs. 34, 35); July 3-August 23; and September 7-9, 1962. The production of perennial grasses averaged 309 kg/ha (n=17, s.e.=60 kg/ha) in 1961 and 108 kg/ha (n=17, s.e.=16 kg/ha) in 1962.

The ensuing four years, 1963-66, had below average precipitation. However, a major storm on September 26, 1962 of 53 mm and subsequent precipitation in the fall-winter of 1962-63 resulted in soil water >-1.5 MPa at the 25-cm depth September 27, 1962-April 24, 1963 (figs. 35, 36). Then the matric potential of the soil water at 25 cm was >-1.5 MPa August 7-15, 1963; August 21-26; September 6-16; October 22-25, 1963; July 13-August 6, 1964 (fig. 37); August 16-September 7; September 13-25; January 9-May 6, 1965 (fig. 38); August 3-5; October 17-21; February 11-May 4, 1966 (fig. 39); and September 10-26, 1966. Perennial grasses yielded 25 kg/ha (n=19, s.e.=7 kg/ha), 36 kg/ha (n=19, s.e.=12 kg/ha), 15 kg/ha (n=18, s.e.=4 kg/ha), and 137 kg/ha (n=18, s.e.=22 kg/ha) for 1963, 1964, 1965, and 1966, respectively.

Annual precipitation for 1967-69 was above average. Soil water at 25 cm was >-1.5 MPa July 3-27, 1967 (fig. 40); August 7-9; August 21-27; September 26-30; December 23, 1967-May 18, 1968 (figs. 40, 41); July 5-August 23; September 6-30; December 27, 1968-May 17, 1969 (figs. 41, 42); July 11-August 11; and September 3-October 1, 1969. The average annual production of perennial grasses was 67 kg/ha (n=18, s.e.=12 kg/ha), 68 kg/ha (n=18, s.e.=24 kg/ha), and 133 kg/ha (n=18, s.e.=29 kg/ha) for 1967-69, respectively.

Precipitation for 1970 and 1971 was below average but a storm of 35 mm rainfall on October 21, 1969 and subsequent fall-winter precipitation resulted in soil water >-1.5 MPa at 25 cm October 23, 1969-May 31, 1970 (figs. 42, 43). Soil water at the 25-cm depth was also >-1.5 MPa July 25-August 22, 1970; November 7, 1970-March 12, 1971 (figs. 43, 44); July 26-31; and August 19, 1971-May 13, 1972 (figs. 44, 45). The 1972 precipitation was considerably above average but the ohmmeter used to determine the matric potential of soil water was inoperative August 1-December 31. Perennial grasses yield d 194 kg/ha (n=18, s.e.=25

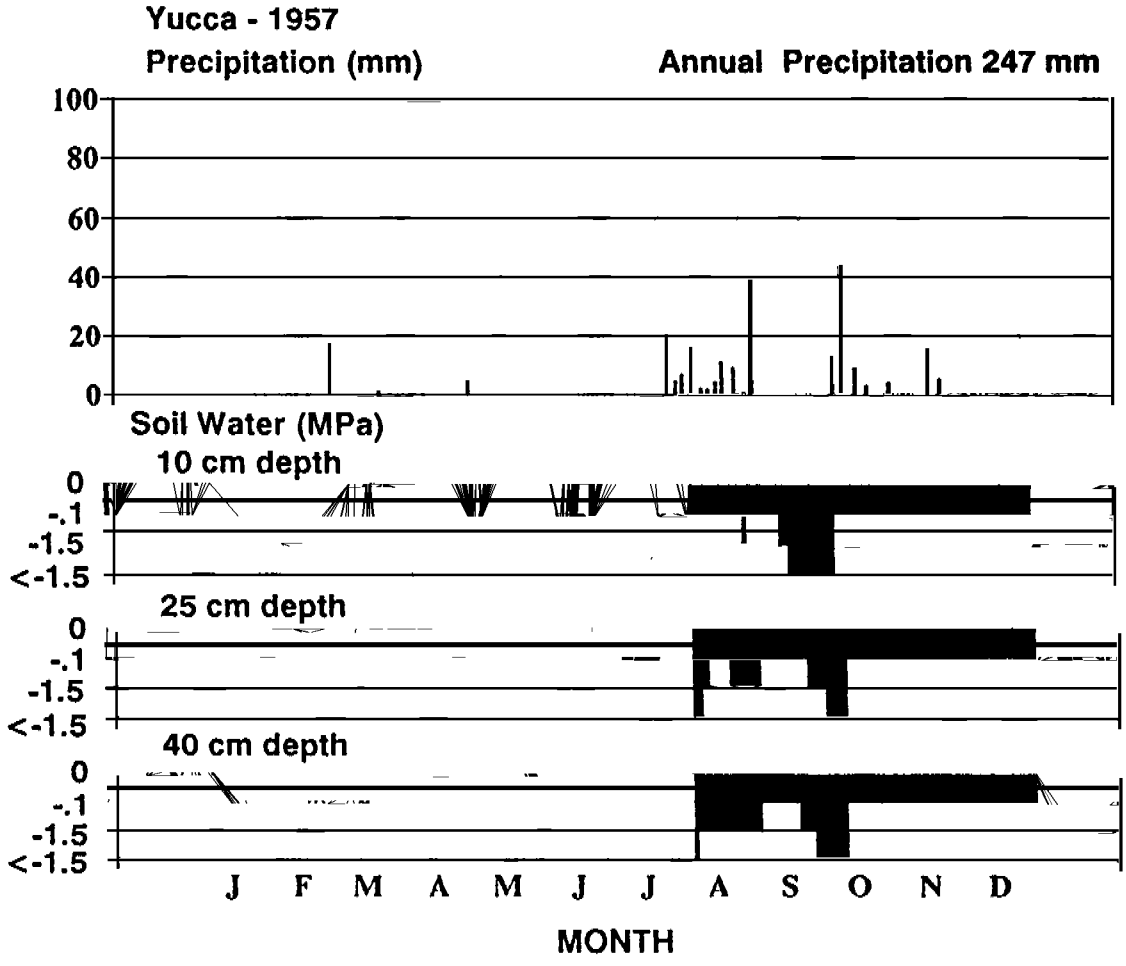


Figure 30. Annual (247 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 5-December 31, 1957 at the Yucca site.

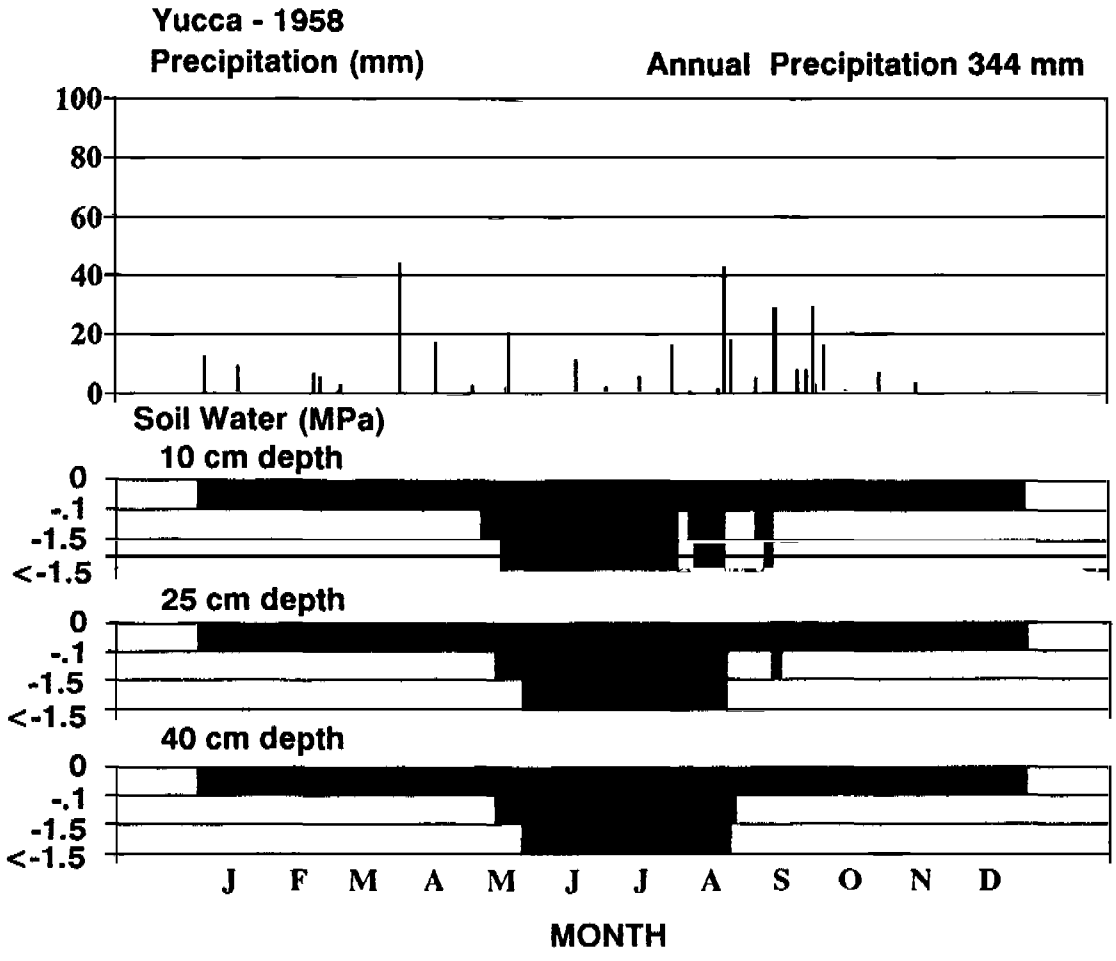


Figure 31. Annual precipitation (344 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Yucca site for 1958.

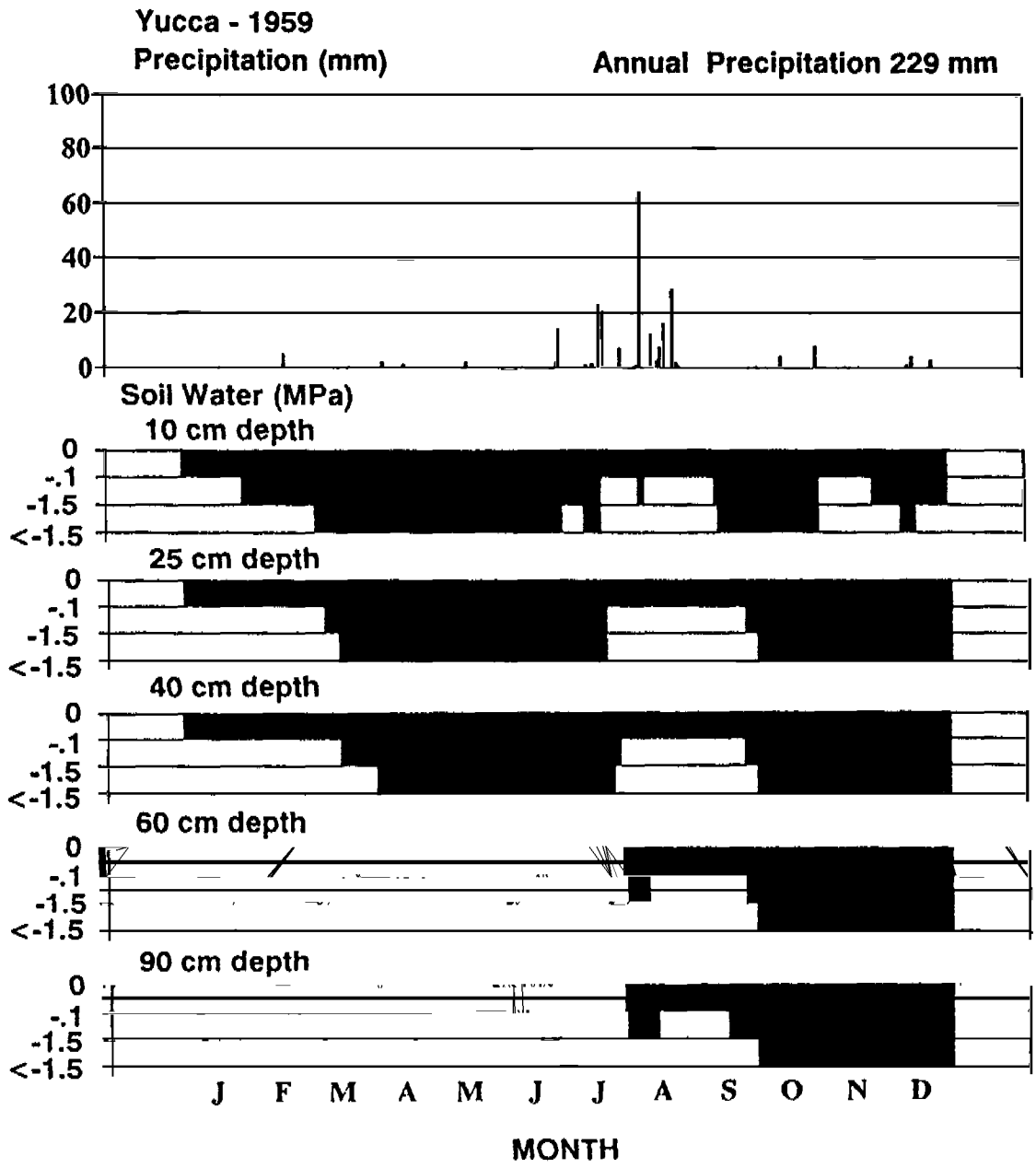


Figure 32. Annual precipitation (229 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Yucca site for 1959. Also shown is the soil water at depths of 60 and 90 cm July 29-December 31, 1959.

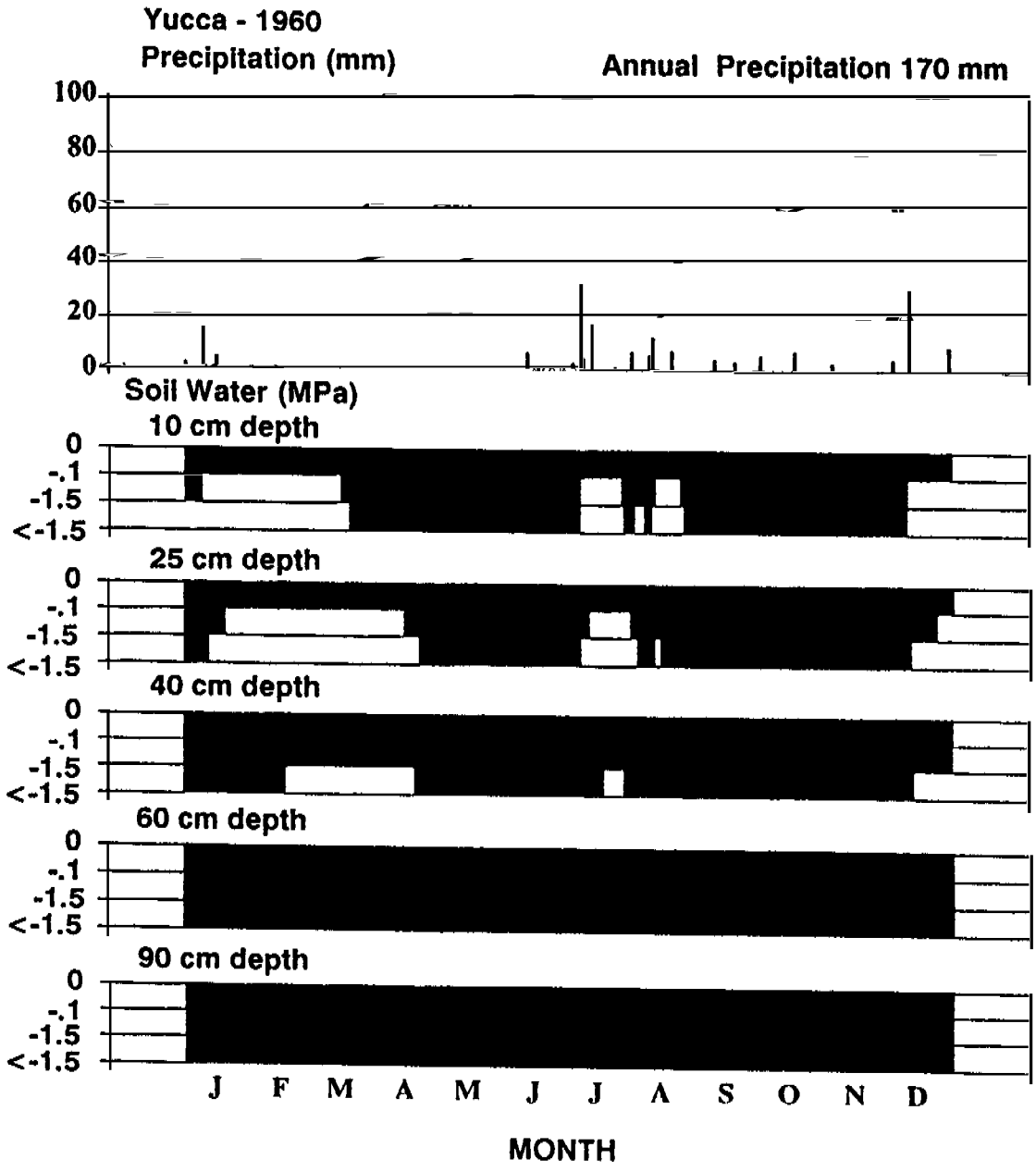


Figure 33. Annual precipitation (170 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1960.

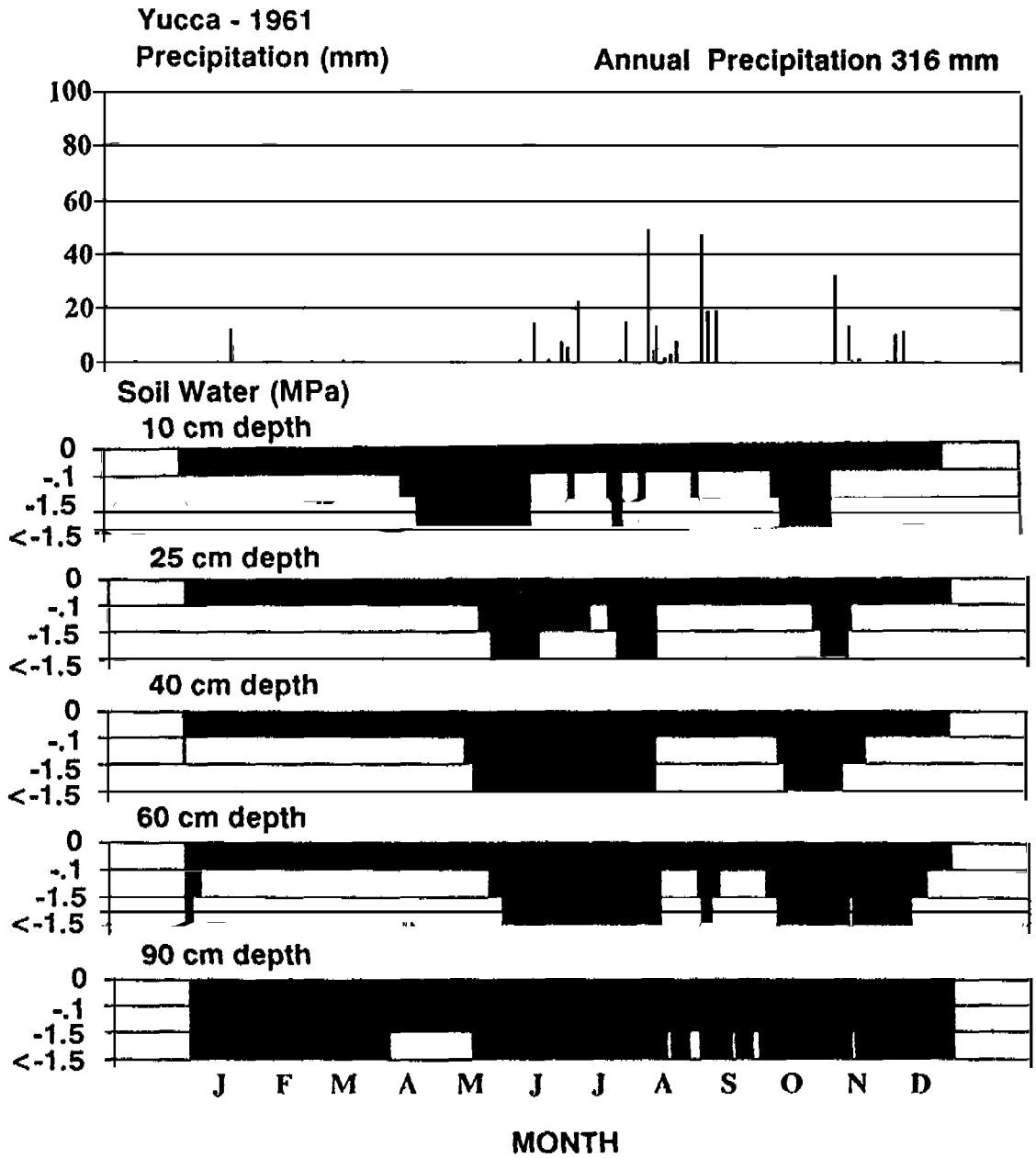


Figure 34. Annual precipitation (316 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1961.

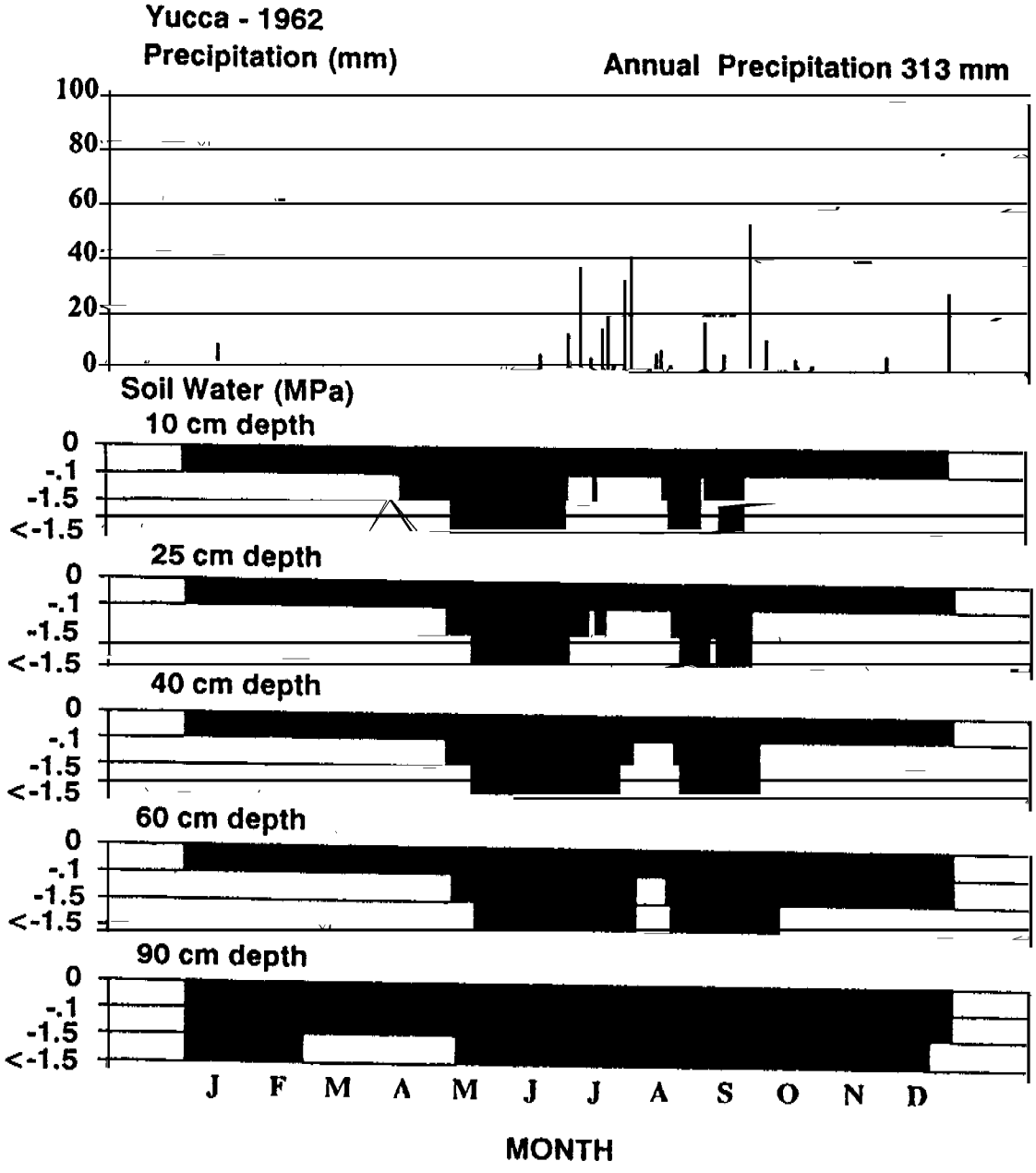


Figure 35. Annual precipitation (313 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1962.

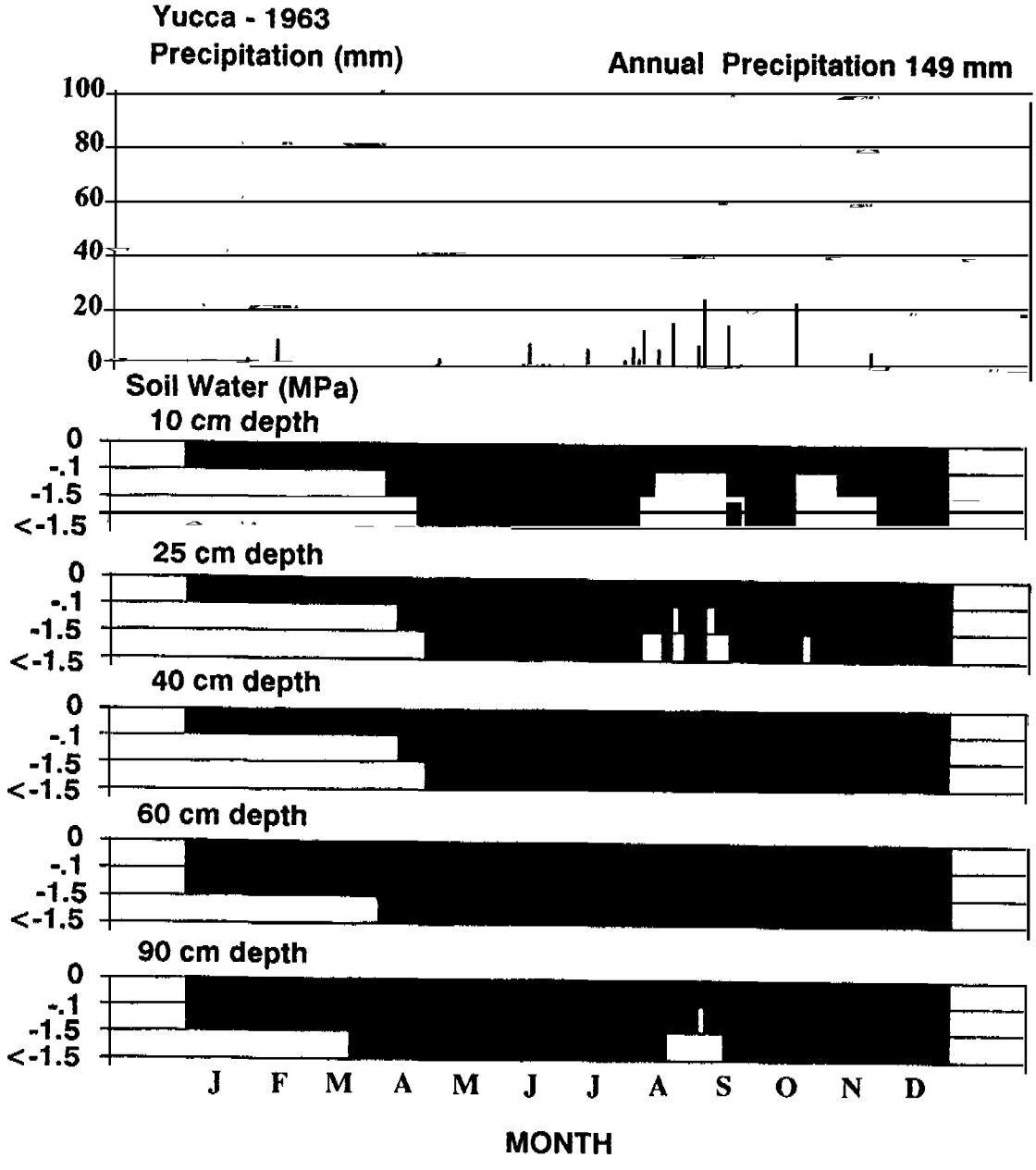


Figure 36. Annual precipitation (149 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1963.

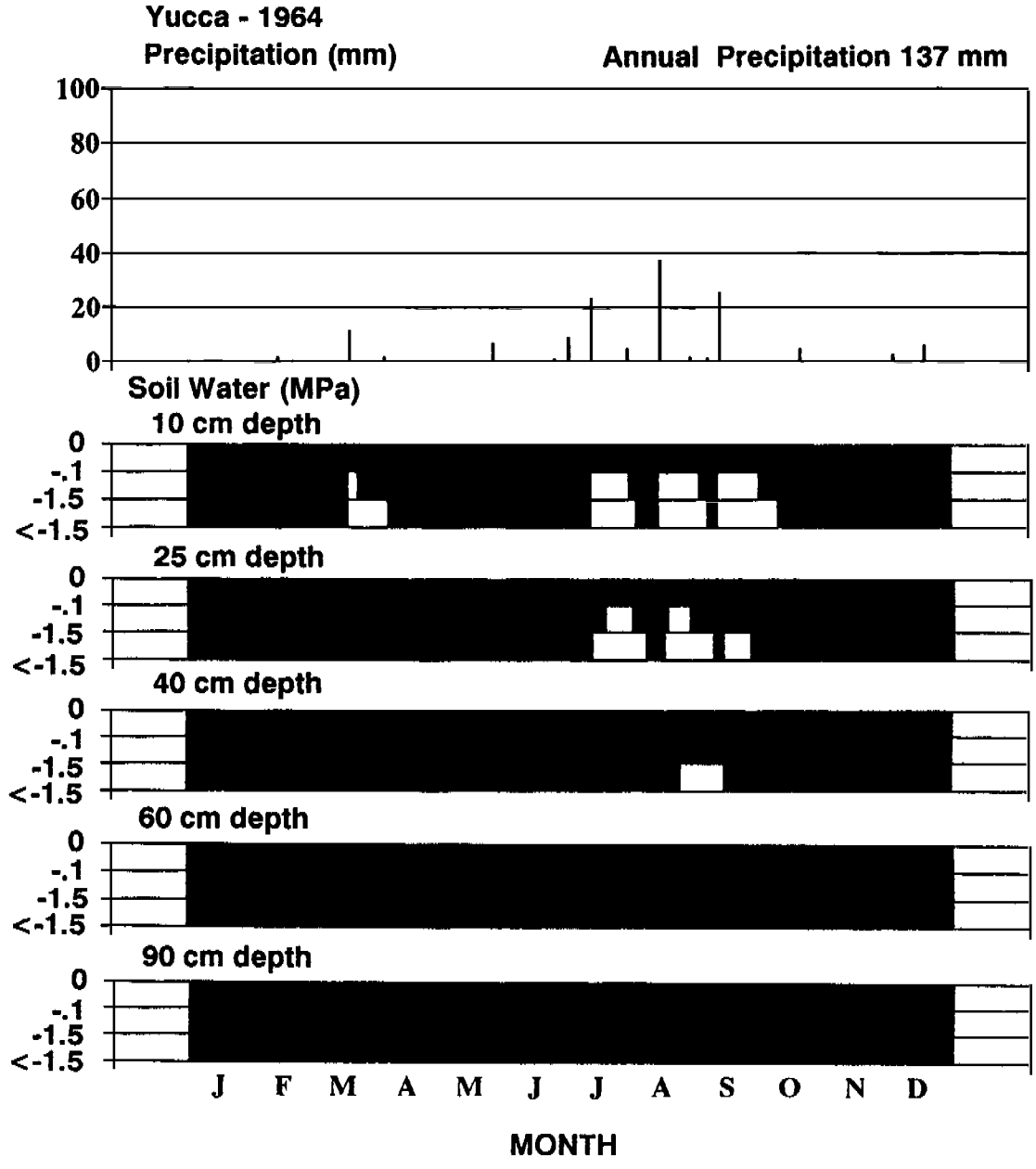


Figure 37. Annual precipitation (137 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1964.

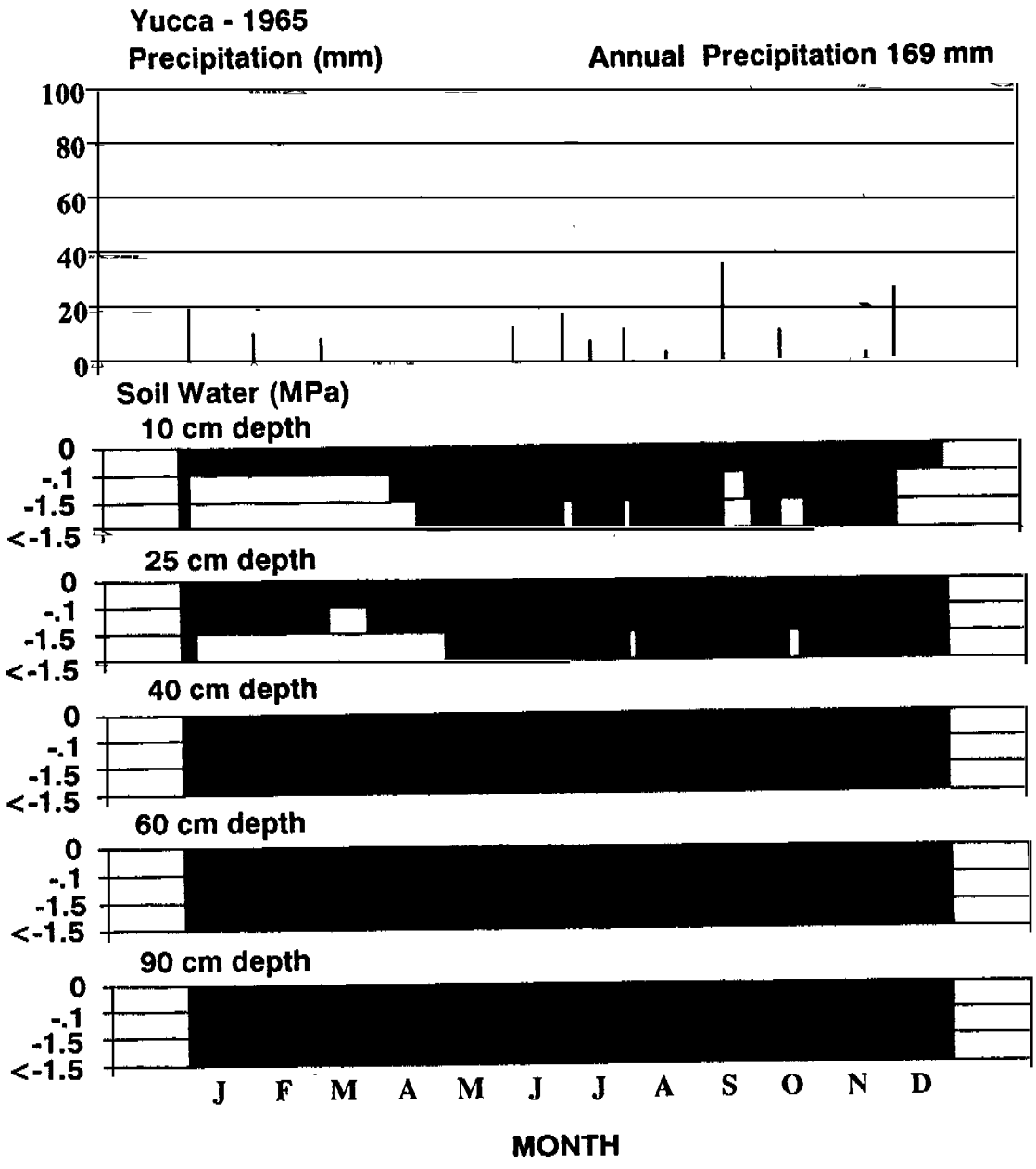


Figure 38. Annual precipitation (169 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1965.

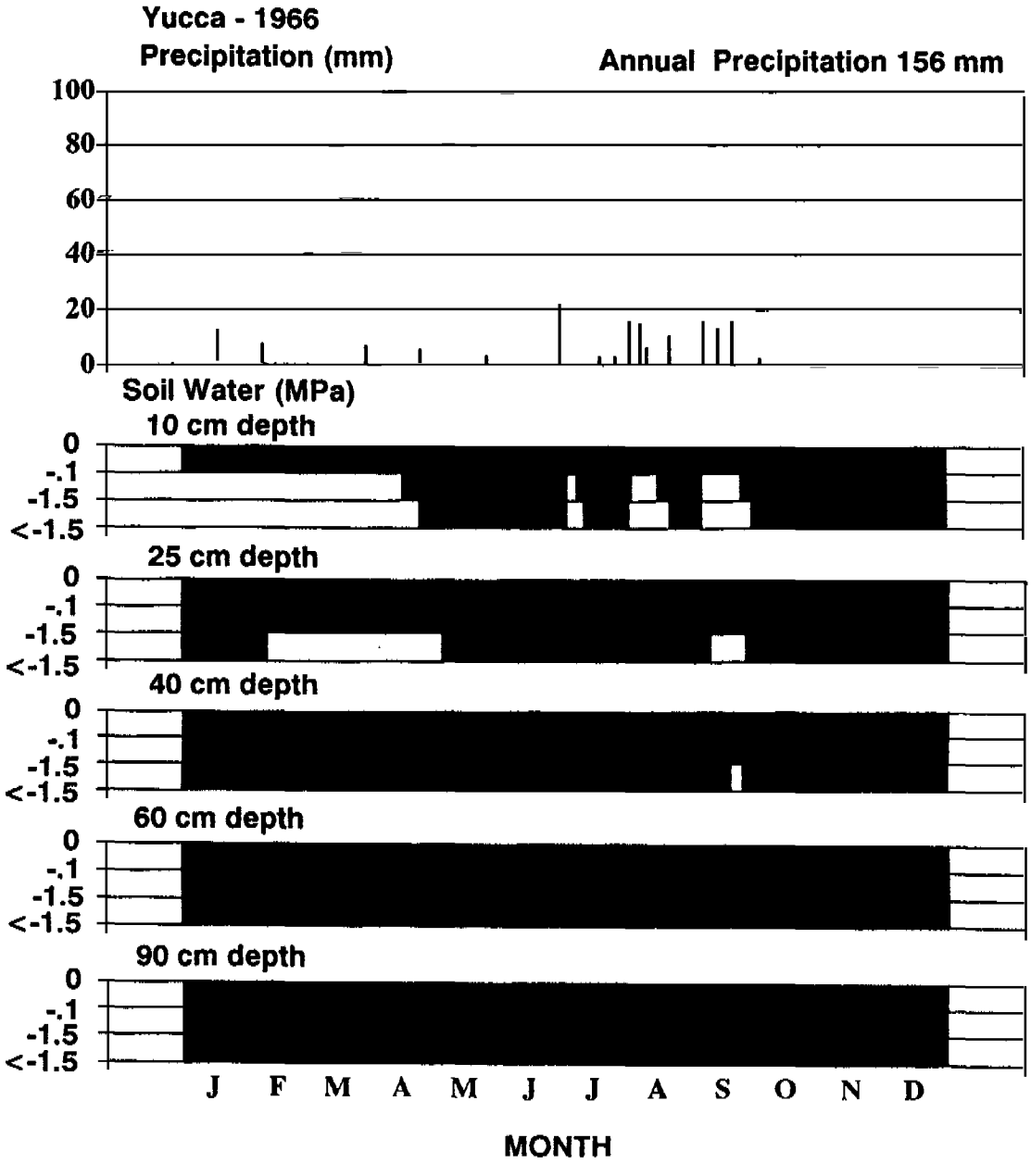


Figure 39. Annual precipitation (156 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1966.

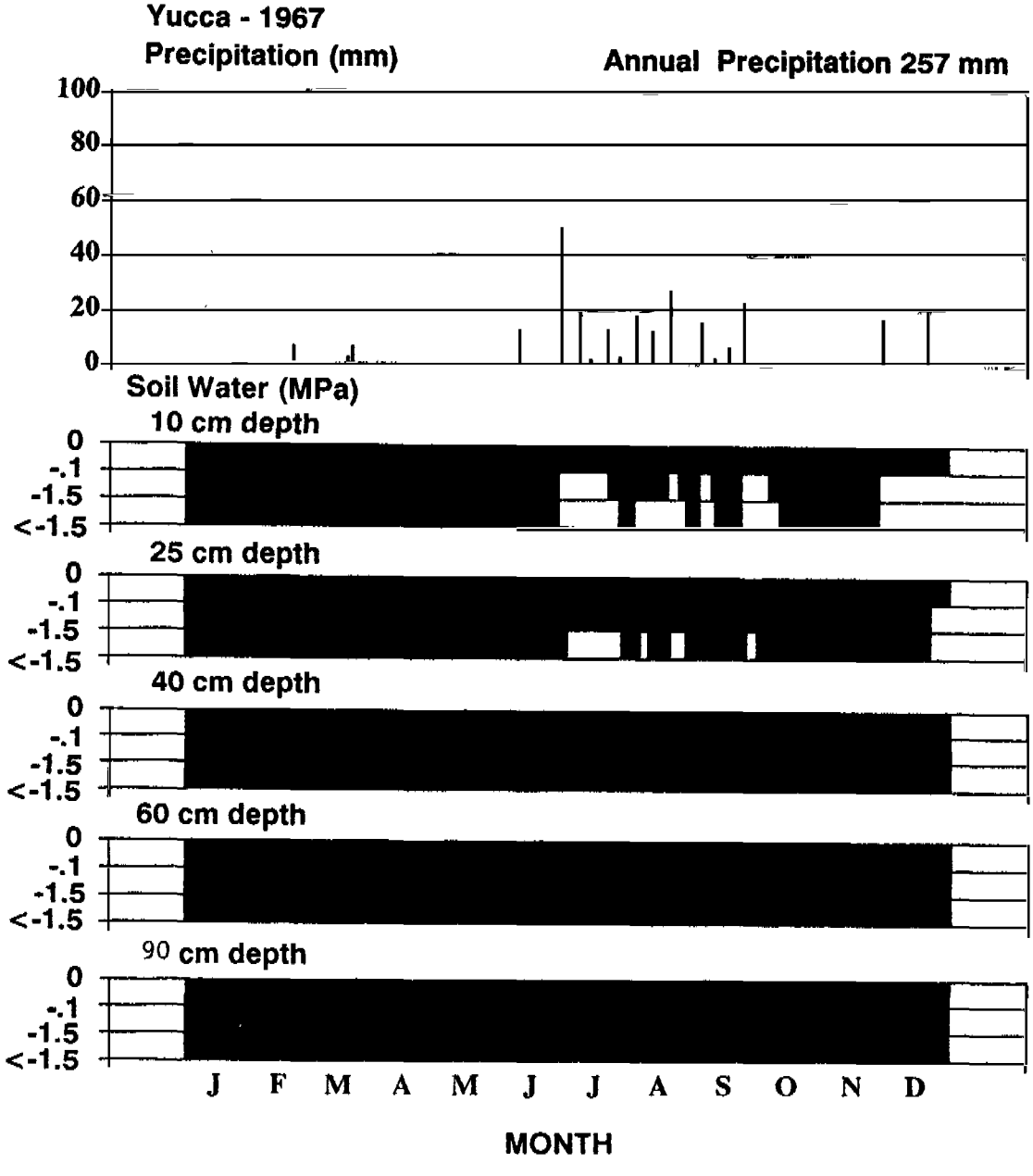


Figure 40. Annual precipitation (257 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1967.

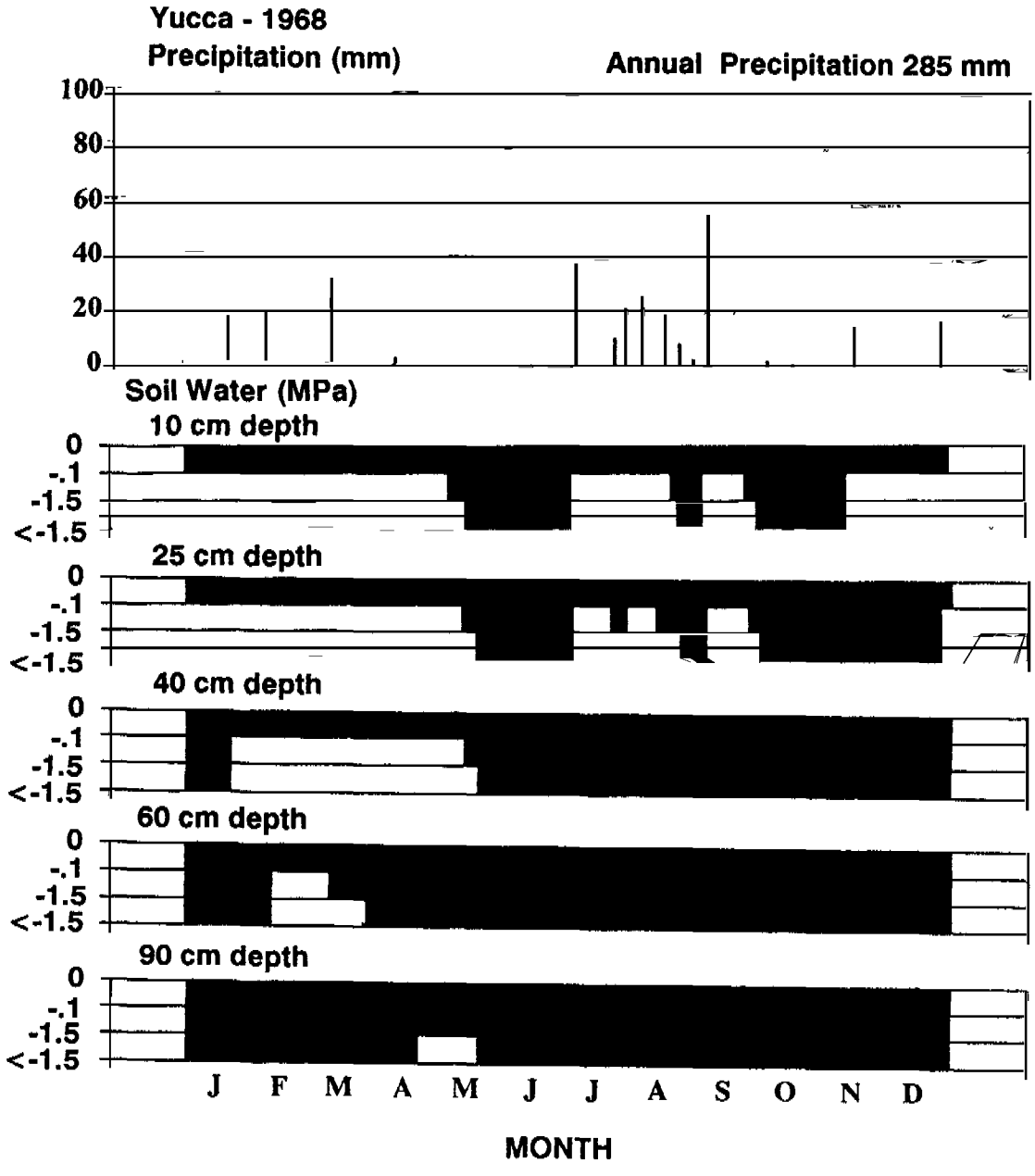


Figure 41. Annual precipitation (285 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1968.

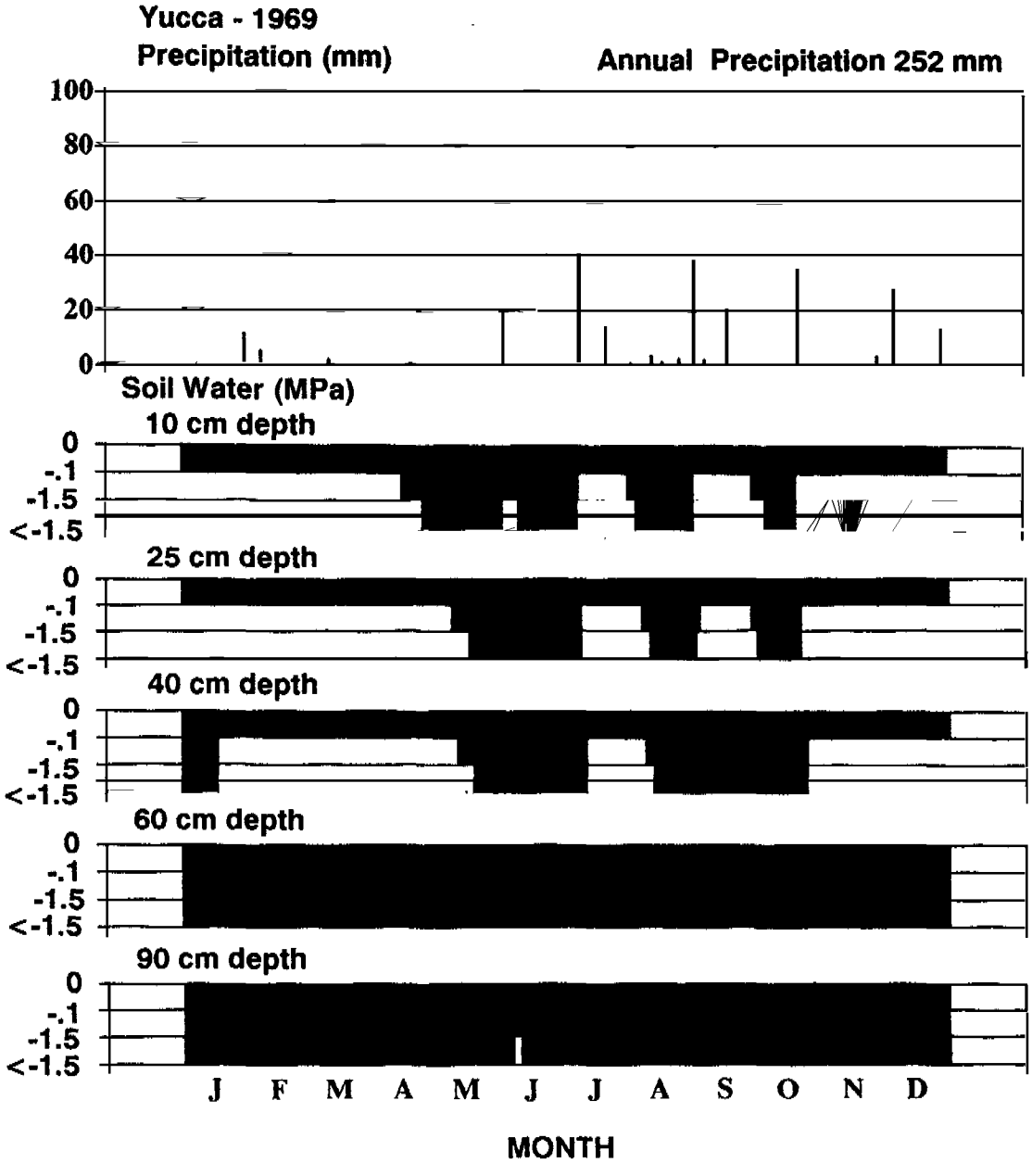


Figure 42. Annual precipitation (252 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1969.

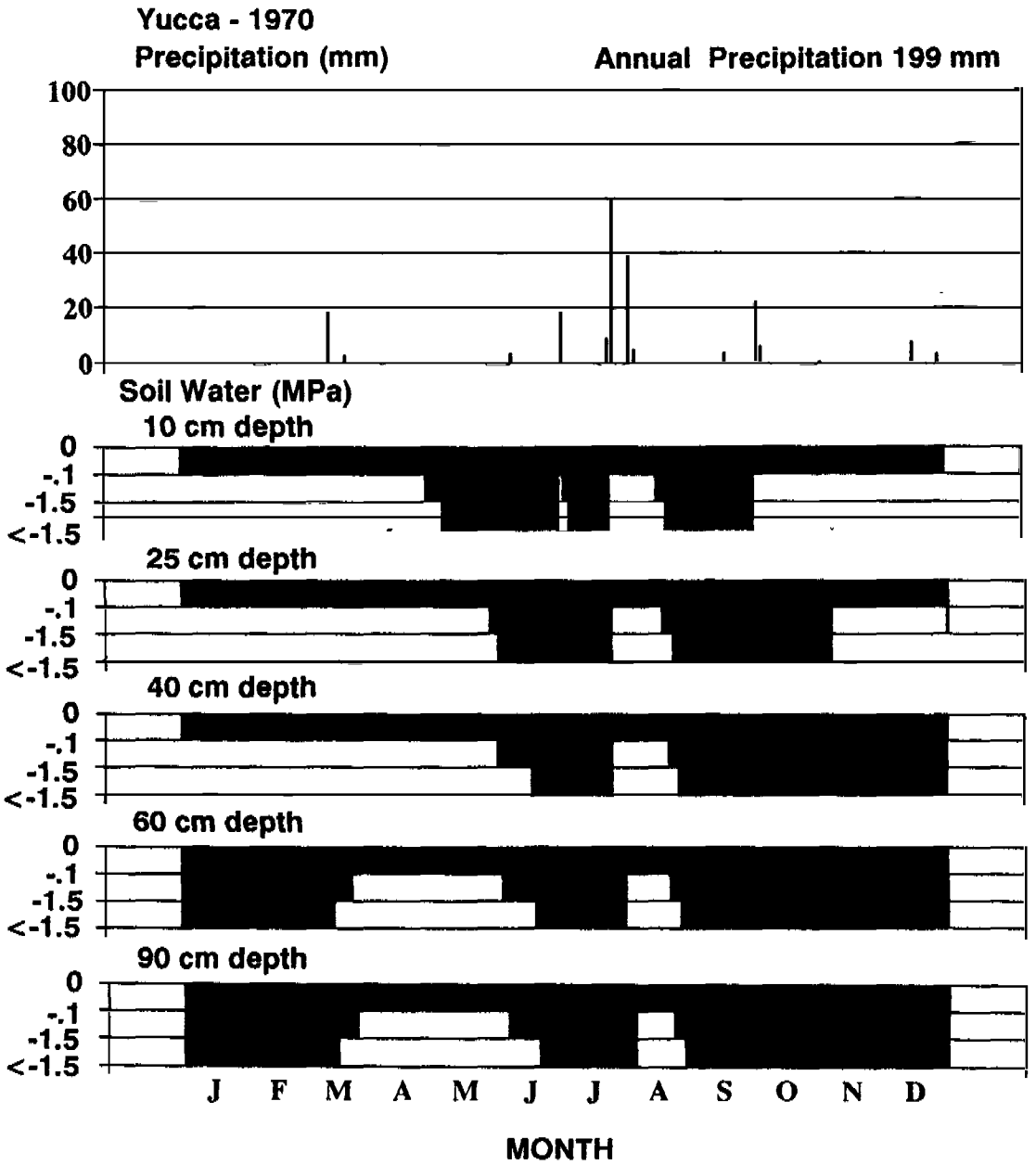


Figure 43. Annual precipitation (199 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1970.

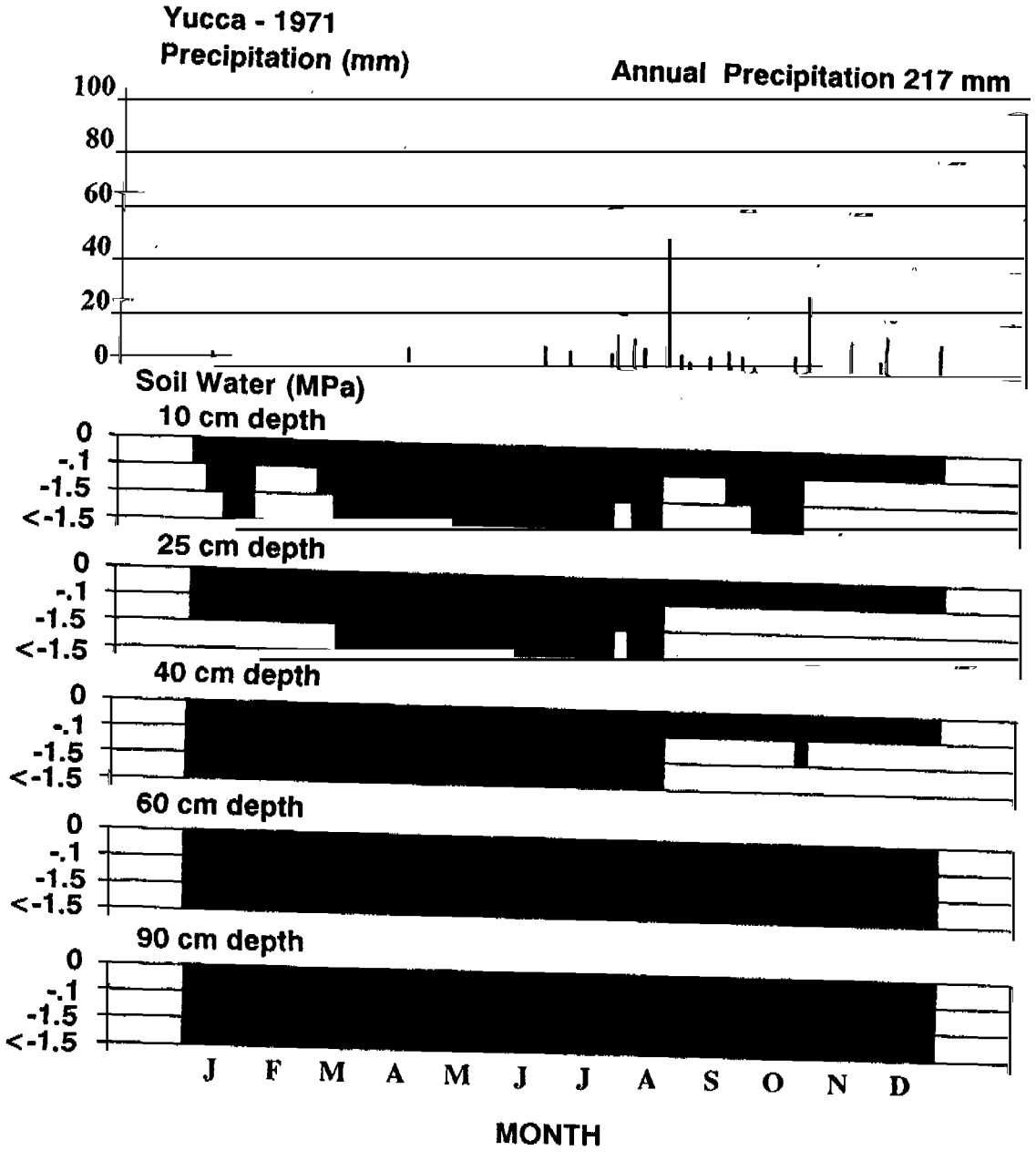


Figure 44. Annual precipitation (217 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1971.

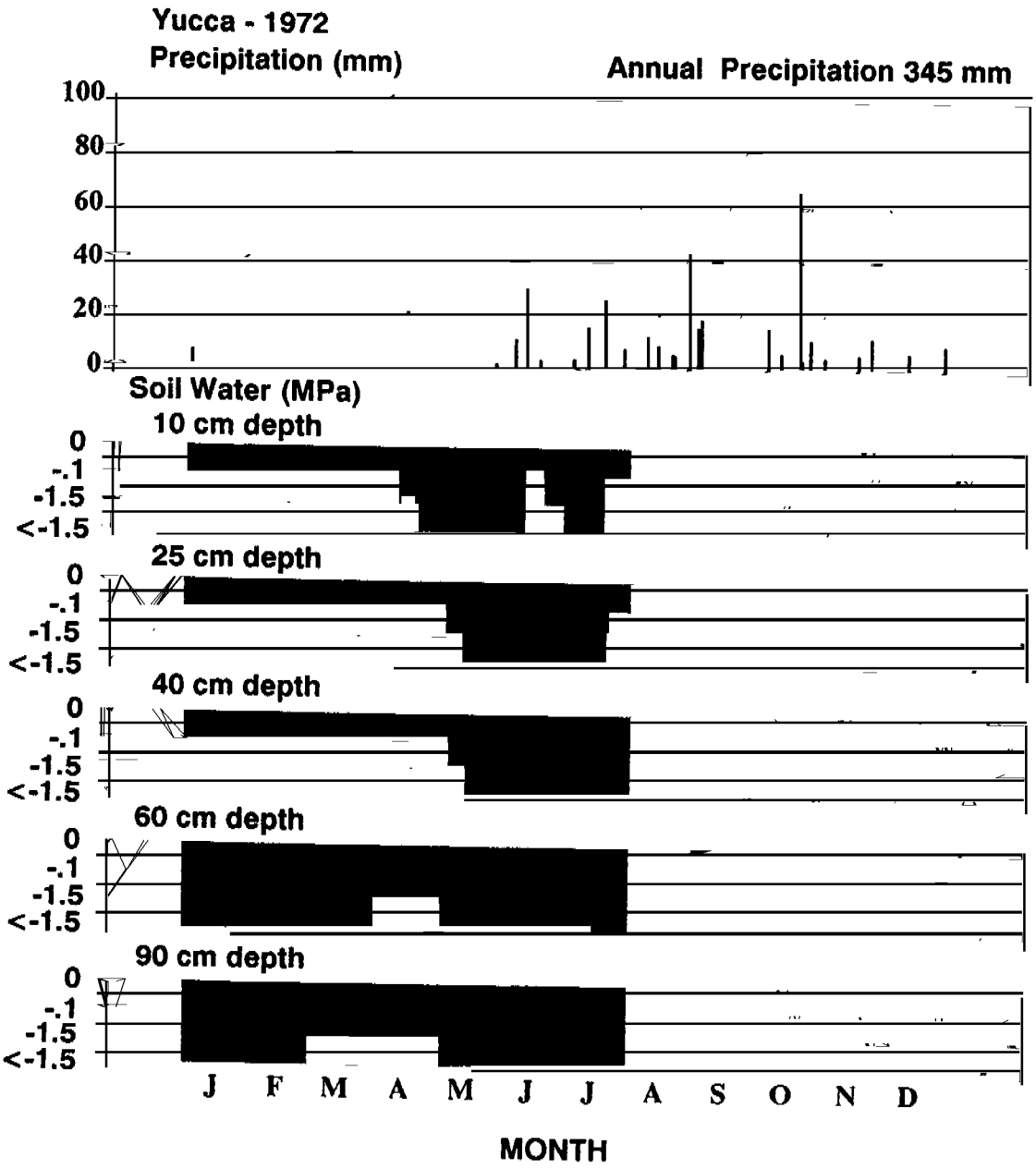


Figure 45. Annual (345 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water at depths of 10, 25, 40, 60, and 90 cm for January 1-August 1, 1972 at the Yucca site.

kg/ha) in 1970, 92 kg/ha (n=18, s.e.=24 kg/ha) in 1971, and 371 kg/ha (n=18, s.e.=59 kg/ha) in 1972.

Precipitation in 1973 was below average but the fall-winter of 1972-73 had considerable precipitation resulting in water >-1.5 MPa at the 25-cm soil depth until May 1 (fig. 46). There was also soil water >-1.5 MPa at this depth July 20-August 4. The perennial grasses produced 353 kg/ha (n=17, s.e.=31 kg/ha).

Precipitation was above average in 1974-75 and about average in 1976. Soil water at 25 cm was >-1.5 MPa July 14, 1974-May 19, 1975 (figs. 47, 48); July 25-31; September 3-5; September 9, 1975-February 29, 1976 (figs. 48, 49); and September 2-October 14. Production of perennial grasses averaged 201 kg/ha (n=18, s.e.=35 kg/ha) in 1974, 453 kg/ha (n=18, s.e.=91 kg/ha) in 1975, and 385 kg/ha (n=18, s.e.=36 kg/ha) in 1976.

Annual precipitation at Yucca Rain Gauge for 1957-76 was above average seven years, about average four years, and below average nine years. Production of perennial grasses averaged 182 kg/ha during 1958-76. The probability of soil water >-1.5 MPa at the 25-cm depth averaged 69.9% for December-April, 16.0% for May-June, 49.0% for July-September, and 42.6% for October-November (fig. 50).

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, nine of 20 years had soil water <-1.5 MPa more than half the time at 10 cm; 11 of 20 years at 25 cm; 13 of 20 years at 40 cm; 16 of 18 years at 60 cm; and every year had soil water <1.5 MPa more than half the time at a depth of 90 cm. Six of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 and 25 cm; 7 of 20 years at 40 cm; 12 of 18 years at 60 cm; and 14 of 18 years at a soil depth of 90 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 18 of 20 years missing only in 1964 and 1967. There were >30 consecutive days of soil water >1.5 MPa at the 25-cm depth between June 21 and October 21, 11 of 18 years. Soil water data were incomplete in 1957 and 1972 but both criteria were observed in 1957 and there were >60 consecutive days of soil water >-1.5 MPa at the 25-cm depth in 1972.

Site Hueco #1 (H1)

Site H1 (figs. 4, 51, 52, table 8) is in Exclosure B on the Jornada Experimental Range. The sampled pedon is about 13 m south of the nonrecording rain gauge and 0.7 m southwest of wires to the soil water blocks. Perennial vegetation is broom snakeweed, mesquite, soaptree yucca, longleaf ephedra (*Ephedra trifurca* Torr. ex S. Wats.), and a very few clumps of mesa dropseed, burrograss, and black grama.

Soils. The soil water blocks are in the Petrocalcic Paleargid Hueco #1 (fig. 52, tables 3, 8; Hueco #1 description and primary data). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a petrocalcic horizon. Silicate clay and organic carbon data (table 8) confirm the presence of the ochric epipedon

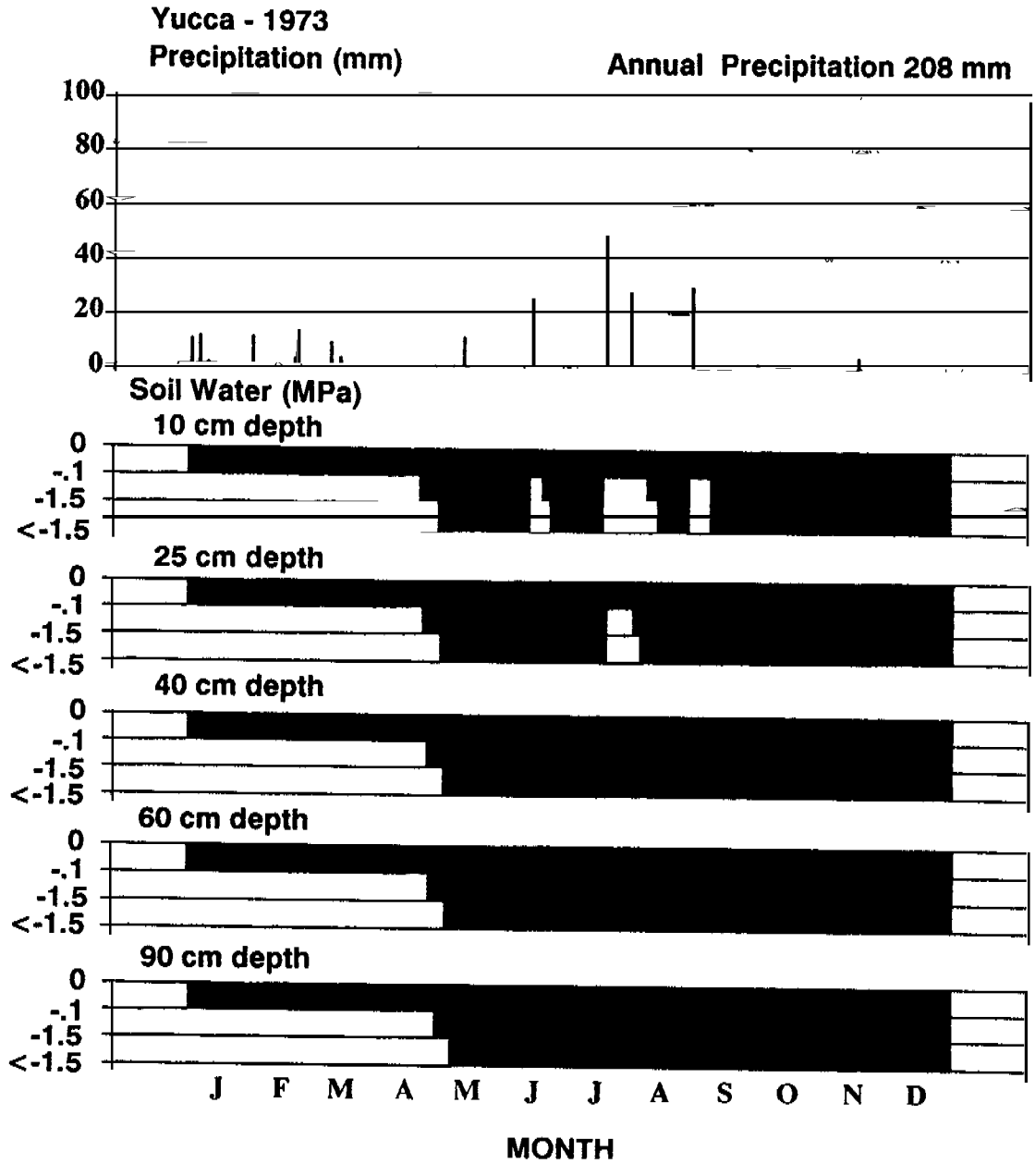


Figure 46. Annual precipitation (208 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1973.

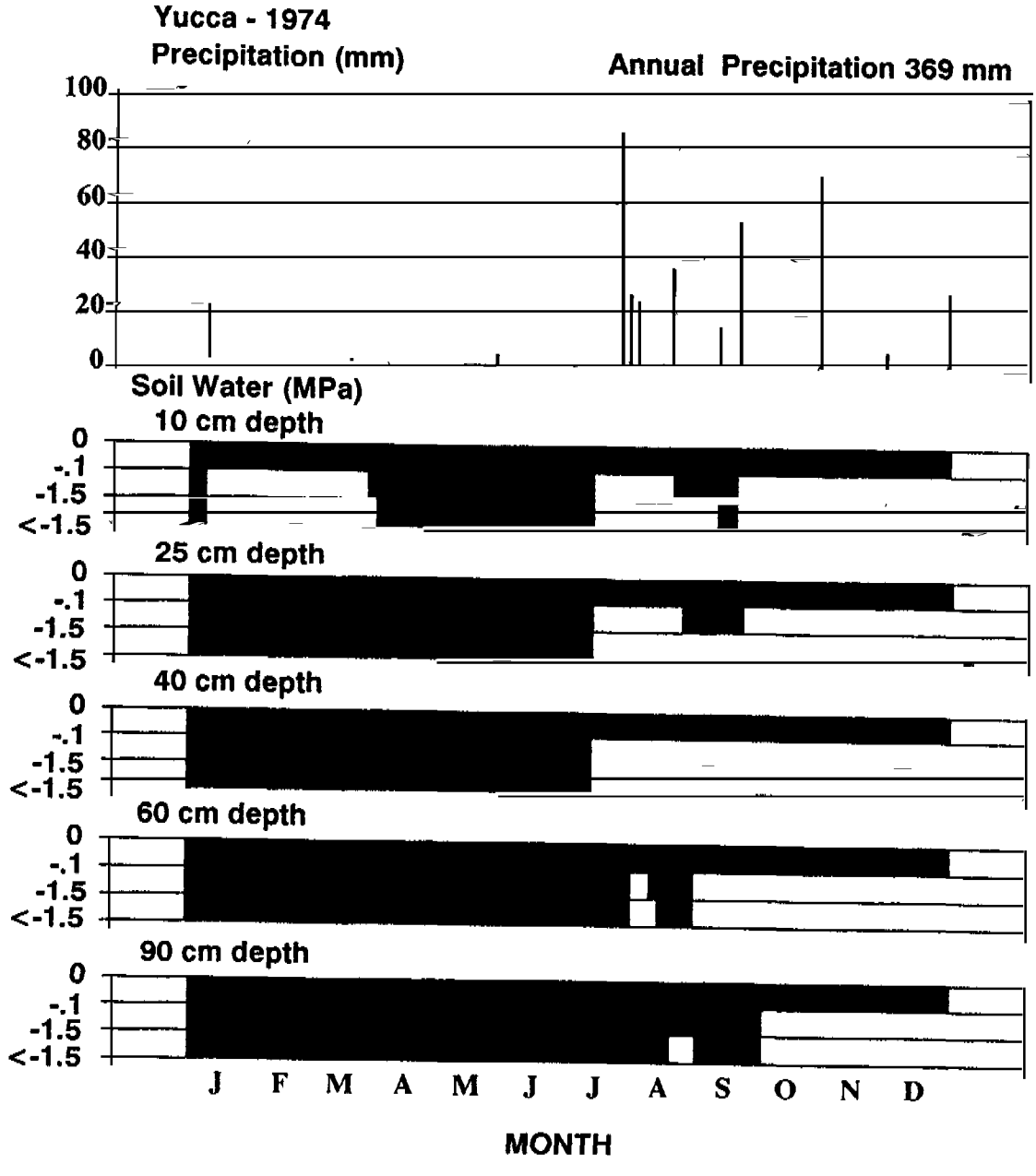


Figure 47. Annual precipitation (369 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1974.

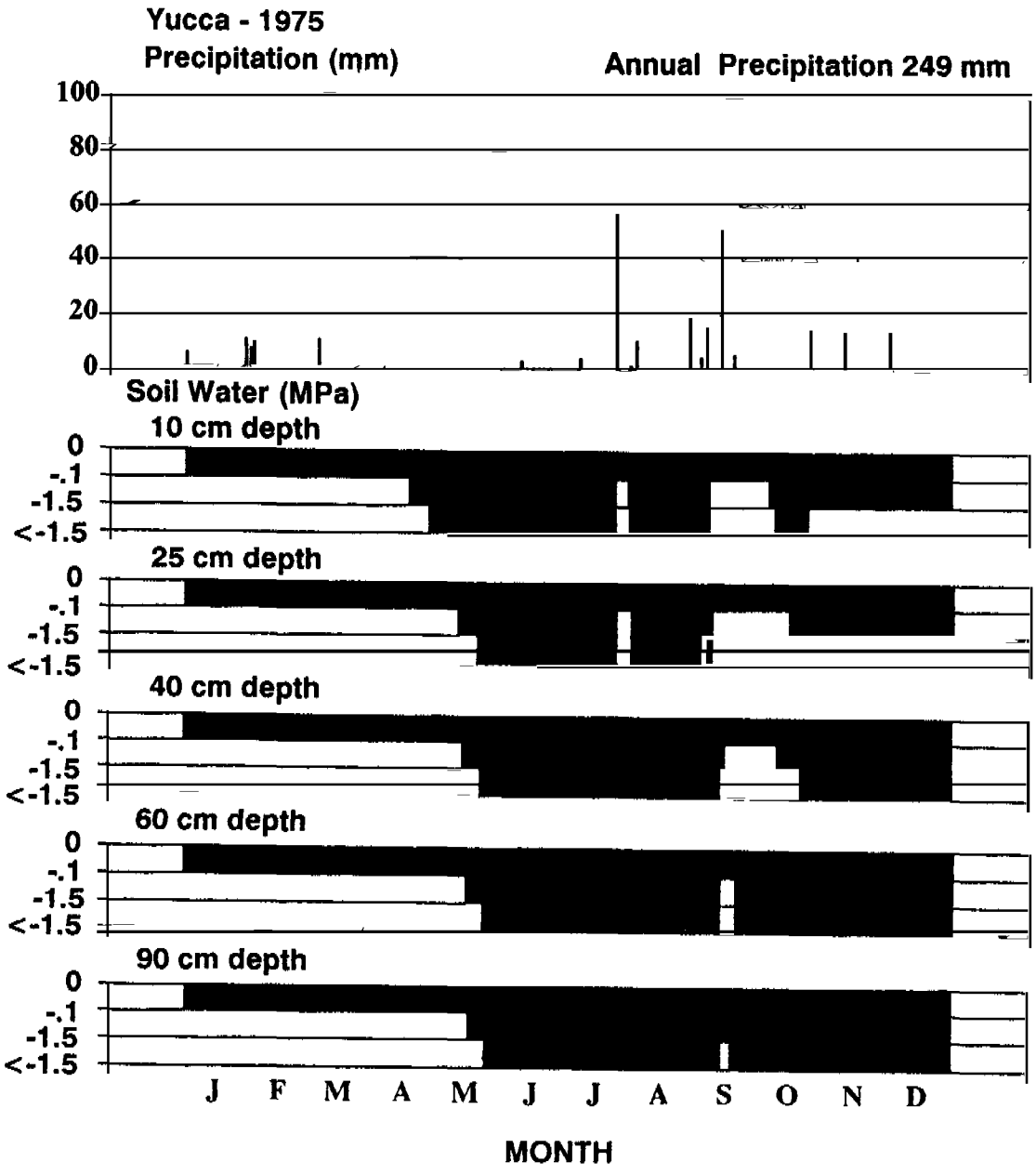


Figure 48. Annual precipitation (249 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1975.

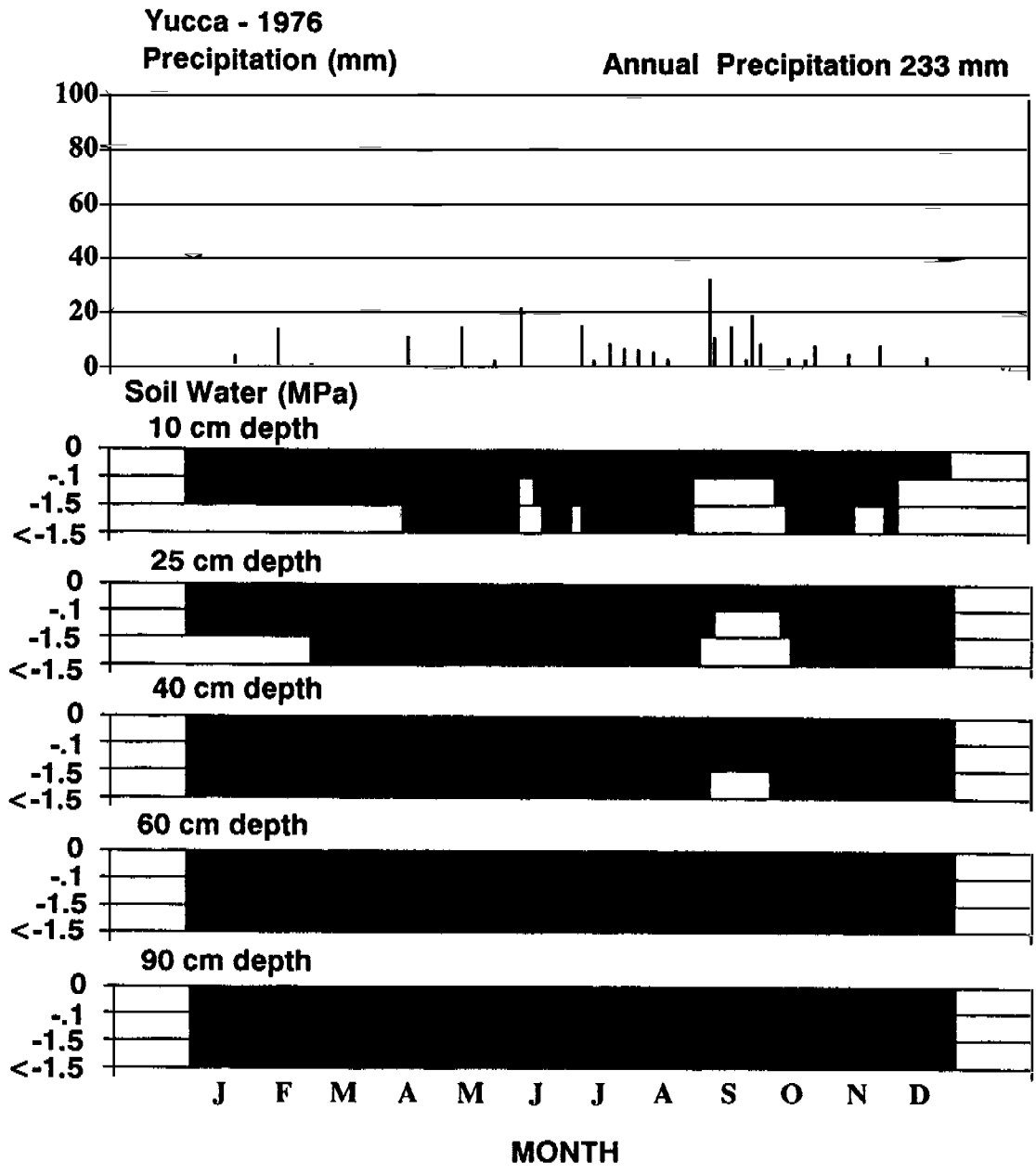


Figure 49. Annual precipitation (233 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Yucca site for 1976.

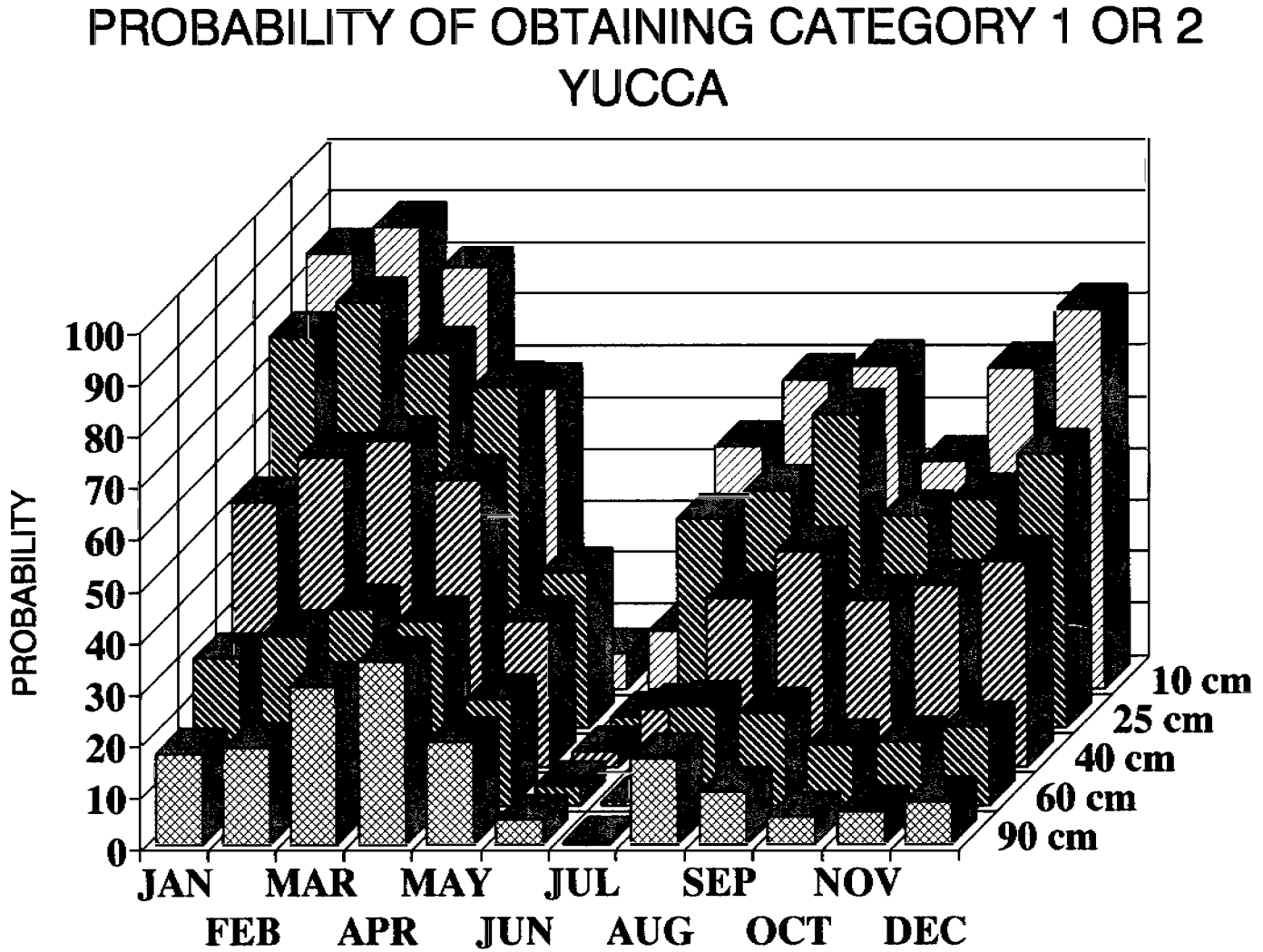


Figure 50. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 60, and 90 cm at the Yucca site.

Table 8. Characteristics of Petrocalcic Paleargids at sites H1-4 and C.

Horizon	Depth cm	Hue	Value/chroma Dry	Moist	Structure	Consistence Dry	Moist	Eff. with HCl	Textural class	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay < 0.002 mm	Organic C	$CaCO_3$
										%				
Hueco #1 (S90NM-013-002) at site H1														
C	0-11	5YR	5/4	4/4	ms,lfgr,sg	s,l	vfr	nc	s	89	5	7	0.17	
Eb	11-18	5YR	5/3	3.5/3	lfpl,lfgr, sg	s,l	vfr	nc	ls	86	7	7	0.21	
BEtb	18-26	5YR	5/5	3.5/5	lmsbk	sh	vfr	nc	ls	85	5	11	0.27	
Bt1b	26-35	5YR	5/6	4/5	lmsbk	sh	vfr	nc	ls	82	5	12	0.22	
Bt2b	35-50	5YR	5/6	4/5	lmsbk	sh	vfr	nc	ls	82	6	12	0.19	
Bt3b	50-71	5YR	5/5	4/4	lmsbk	sh	vfr	nc	fsl	81	7	12	0.16	
Btkb	71-84	6YR	5/4	4/4	lmsbk	sh	vfr	es	fsl	78	8	14	0.20	1
K2lmb	84-	7.5YR	8.4	7/4	(carbonate-cemented upper subhorizon of the petrocalcic horizon)								0.23	65
Hueco #2 (S90NM-013-003), at site H2														
C	0-11	5YR	5/4	4/4	ms,lfgr,sg	s,l	vfr	nc	s	89	4	7	0.15	TR
Eb	11-18	6YR	5/3	3.5/3	lmsbk	sh	fr	nc	ls	82	8	10	0.26	TR
Bt1b	18-29	5YR	5/5	3.5/5	lm,csbk	h,vh	fr	nc	ls	83	5	12	0.19	TR
Bt2b	29-41	5YR	5/5	4/5	lmsbk	h,vh	fr	nc	ls	83	5	12	0.17	TR
Btklb	41-53	5YR	5/5	4/5	lmsbk	h	fr	e	fsl	81	4	15	0.17	1
Btk2b	53-66	5YR	5.5/4	4/4	lf,msbk	sh,h	fr	es	fsl				0.24	4
K1b	66-76	5YR	5/4	4/4	lfgr	s	vfr	es	vgsl				0.21	80
K2lmb	76-80	7.5YR	8/2	7/3	(carbonate-cemented upper subhorizon of the petrocalcic horizon)								0.26	82
		7.5YR	9/2											
Hueco #3 at site H3														
C	0-5	7.5YR	6/4	5/4	sg,m	l,s	l,vfr	nc	s					
Eb	5-10	6YR	5.5/4	4.5/4	m	s	vfr	nc	fsl					
BEtb	10-23	5YR	5/4	4/4	m	sh	fr	nc	fsl					
Btb	23-36	5YR	5.5/4	4/4	m	sh,h	fr	nc	fsl					
Btkb	36-46	6YR	6/4	5/4	m	sl,h	fr	e,es	fsl					
BCkb	46-71	6YR	6.5/4	4.5/4	lmsbk	sh,h	fr	es	sl					
K1b	71-79	6YR	6/4	5/4	2fgr	l	l	es	sl					
		10YR	8/2	7/3										
K2lm	79-90	10YR	8/2	7/3	(carbonate-cemented upper subhorizon of the petrocalcic horizon)									
Hueco #4 (S90NM-013-005) at site H4														
A	0-5	5YR	5/6	3.5/6	lfpl,lfgr, sg	s,l	vfr,l	nc	s	89	2	9	0.28	TR
C	5-12	5YR	5/6	3.5/6	m	s	vfr	nc	s	89	2	9	0.11	TR
BAtkb	12-23	5YR	5.5/4	4/4	lcsbk	sh	fr	es	ls	81	4	15	0.18	2
Btklb	23-34	5YR	5.5/6	4/4	lf,msbk	sh	fr	es	ls	76	5	19	0.21	4
Btk2b	34-44	6YR	6/4	5/4	lf,msbk	sh,h	fr	es	fsl	76	4	20	0.16	4
		5YR	5/5											
Btk3b	44-57	5YR	5/6	4/6	lf,msbk	sh,h	fr	es	fsl	77	7	16	0.16	4
		5YR	6.5/4											
Kltb	57-67	7.5YR	8/3	7/4	2f,msbk	vh	fi	es	fsl	70	11	20	0.21	12
		5YR	5/4											
K2lmb	67-69	7.5YR	8/3	7/4	(carbonate-cemented upper subhorizon of the petrocalcic horizon)									
		7.5YR	9/2											
Cruces at site C														
C	0-7	7.5YR	6/4	4.5/4	m,sg	s,l	vfr,l	nc	s					
Eb	7-15	7.5YR	5/4	4/4	m	sh	fr	nc	ls					
Bt1b	15-26	5YR	5/4	4/4	m	sh	fr	nc	sl					
Bt2b	26-40	5YR	5.5/4	4.5/4	m	sh	fr	e,es	sl					
Klb	40-46	7.5YR	6/4	5/4	lfgr	l	vfr	es	vgsl					
K2lmb	46-50	7.5YR	9/2	8/2	(carbonate-cemented upper subhorizon of the petrocalcic horizon)									

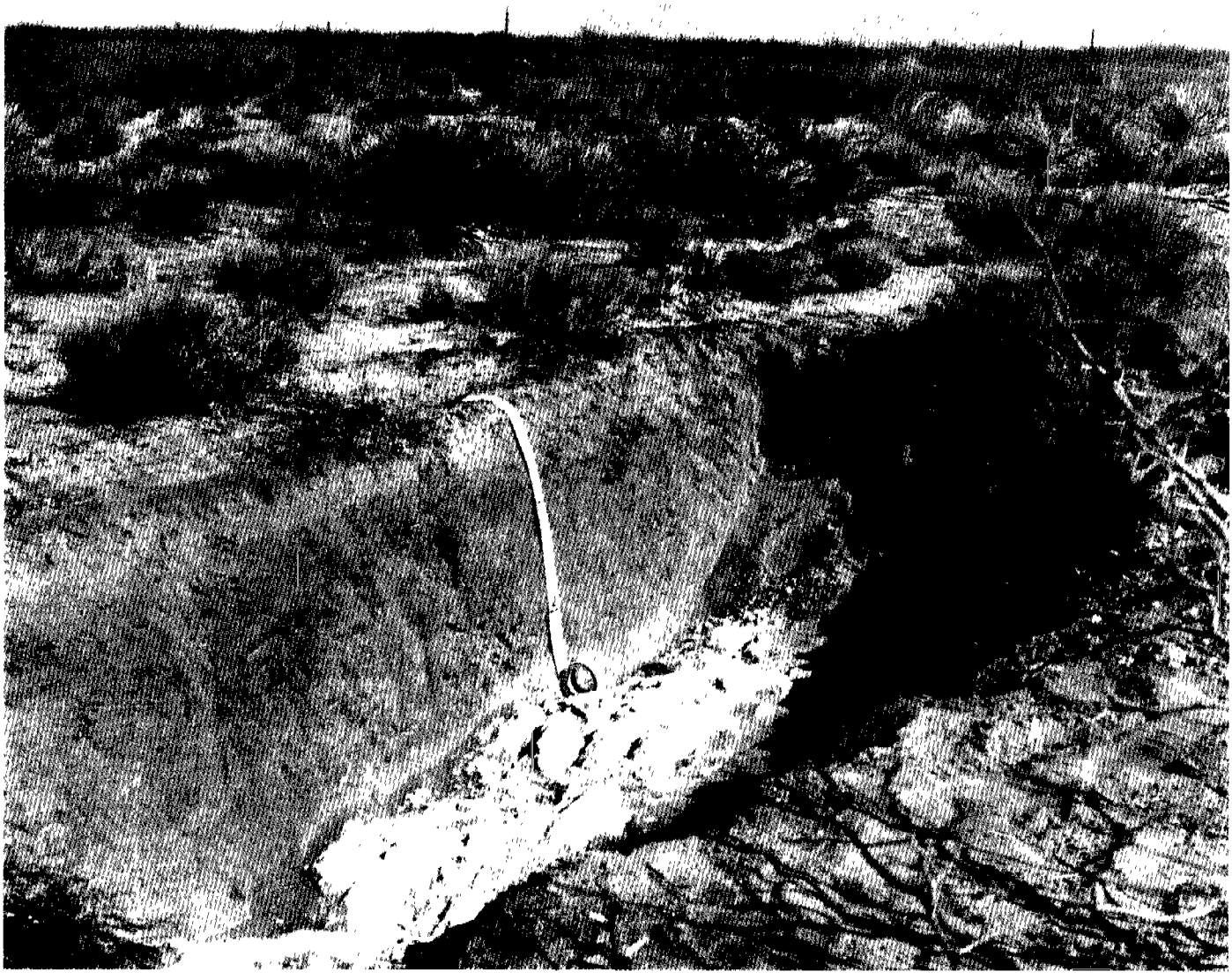


Figure 51. Landscape at Site H1 (fig. 4), and the Petrocalcic Paleargid Hueco #1, in Exclosure B on the Jornada Experimental Range. The San Andres Mountains are on the skyline. Photographed January 1990.

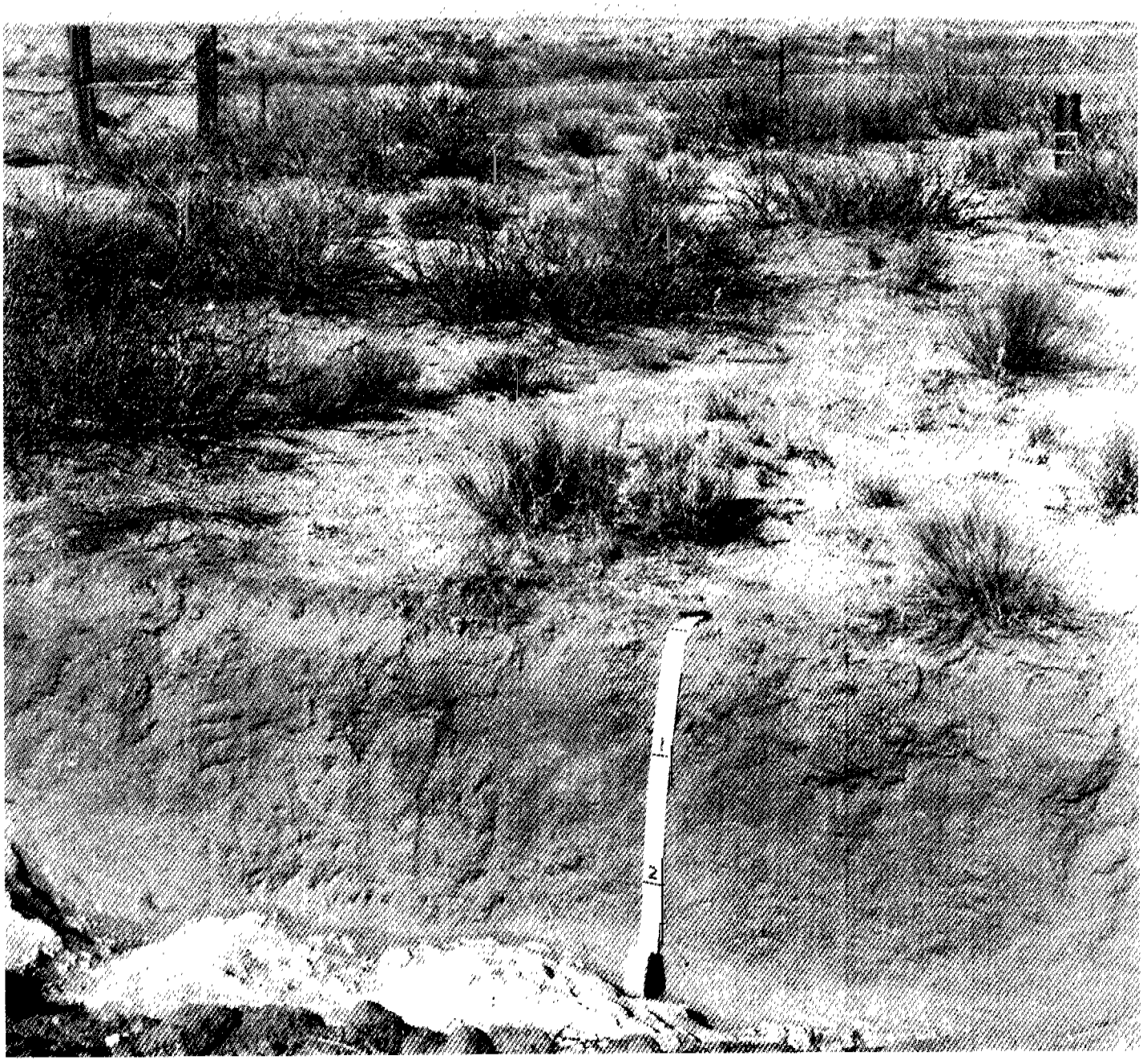


Figure 52. Profile of upper horizons of the Petrocalcic Paleargid Hueco #1. Stakes and wires to the soil water blocks are beyond the trench in center foreground. Note undulations in the top of the petrocalcic horizon. Scale is in feet.

USDA Soil Conservation Service
Pedon Narrative Description
Soil Series: Hueco
Classification: Coarse-loamy, mixed, thermic Petrocalcic Paleargid
NSSL ID#: 90P0493
Soil Survey #: S90NM-013-002
Location: The NW1/4SW1/4NW1/4 section 13, T.20S., R.1E., in Exclosure B on the Jornada Experimental Range. The northwest corner of Exclosure B is about 58 m south of the edge of the road to Headquarters. The sampled pedon is about 13 m south of the nonrecording rain gauge, and 0.7 m southwest of wires to the soil moisture blocks.
Elevation: 4345 ft, 1324 m
Landform: Nearly level basin floor
Geomorphic Surface: La Mesa
Par nt Material: Upper Camp Rice Formation (fluvial facies) sand
Vegetation: Snakeweed, mesquite, soaptree yucca, Mormon tea, and a very few clumps of dropseed, burrograss, and black grama
Described By: L.H. Gile
Date: Jan. 22, 1990

Soil surface: alternating areas of smooth crust and loose, thin sand.

C--0 to 11 cm; stratified reddish brown (5YR 5/4) sand; reddish brown (5YR 4/4) moist; massive but with horizontal cleavage to thin and medium lenses; generally soft, with some lenses separated by soft fine granules or loose, single grain material; soft and loose, very friable; few fine and medium roots; 90P2716; stratified; noncalcareous; abrupt wavy boundary.

Eb--11 to 18 cm; reddish brown (5YR 5/3) loamy sand; dark reddish brown (5YR 3.5/3) moist; weak fine and medium platy structure; slightly hard and soft, very friable; few fine and medium roots; 90P2717; noncalcareous; abrupt wavy boundary.

BEtb--18 to 26 cm; yellowish red (5YR 5/5) loamy sand; yellowish red (5YR 3.5/5) moist; weak medium subangular blocky structure; slightly hard, very friable; few fine and medium roots; 90P2718; sand grains coated with oriented clay; noncalcareous; abrupt wavy boundary.

Bt1b--26 to 35 cm; yellowish red (5YR 5/6) loamy sand; yellowish red (5YR 4/5) moist; weak medium subangular blocky structure; slightly hard, very friable; few fine and medium roots; 90P2719; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt2b--35 to 50 cm; yellowish red (5YR 5/6) loamy sand; yellowish red (5YR 4/5) moist; weak medium subangular blocky structure; slightly hard, very friable; very few fine roots; 90P2720; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt3b--50 to 71 cm; yellowish red (5YR 5/5) fine sandy loam; reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable; very few fine roots; 90P2721; sand grains coated with oriented clay; a few dark insect burrow fillings, commonly ranging from about 2 mm to 1 cm in diameter, and some being horizontally elliptical; noncalcareous; clear wavy boundary.

Btkb--71 to 84 cm; reddish brown (6YR 5/4) fine sandy loam; reddish brown (6YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable; very few fine roots; 90P2722; sand grains coated with oriented clay; a few dark burrow fillings, commonly ranging from about 2 mm to 1 cm in diameter, and some being horizontally elliptical; strongly effervescent; abrupt wavy boundary.

K21mb--84 to 88 cm; breaks out with hammer as roughly platy units consisting of a surficial laminar horizon and an attached plugged horizon; laminar horizons dominantly pink (7.5YR 8/4) or pink (7.5yr 7/4) moist with some pink (7.5YR 7/4, dry); attached plugged horizon is dominantly pink (7.5YR 7.5/4) or light brown (7.5YR 6.5/4) moist, with some white (7.5YR 9/2 dry and moist) occurring as crack fillings; extremely hard and firm; no roots; 90P2723; strongly effervescent.

Soil series: HUECO COARSE-LOAMY, MIXED, THERMIC PETROCALCIC PALEARGID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 493, SAMPLES 90P2716-2725
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CO3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SILT VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS(MM) WEIGHT 2 -5	5 -20	20 -75	.1-75	>2MM WT PCT OF WHOLE SOIL
			<- - - - - - - - - - - PCT OF <2MM (3A1) - - - - - - - - - - ->												<- PCT OF <75MM(3B1)->				
90P2716S	0- 11	C	6.5	5.0	88.5			1.5	3.5	16.0	42.5	27.7	2.2	0.1	--	--	--	72	--
90P2717S	11- 18	EB	7.4	7.0	85.6			2.0	5.0	17.0	41.8	23.8	2.7	0.3	TR	--	--	69	--
90P2718S	18- 26	BET8	10.8	4.7	84.5			1.8	2.9	10.9	37.5	30.1	5.6	0.4	--	--	--	74	--
90P2719S	26- 35	BT1B	12.2	5.4	82.4			1.7	3.7	12.4	38.5	26.2	4.8	0.5	--	--	--	70	--
90P2720S	35- 50	BT2B	11.8	6.0	82.2			1.9	4.1	15.6	38.0	24.0	3.9	0.7	TR	TR	--	67	TR
90P2721S	50- 71	BT3B	11.9	7.1	81.0		0.3	2.1	5.0	12.8	35.2	25.6	6.2	1.2	TR	--	--	68	TR
90P2722S	71- 84	BTKB	14.1	8.1	77.8		1.1	2.8	5.3	13.6	34.4	22.9	5.3	1.6	1	TR	--	65	1
90P2723S	84- 88	K21MB	9.0	14.0	77.0	2.5		6.9	7.1	5.3	14.9	16.5	16.2	24.1	TR	TR	--	72	TR
															--	--	--		--
															--	--	--		--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B3a <2MM	EXTR P 6S3 PPM	EXTR S 6R3a	DITH-CIT EXTRACTABLE FE 6C2b	AL 6G7a	MN 6D2a	RATIO/CLAY CEC 15 BAR 8D1	8D1	ATTERBERG LL 4F1	PI 4F	BULK DENSITY FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
	PCT			<- PERCENT OF <2MM -->						PCT	<0.4MM	<- - G/CC - - ->			CM/CM	<- - -PCT OF <2MM - ->				CM/CM
0- 11	0.17							0.80	0.35										2.3	
11- 18	0.21							0.85	0.36										2.7	
18- 26	0.27							0.72	0.33										3.6	
26- 35	0.22							0.77	0.37				1.73	1.83	0.016			17.0	4.5	0.22
35- 50	0.19							0.75	0.37				1.59	1.80	0.014			21.0	4.4	0.26
50- 71	0.16							0.69	0.38				1.65	1.72	0.014			6.9	4.5	0.04
71- 84	0.20							0.60	0.38										5.3	
84- 88	0.23							0.43	1.23					1.98					11.1	

AVERAGES, DEPTH 18- 68: PCT CLAY 12 PCT .1-75MM 69

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA 5B5a 6N2a	MG 5B5a 6O2d	NA 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACIDITY 6H5a	CEC SUM CATS 5A3a	CEC NH4-OAC 5A8b	EXCH NA 5B5b PCT	SAR 5E	BASE SATURATION SUM 5C3	BASE SATURATION NH4OAC 5C1	CARBONATE AS CACO3 <2MM 6E1g	CARBONATE AS CACO3 <20MM 6E4	CASO4 AS GYPSUM <2MM 6F1a	CASO4 AS GYPSUM <20MM 6F4	PH SAT PASTE 8C1b	PH CACL2 .01M 8C1f 1:2	PH H2O 8C1f 1:1
	<- - - - - - - - -MEQ / 100 G - - - - - - - - - ->								PCT		<- -PCT- >		<- -PCT ->		<- -PCT ->				
0- 11	4.0	1.0	0.1	0.5	5.6	0.2	5.8	5.2	3		97	100	--					6.8	7.2
11- 18	6.2	0.9	TR	0.5	7.6	0.4	8.0	6.3	1		95	100	--					7.0	7.3
18- 26	7.6	1.1	--	0.6	9.3	--	9.3	7.8	TR		100	100	--					7.4	7.7
26- 35	8.4	1.4	--	0.6	10.4	--	10.4	9.4	TR		100	100	--					7.4	7.7
35- 50	8.0	1.5	TR	0.5	10.0	--	10.0	8.8	TR		100	100	--					7.4	8.1
50- 71	7.9	1.6	--	0.4	9.9		9.9	8.2	TR		100	100	--					7.5	8.0
71- 84		2.3	0.1	0.5				8.5	1		100	100	1					7.7	8.0
84- 88	41.0	1.6	0.1	0.1	42.8	--	42.8	3.9	1	1	100	100	65				7.9	7.9	8.2

DEPTH (CM)	WATER EXTRACTED FROM SATURATED PASTE CA 6N1b	MG 6O1b	NA 6P1b	K 6Q1b	CO3 6I1b	HCO3 6J1b	CL 6K1c	SO4 6L1c	NO3 6M1c	H2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A3a MMHOS /CM
	<- - - - - - - - - -MEQ / LITER - - - - - - - - - ->									<- -PCT ->		
0- 11												0.07
11- 18												0.07
18- 26												0.14
26- 35												0.13
35- 50												0.13
50- 71												0.14
71- 84												0.18
84- 88	3.3	1.0	0.8	0.1	--	2.2	0.8	1.8	--	42.9	TR	0.53

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 1, 2, 3, 4, 5, 6, 7,

ANALYSES: S* ALL ON SIEVED <2mm BASIS

and the argillic horizon. Hueco #1 is on La Mesa geomorphic surface of middle Pleistocene age (table 2), and has formed in sandy fluvial sediments of the Camp Rice Formation. The prominent petrocalcic horizon is characteristic of soils in nongravelly sediments of La Mesa age (see study areas 5 and 6, Gile et al., 1981). The area is level.

The gradual increase in the carbonate stages with depth that occurred at sites O and Y is not present here. In contrast, beneath the thick (71 cm) noncalcareous zone, a thin horizon of stage I filaments extends only from 71-84 cm depth and rests abruptly on the petrocalcic horizon. The petrocalcic horizon is the most prominent horizon in the soil (fig. 52, table 8) and has the extreme values for the properties of cementation, hardness, and carbonate content. The surface of the petrocalcic horizon has distinct undulations and its upper part has pisoliths characteristic of stage V morphology (Birkeland et al., 1991).

Several factors indicate that site H1 is a very stable site. Landscape instability in these ancient soils with petrocalcic horizons is indicated by evidence of strong erosion or other cause that results in marked thinning of materials above the petrocalcic horizon, and/or mixing of the horizons above it. Such thinning and mixing are generally indicated by calcrete fragments on the surface and above the petrocalcic horizon that were derived from fracture of upper horizons of the petrocalcic horizon and subs quent movement of the fragments upward in the soil (for further discussion of this, see p. 69 and 70 in Gile et al., 1981; see also site C, discussed later, for illustration of a less stable surface). Such calcrete fragments are almost totally absent from the soil above the petrocalcic horizon at this site, there only being a very few that rest on top of it.

The absence of evidence of such mixing in the soil is also reflected by the thick (71 cm) noncalcareous zone, which indicates quite uniform descent of the wetting front and its relatively common penetration to the petrocalcic horizon. This is supported by the wetting pattern shown by the soil water data (figs. 53-72), which indicates that the uppermost subhorizon of the petrocalcic horizon is forming at the present time.

Soil Water, Precipitation, and Yields. The gypsum impregnated resistance blocks were installed in three replications within a rodent exclosure at Exclosure B at soil depths of 10, 25, and 40 cm on August 13, 1957, and at the 60- and 81-cm depths on July 28, 1959. The rain gauge was installed April 15, 1958. Estimates of precipitation until this date were obtained from Hueco #2 which is about 1.6 km from Hueco #1. The rodent exclosure was 38 x 46 m. The perennial grasses on 15, 5-cm x 30.5-m transects were clipped to ground level each fall beginning in 1959. The grass stand in this area was a mixture of black grama and mesa dropseed.

The moisture control section (25-cm depth) had soil water >1.5 MPa August 13, 1957-May 26, 1958 (figs. 53, 54); August 25-September 10; and September 19, 1958-April 6, 1959 (figs. 54, 55). Rainfall of 60 mm on September 13, 1958 and subsequent rainfall in September and October were prominent factors in the soil water

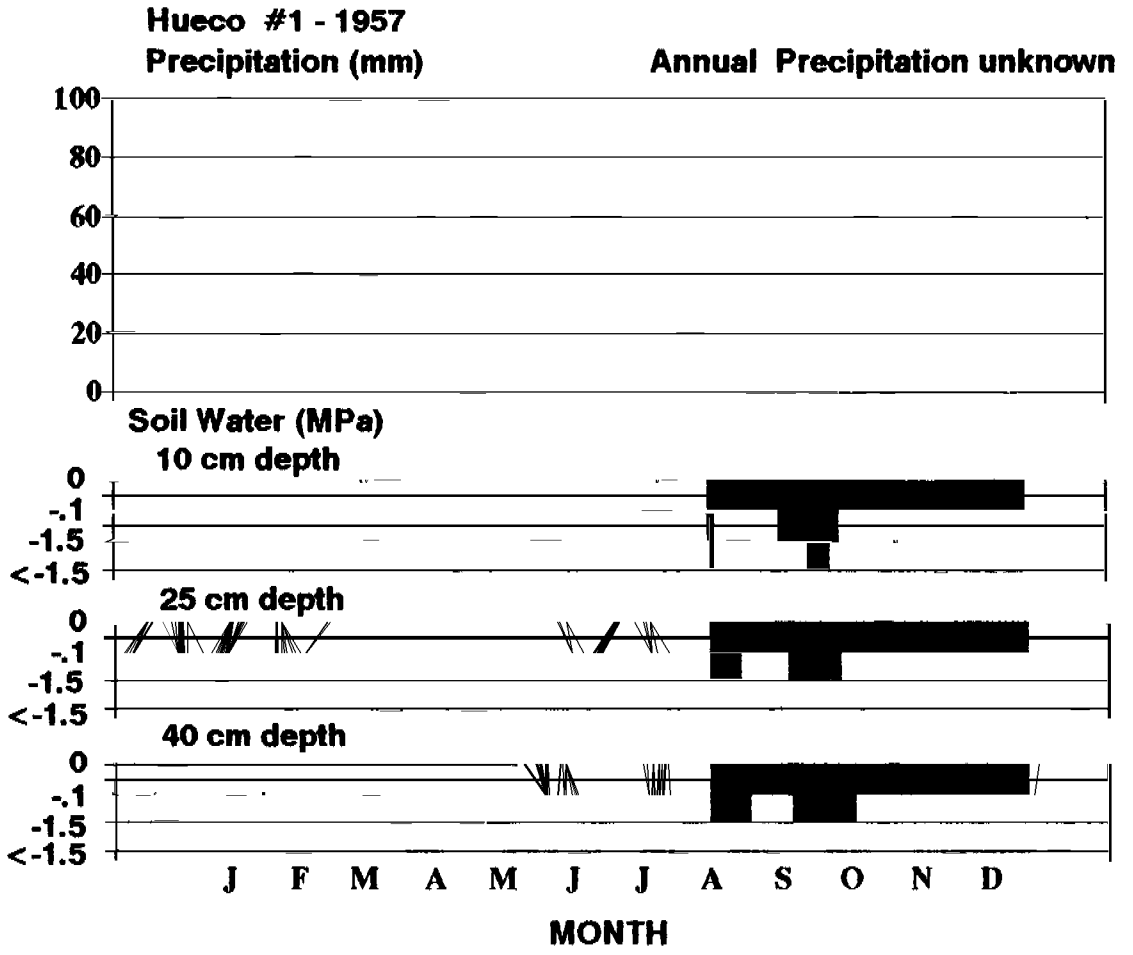


Figure 53. The matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for the Hueco #1 site for August 13-December 31, 1957. No estimates of precipitation were available.

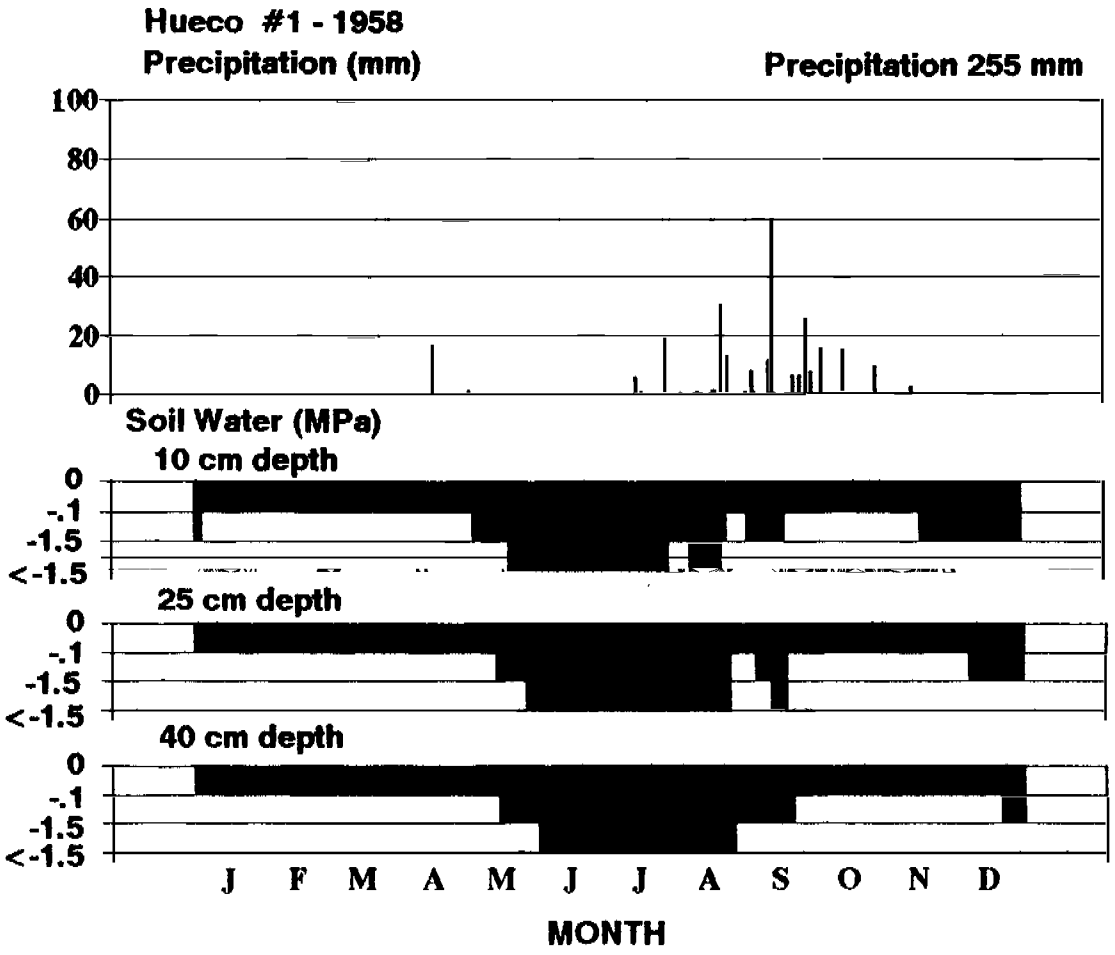


Figure 54. Total precipitation (255 mm) and daily precipitation (mm) for April 15-December 31, 1958, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for 1958 at the Hueco #1 site.

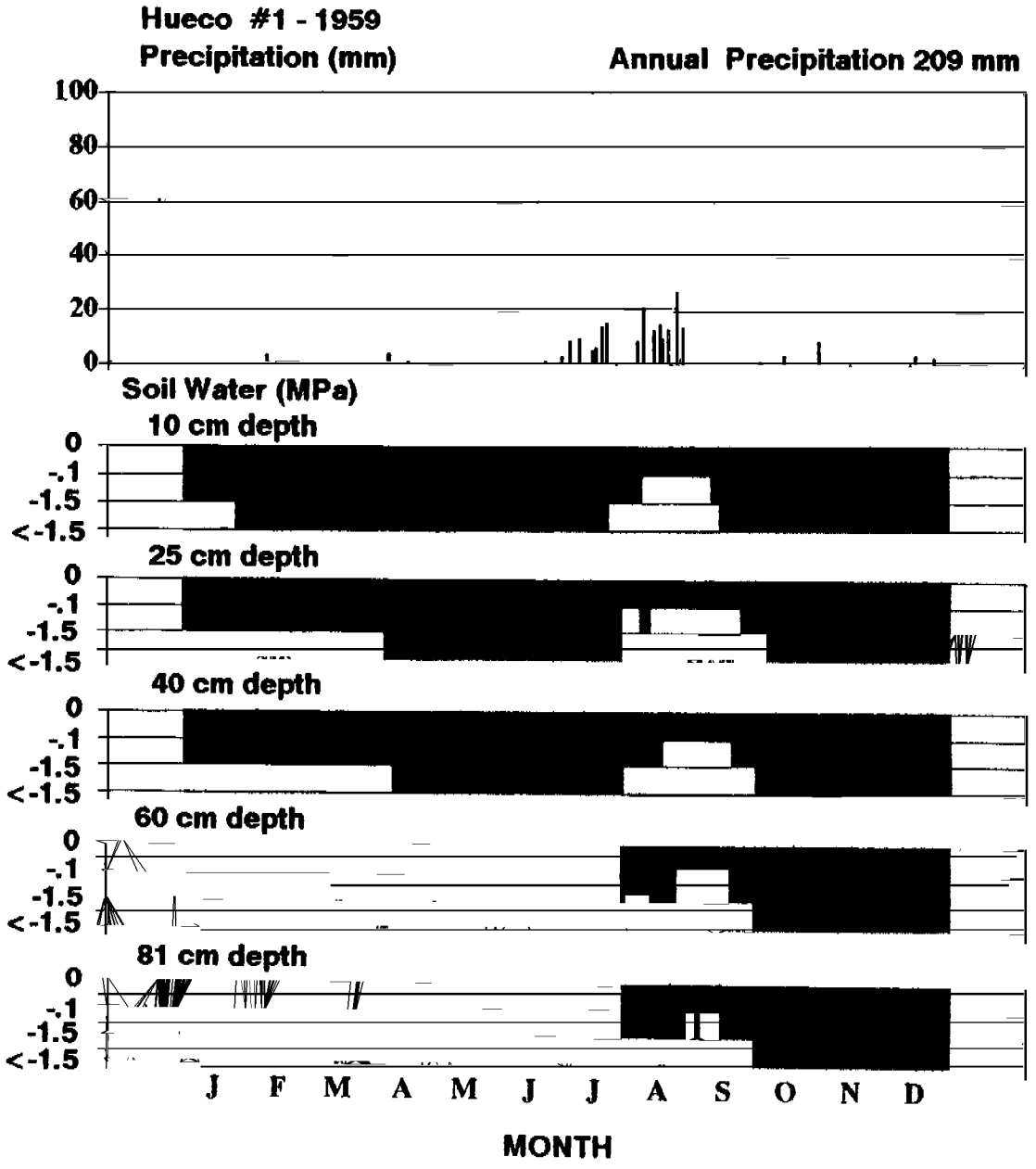


Figure 55. Annual precipitation (209 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Hueco #1 site for 1959. Also shown is the soil water at depths of 60 and 81 cm July 28-December 31, 1959.

status in the fall and winter of 1958-59. Smaller, but more frequent, amounts of rainfall in early summer 1959 resulted in soil water >-1.5 MPa at the 25-cm depth July 29-October 5 (fig. 55). The production of perennial grasses was 471 kg/ha (s.e.=47 kg/ha) in 1959.

The fall and winter of 1959 and most of 1960 were quite dry. Perennial grasses yielded 76 kg/ha (s.e.=18 kg/ha) in 1960. Precipitation of 32 mm on December 11, 1960 along with smaller amounts later in December and in January gave soil water >-1.5 MPa at the 25-cm depth December 16, 1960-June 12, 1961 (figs. 56, 57). Light rainfall in July, 1961 resulted in soil water >-1.5 MPa at depths of 10, 25, and 40 cm but 65 mm on August 12 wet the entire profile. Production of perennial grasses was 277 kg/ha (s.e.=48 kg/ha) in 1961. Yields in 1961 were somewhat reduced because of droughty conditions in 1960.

Soil water at a depth of 25 cm was >-1.5 MPa continuously July 10, 1961-May 18, 1962 (figs. 57, 58). Summer soil water >-1.5 MPa at the 25-cm depth occurred July 3-August 29, 1962 (fig. 58). Yields of perennial grasses averaged 356 kg/ha (s.e.=46 kg/ha) in 1962. There was soil water >-1.5 MPa at 25 cm September 27, 1962-May 7, 1963 (figs. 58, 59); September 5-26; and October 24-November 3, 1963. Perennial grasses yielded 82 kg/ha (s.e.=13 kg/ha) in 1963. The annual precipitation was only 101 mm (fig. 59).

Annual precipitation was also below average 1964-67. Soil water was >-1.5 MPa at the 25-cm depth July 13-September 6 (fig. 60); September 13-October 11, 1964; July 5-22, 1965 (fig. 61); September 19-24; February 9-May 6, 1966 (fig. 62); August 3-4; September 13-October 4, 1966; June 30-July 25, 1967 (fig. 63); and August 25-October 14, 1967. With the exception of a few days in 1964 and 1966, soil water was <-1.5 MPa at the 60- and 81-cm depths. Perennial grasses yielded 207 kg/ha (s.e.=29 kg/ha) in 1964, 163 kg/ha (s.e.=25 kg/ha) in 1965, 401 kg/ha (s.e.=69 kg/ha) in 1966, and 231 kg/ha (s. e.=52 kg/ha) in 1967. The year 1966 is the only one that had winter and early spring soil water >-1.5 MPa at the 25-cm depth (fig. 62).

The annual precipitation in 1968 was above average. There was soil water >-1.5 MPa at the 25-cm depth December 21, 1967-May 20, 1968 (figs. 63, 64); July 5-27; August 5-22; and August 29-September 27, 1968. The yield of perennial grasses averaged 342 kg/ha (s.e.=58 kg/ha).

Annual precipitation for 1969-70 was below average. Soil water was >-1.5 MPa at the 25-cm depth December 27, 1968-May 11, 1969 (figs. 64, 65); July 9-August 1; October 22, 1969-May 5, 1970 (figs. 65, 66); July 24-August 27; and October 6-November 14, 1970. Perennial grasses yielded 190 kg/ha (s.e.=47 kg/ha) in 1969 and 208 kg/ha (s.e.=40 kg/ha) in 1970. Both years had soil water >-1.5 MPa at the 10-, 25-, and 40-cm depths during the winter and early spring (also the 60-cm depth in 1970); only a few days of soil water >-1.5 MPa during the summer; and largely dry conditions at the 60- and 81-cm depths (figs. 65, 66).

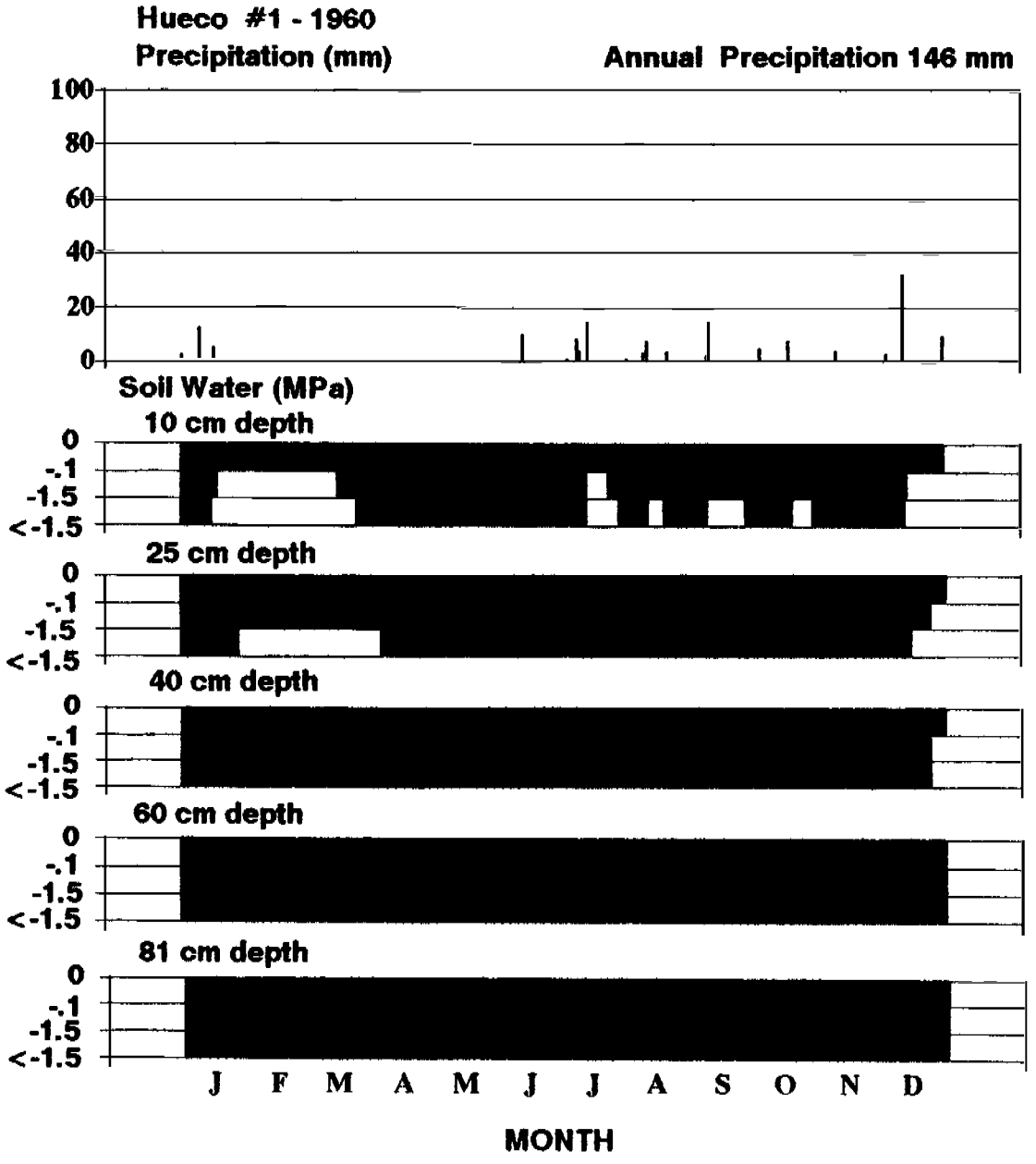


Figure 56. Annual precipitation (146 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1960.

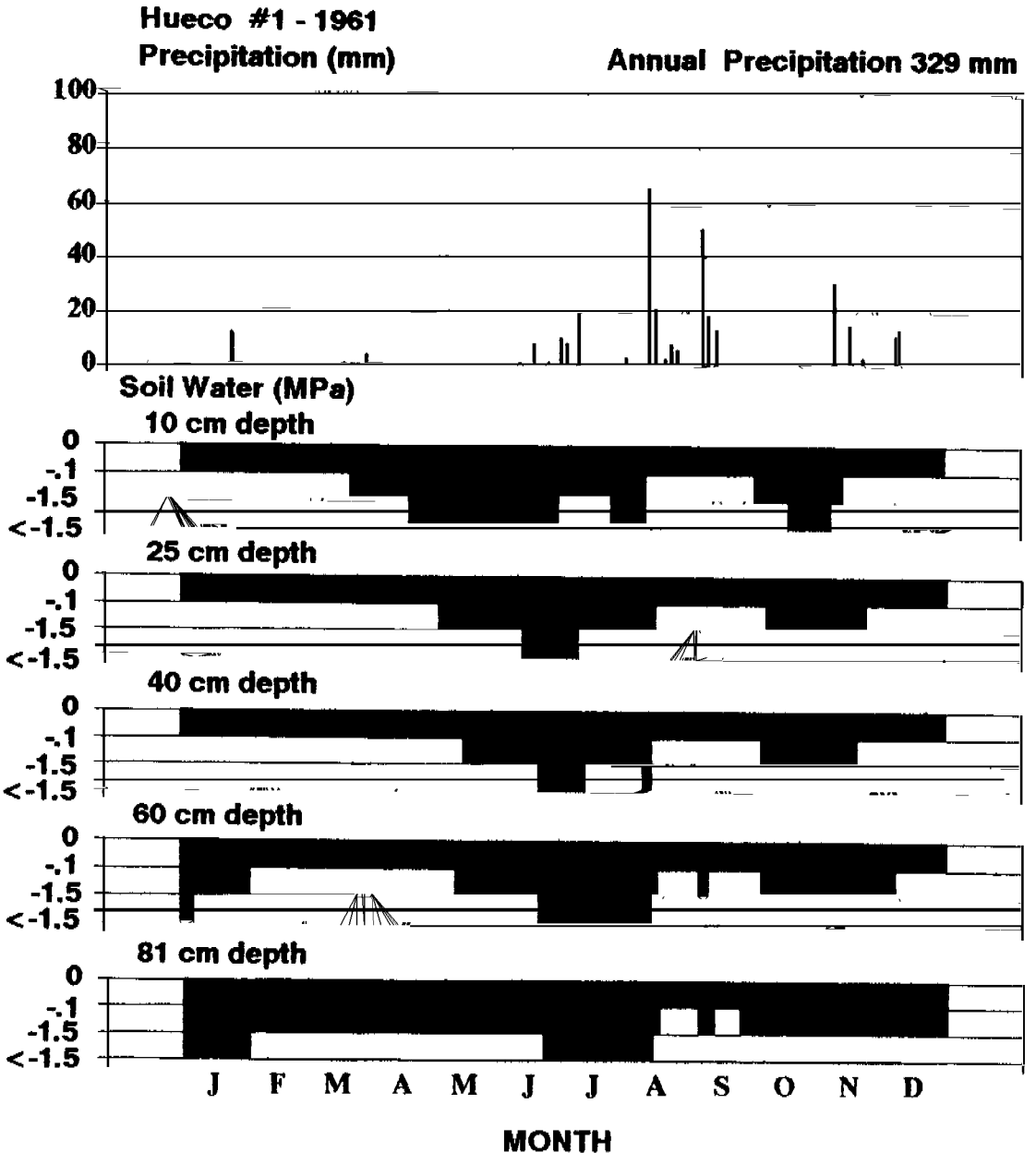


Figure 57. Annual precipitation (329 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1961.

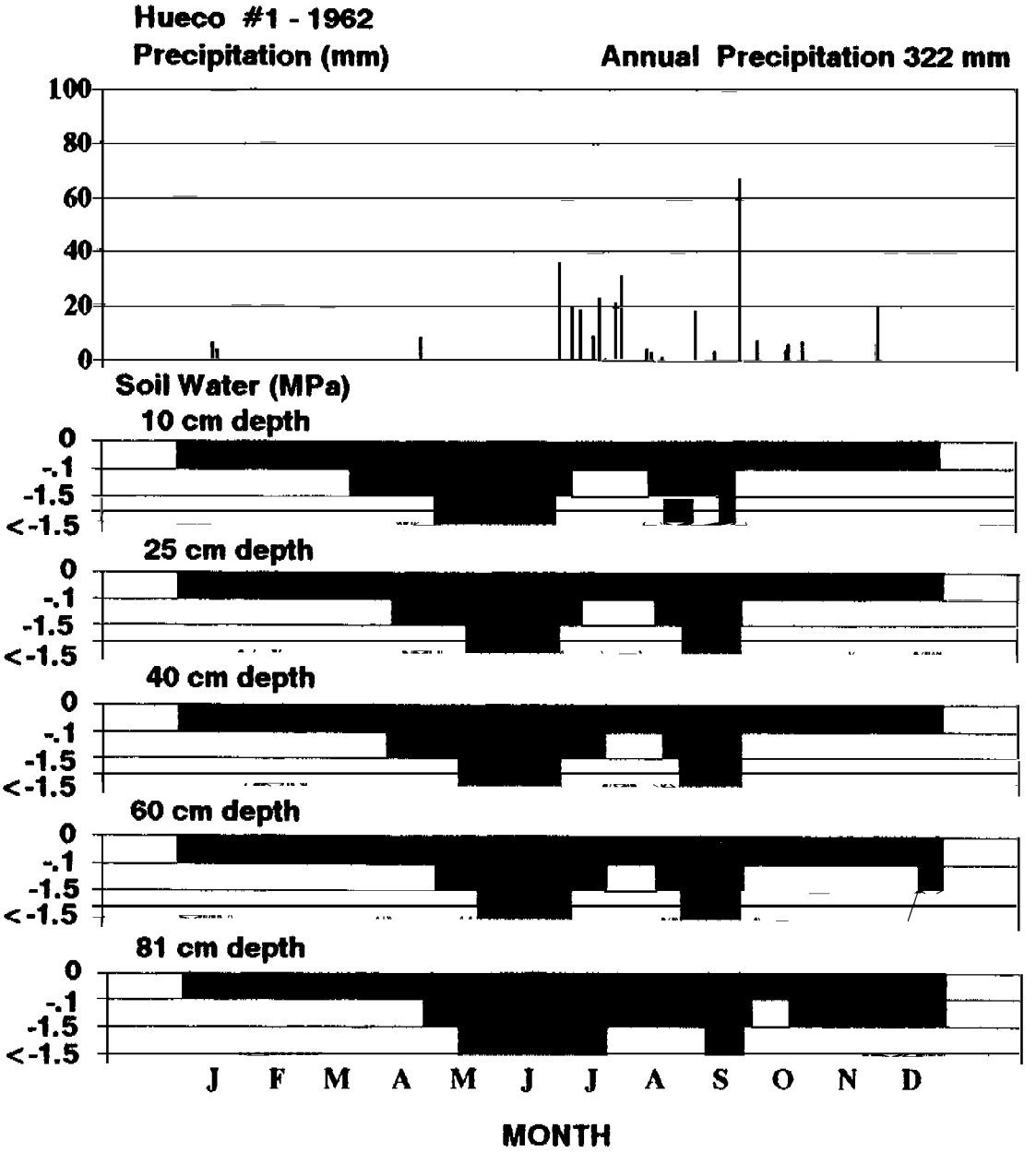


Figure 58. Annual precipitation (322 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1962.

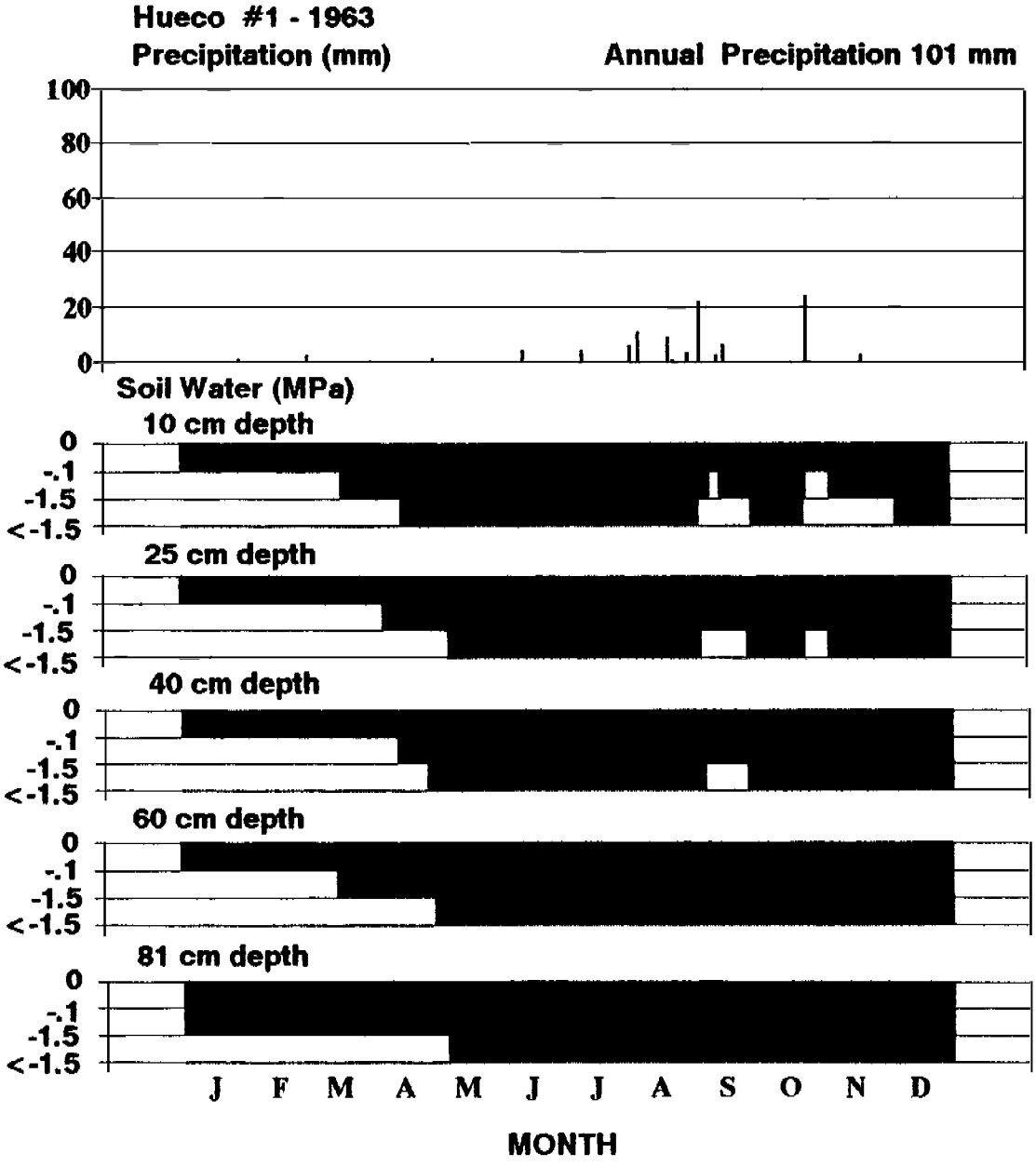


Figure 59. Annual precipitation (101 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1963.

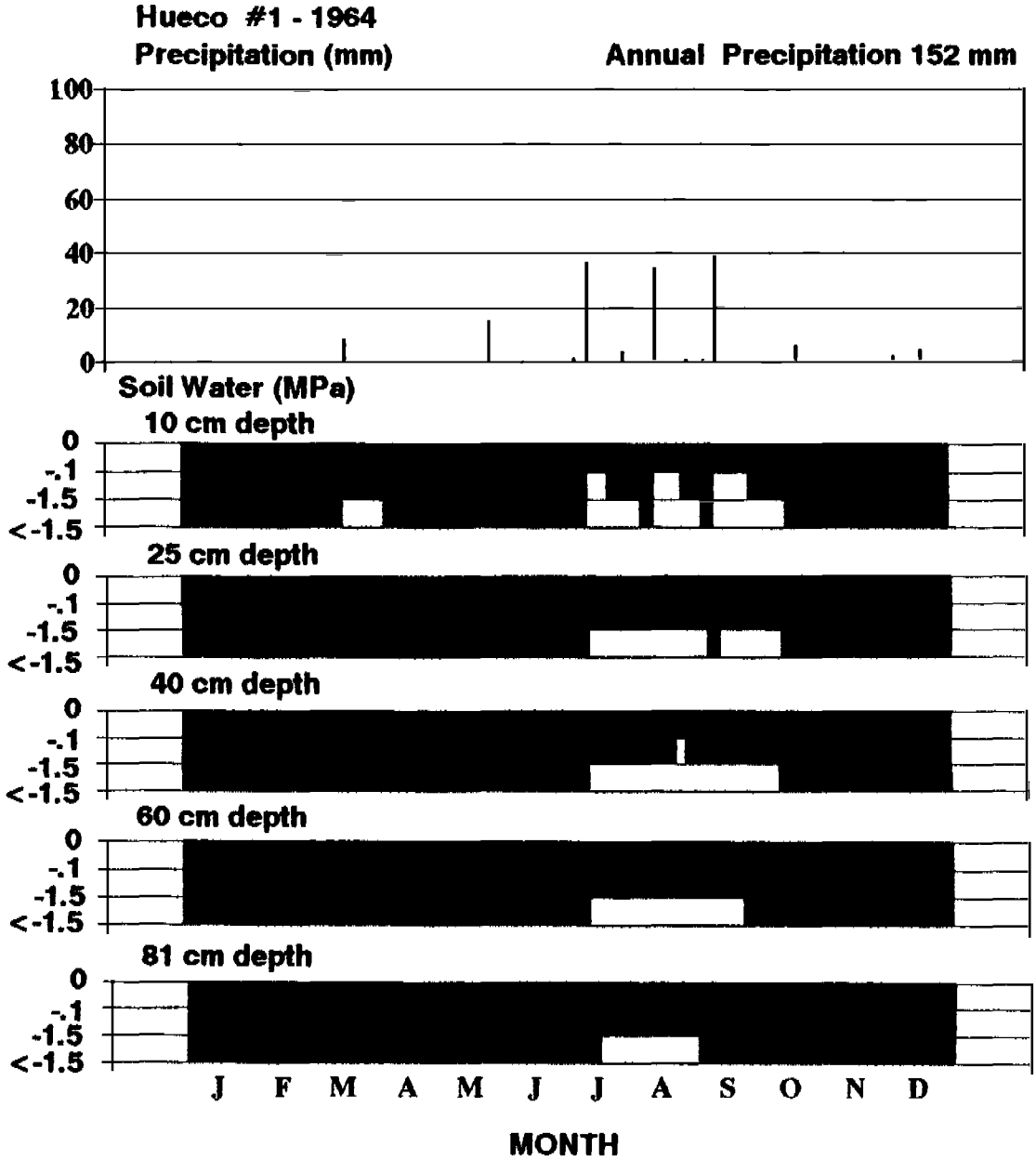


Figure 60. Annual precipitation (152 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1964.

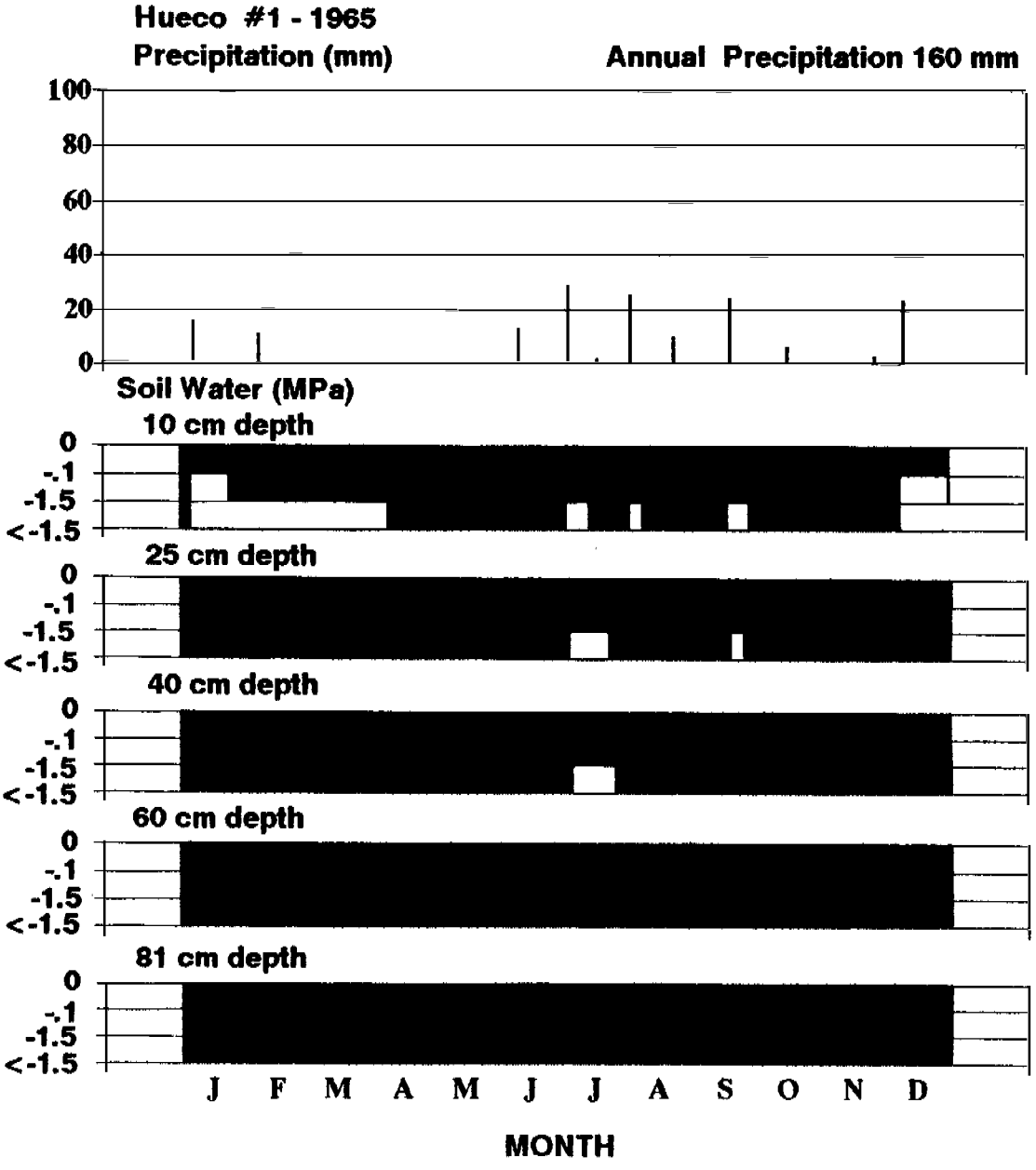


Figure 61. Annual precipitation (160 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1965.

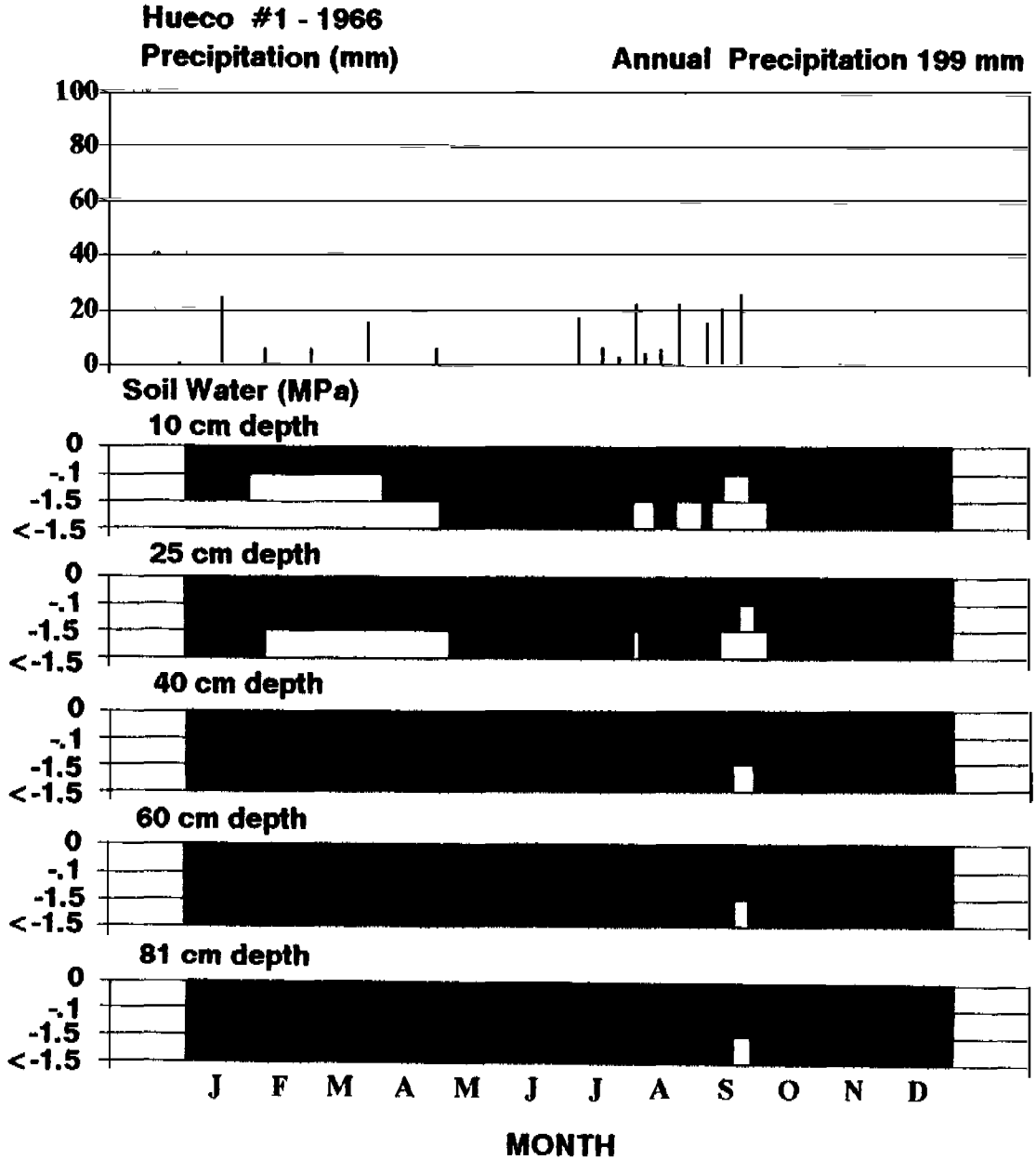


Figure 62. Annual precipitation (199 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1966.

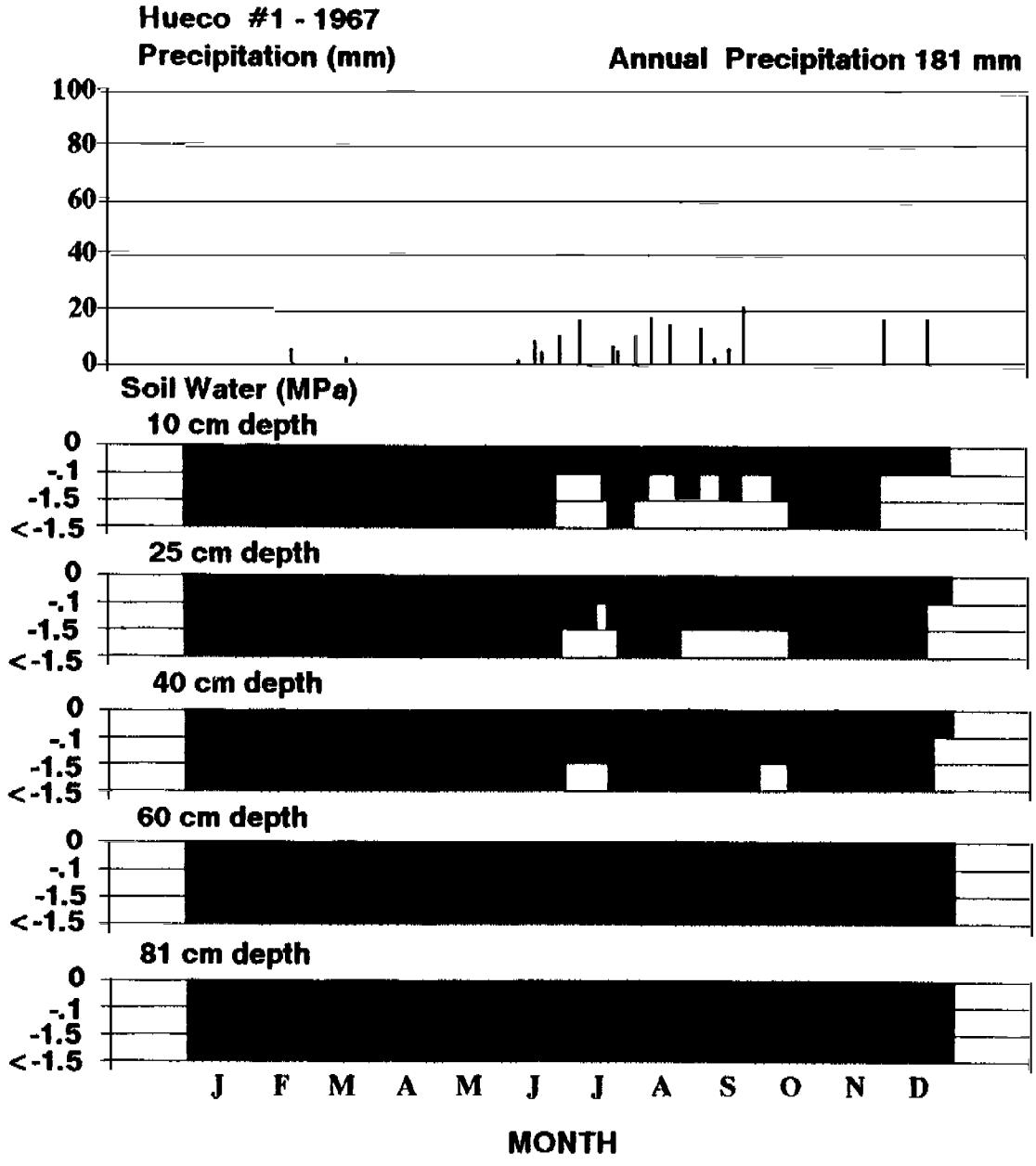


Figure 63. Annual precipitation (181 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1967.

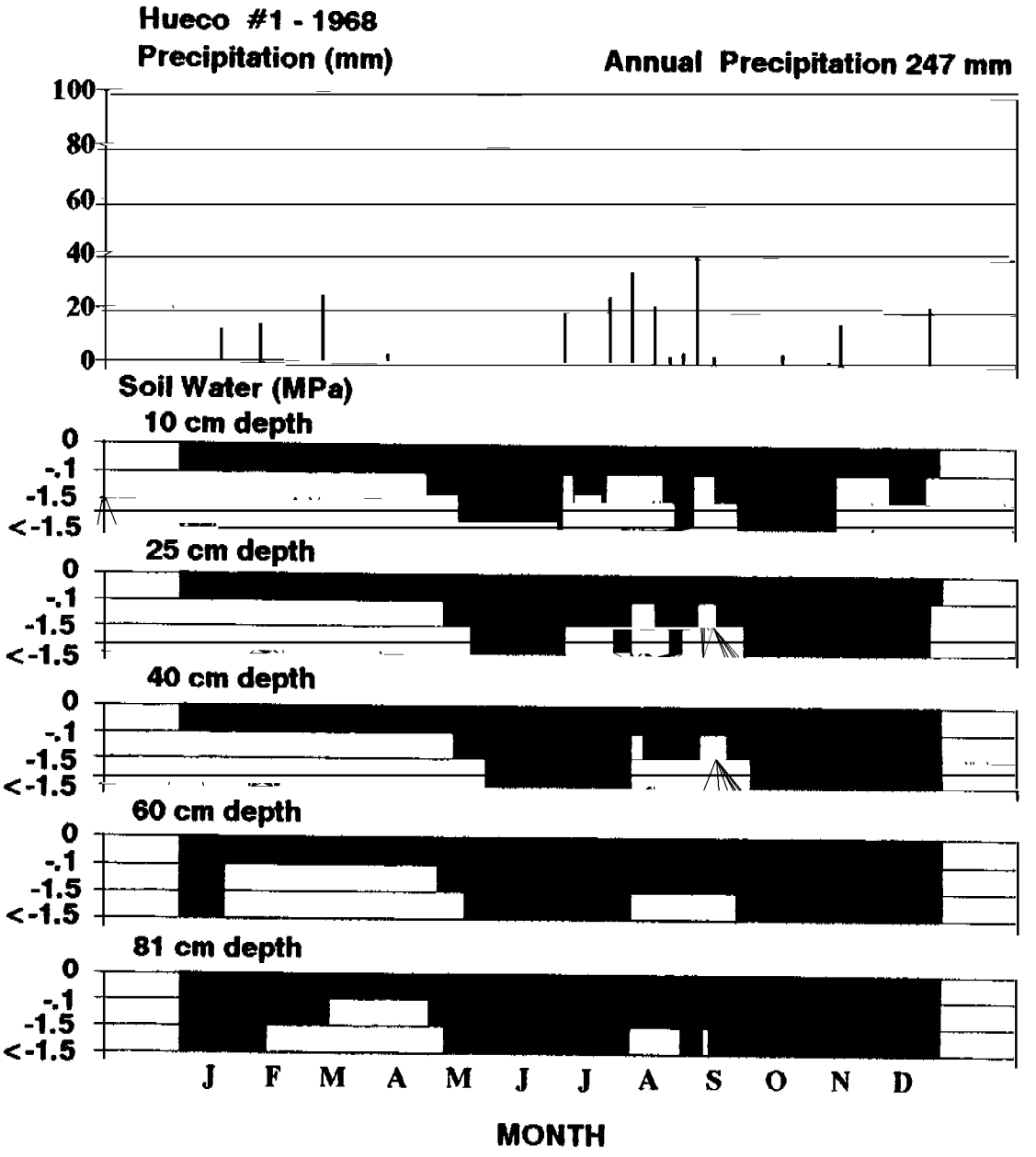


Figure 64. Annual precipitation (247 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1968.

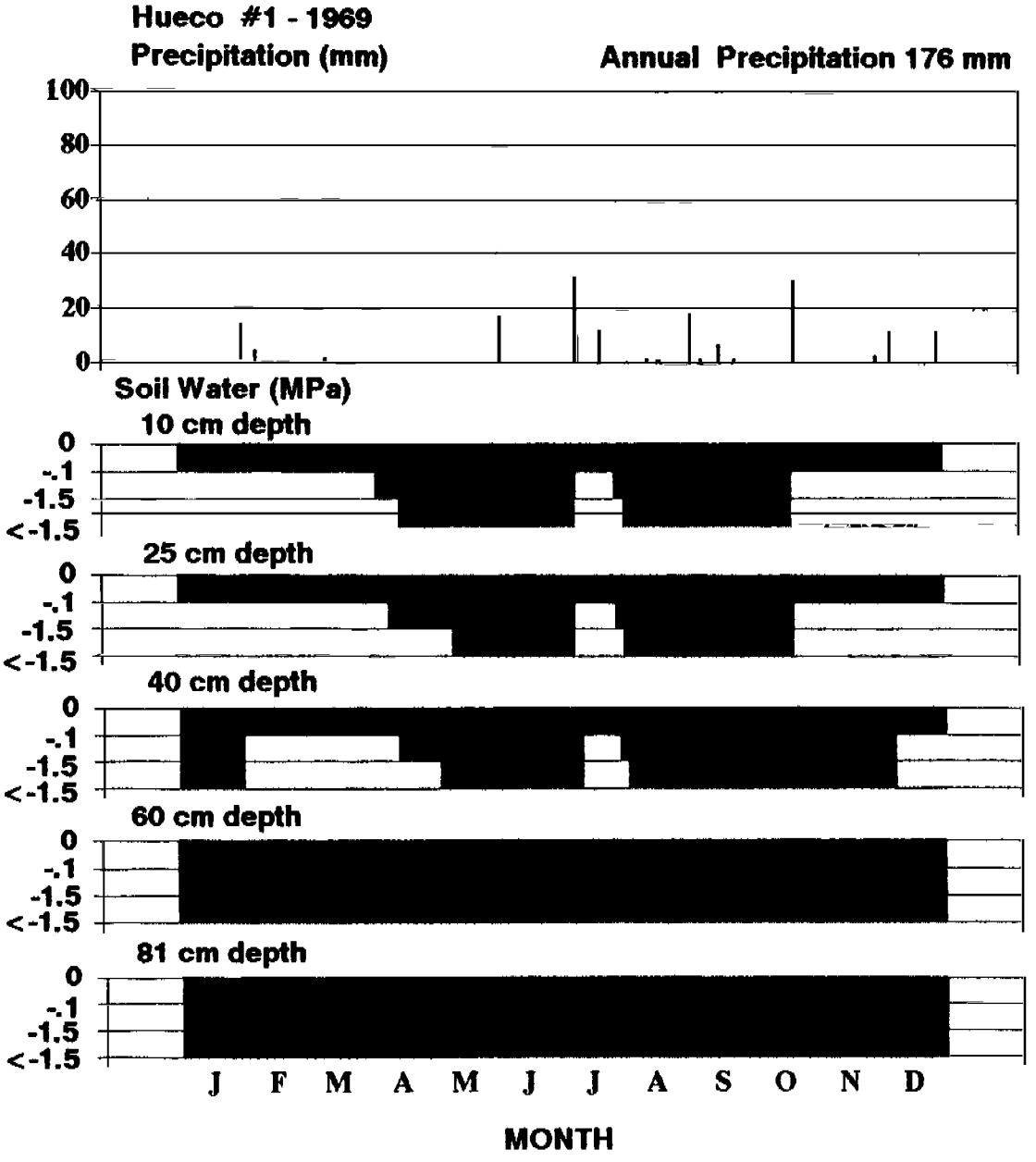


Figure 65. Annual precipitation (176 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1969.

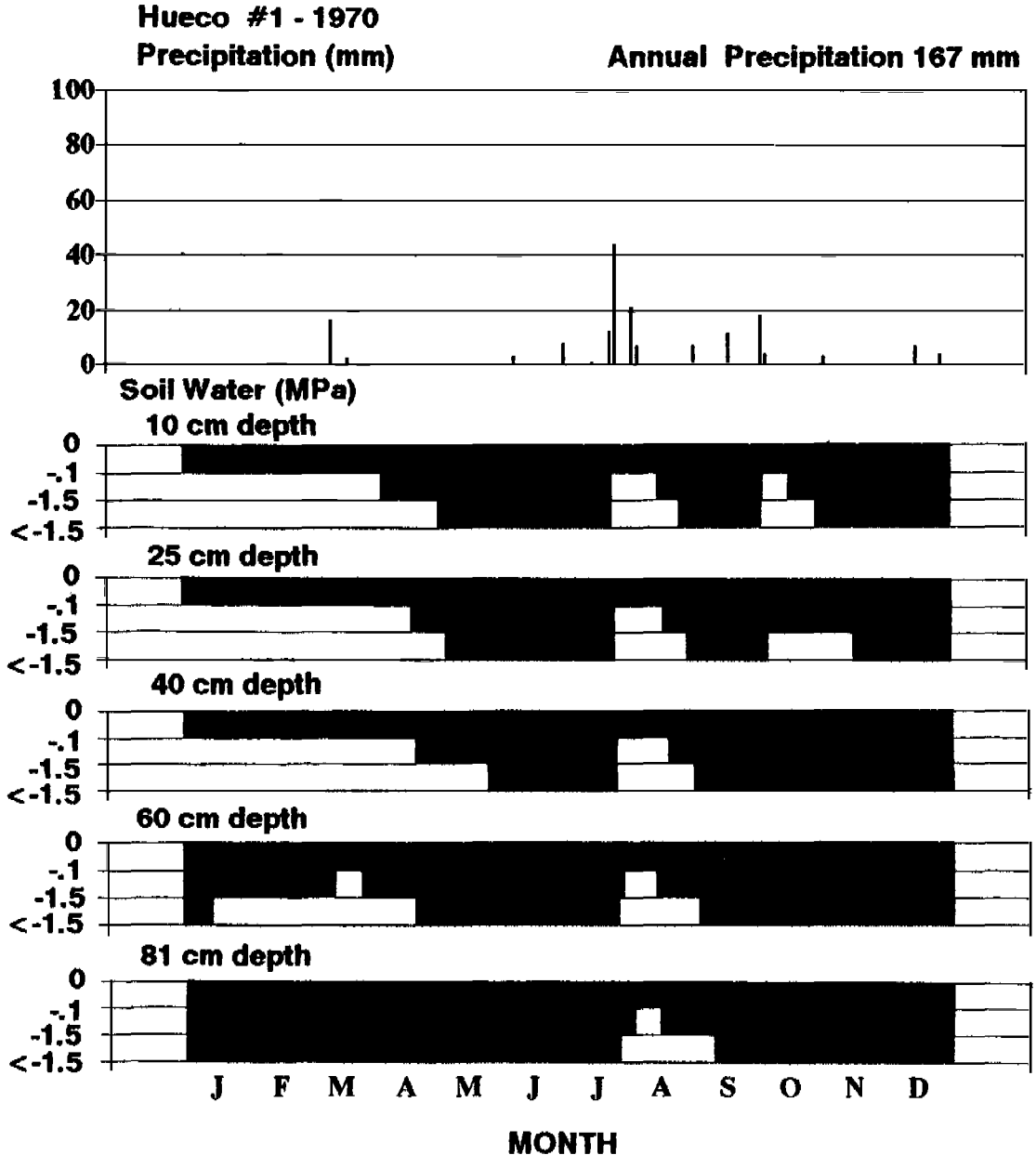


Figure 66. Annual precipitation (167 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at th Hueco #1 site for 1970.

Precipitation for 1971 was about average and above average for 1972. There was water >-1.5 MPa at the 25-cm soil depth August 19-September 14 and October 25, 1971-April 22, 1972 (figs. 67, 68). The ohmmeter was inoperative August 1-December 31, 1972. The yield of perennial grasses was 209 kg/ha (s.e.=57 kg/ha) in 1971 and 329 kg/ha (s.e.=70 kg/ha) in 1972. Note the dry soil conditions in 1971 (fig. 67).

Precipitation for 1973 was below average but there was soil water >-1.5 MPa at the moisture control section (25-cm depth) January 1-May 31 and July 20-September 7 (fig. 69). Perennial grasses averaged 457 kg/ha (s.e.=78 kg/ha).

Three rainfall events >60 mm in July, September, and October characterized the above-average precipitation in 1974 (fig. 70). Soil water >-1.5 MPa at 25 cm occurred July 15-September 2 and September 23, 1974-May 24, 1975 (figs. 70, 71). Estimates of perennial grasses in fall 1974 were 239 kg/ha (s.e.=74 kg/ha).

Precipitation was slightly below average in both 1975 and 1976 but the soil water >-1.5 MPa was markedly different (figs. 71, 72). In 1975 the water at 25 cm was >-1.5 MPa during the winter and early spring and September 7-October 25, whereas in 1976 it was <1.5 MPa at 25 cm the entire year. However, at 10 cm the soil water was >-1.5 MPa from June through September, 45 days in 1975 and 92 days in 1976 (figs. 71, 72). This was reflected in perennial grass yields of 268 kg/ha (s.e.=30 kg/ha) in 1975 and 471 kg/ha (s.e.=56 kg/ha) in 1976.

Annual precipitation for 1958-76 was below average nine years, about average three years, and above average seven years. Figure 73 shows the probability of soil water >-1.5 MPa at the five depths studied. The probability of soil water >-1.5 MPa at the 25-cm depth averaged 58.9% for December-April, 16.3% for May-June, 44.8% for July-September, and 42.3% for October-November.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, nine of 20 years had soil water <-1.5 MPa more than half the time at 10 cm; 10 of 20 years at 25 cm; 12 of 20 years at 40 cm; 15 of 18 years at 60 cm; and 16 of 18 years at a soil depth of 81 cm. Six of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 7 of 20 years at 25 cm and 40 cm; 9 of 18 years at 60 cm; and 12 of 18 years at a soil depth of 81 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section 16 of 20 years and >30 consecutive days within 4 months after June 21 in 11 years. Both criteria were observed in the same year nine of 19 times. Data were incomplete in 1957 and 1972 but both criteria were observed in 1957.

Site Hueco #2 (H2)

Site H2 (figs. 4, 74, 75, table 8) is in the Co-op Well exclosure on the Jornada Experimental Range. The sampled pedon is 4.3 m south of the nonrecording rain gauge and 1.7 m southeast of wires to the soil water blocks. The perennial vegetation is broom

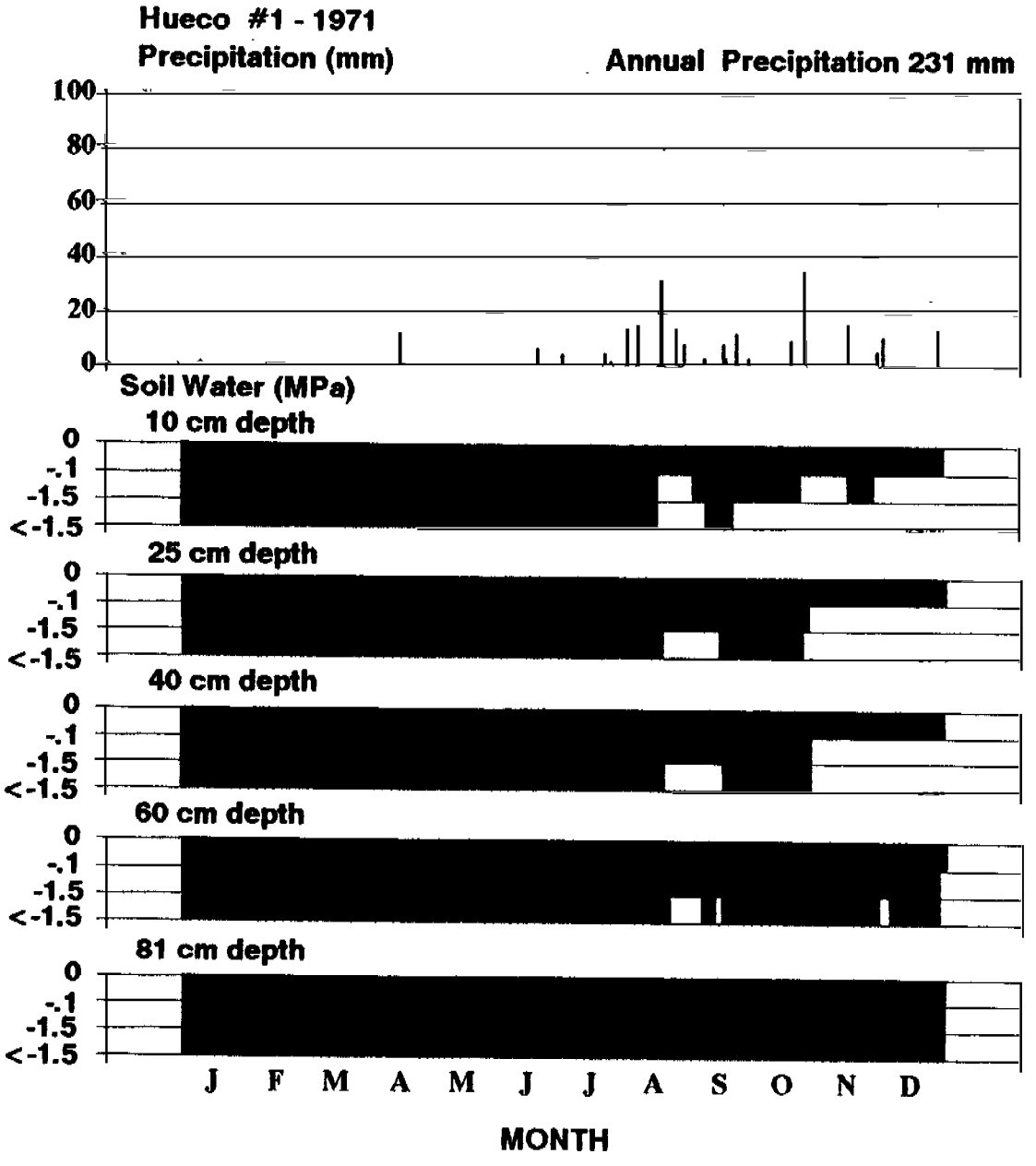


Figure 67. Annual precipitation (231 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1971.

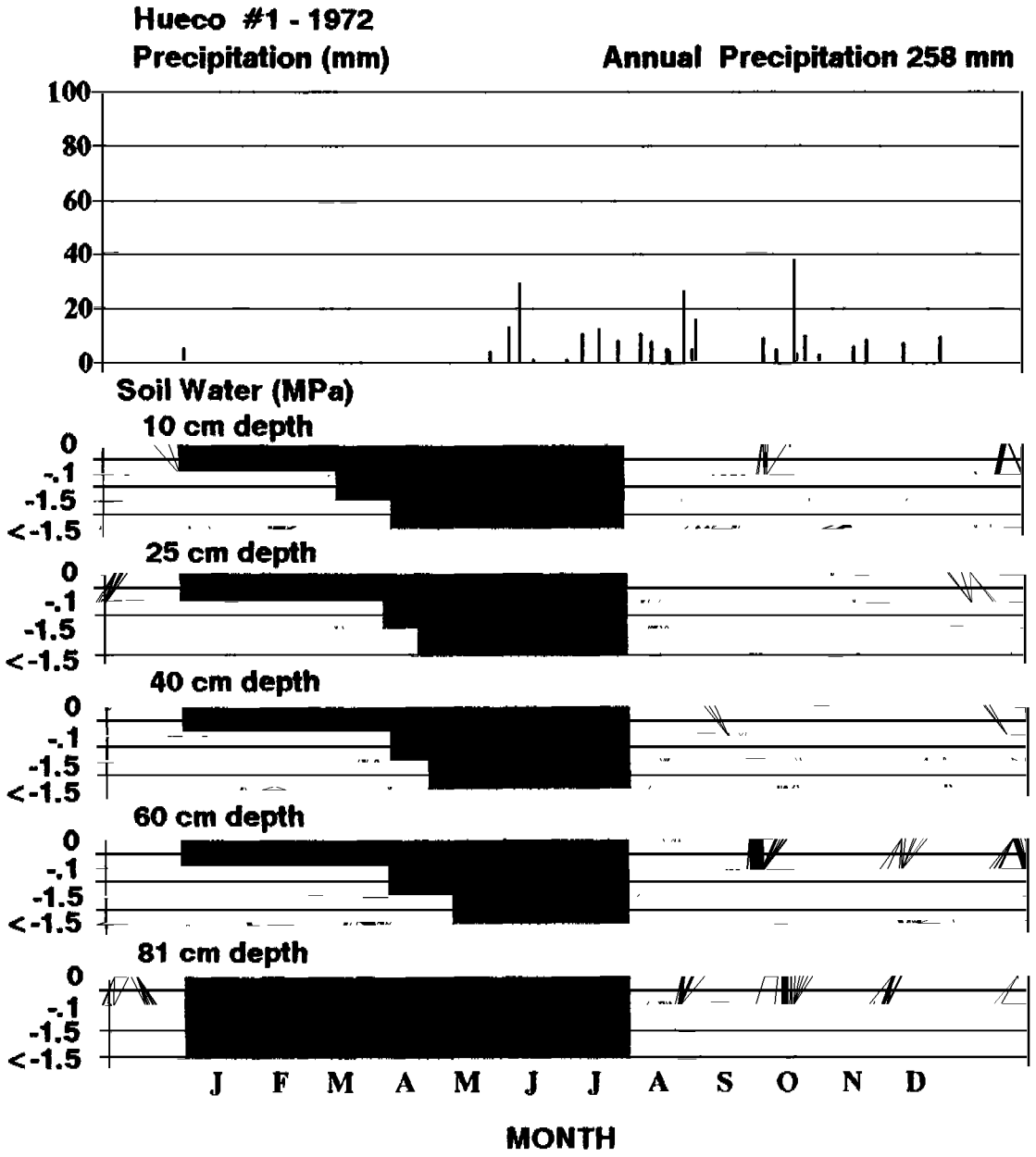


Figure 68. Annual (258 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm for January 1-August 1, 1972 at the Hueco #1 site.

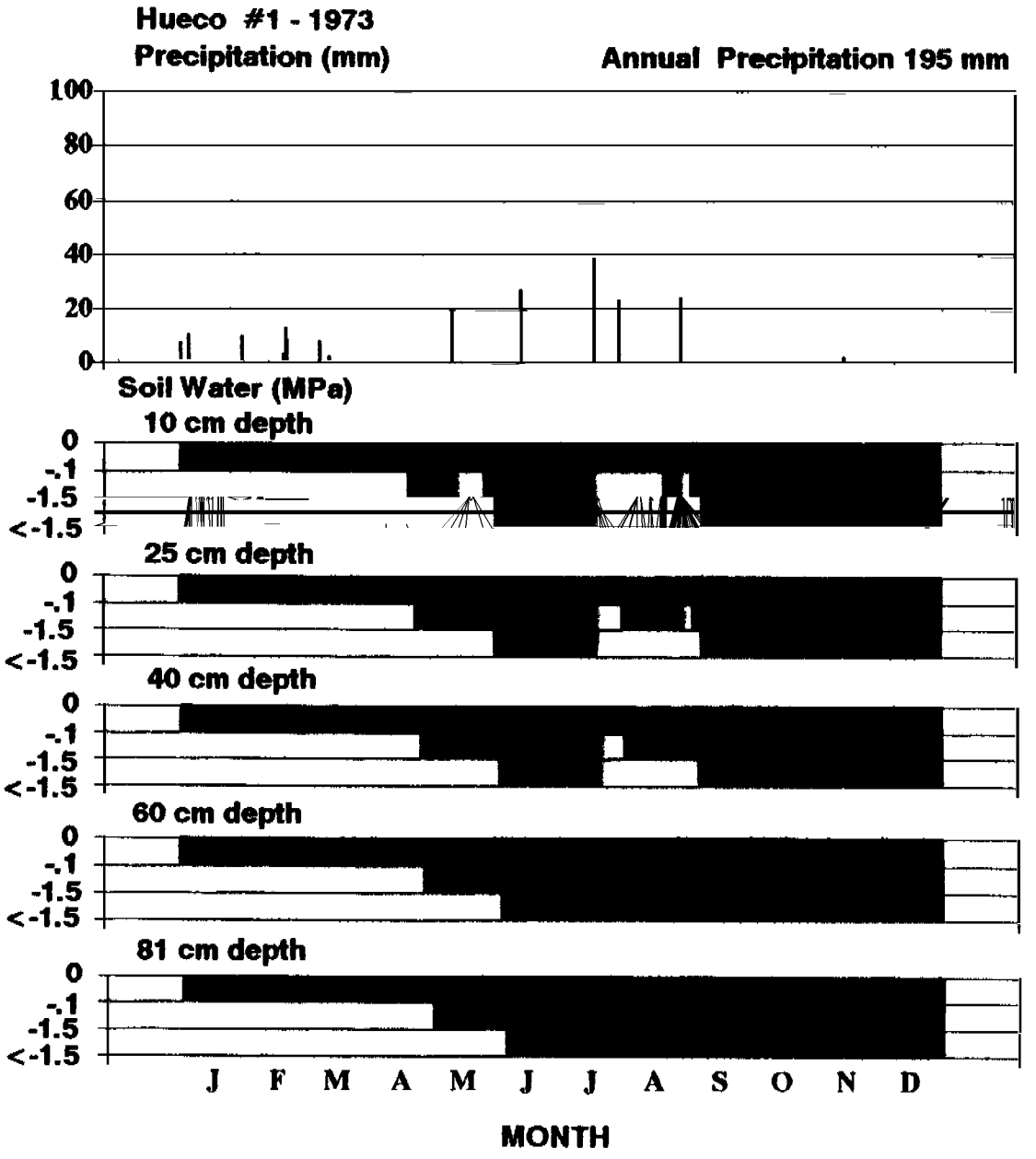


Figure 69. Annual precipitation (195 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1973.

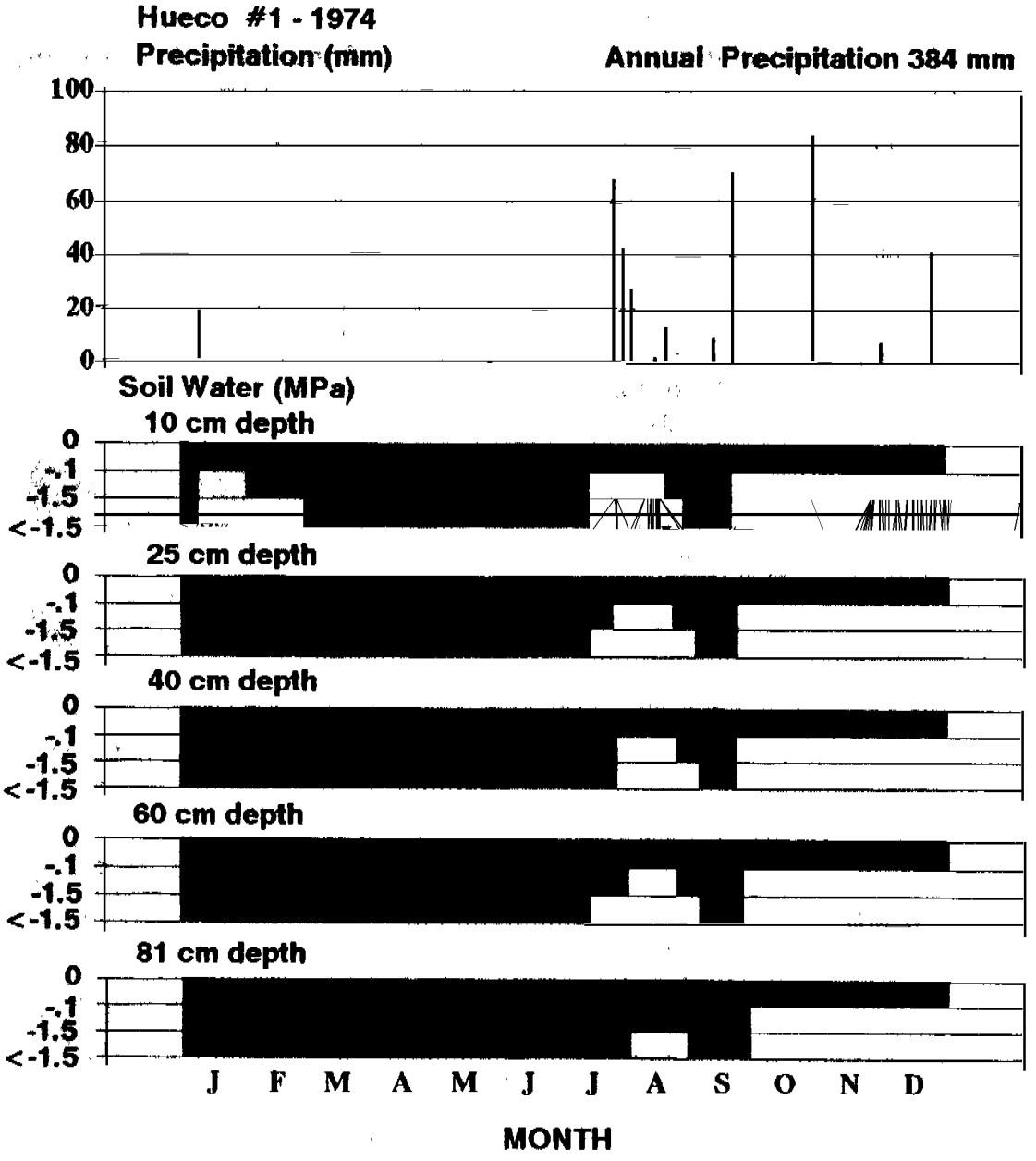


Figure 70. Annual precipitation (384 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1974.

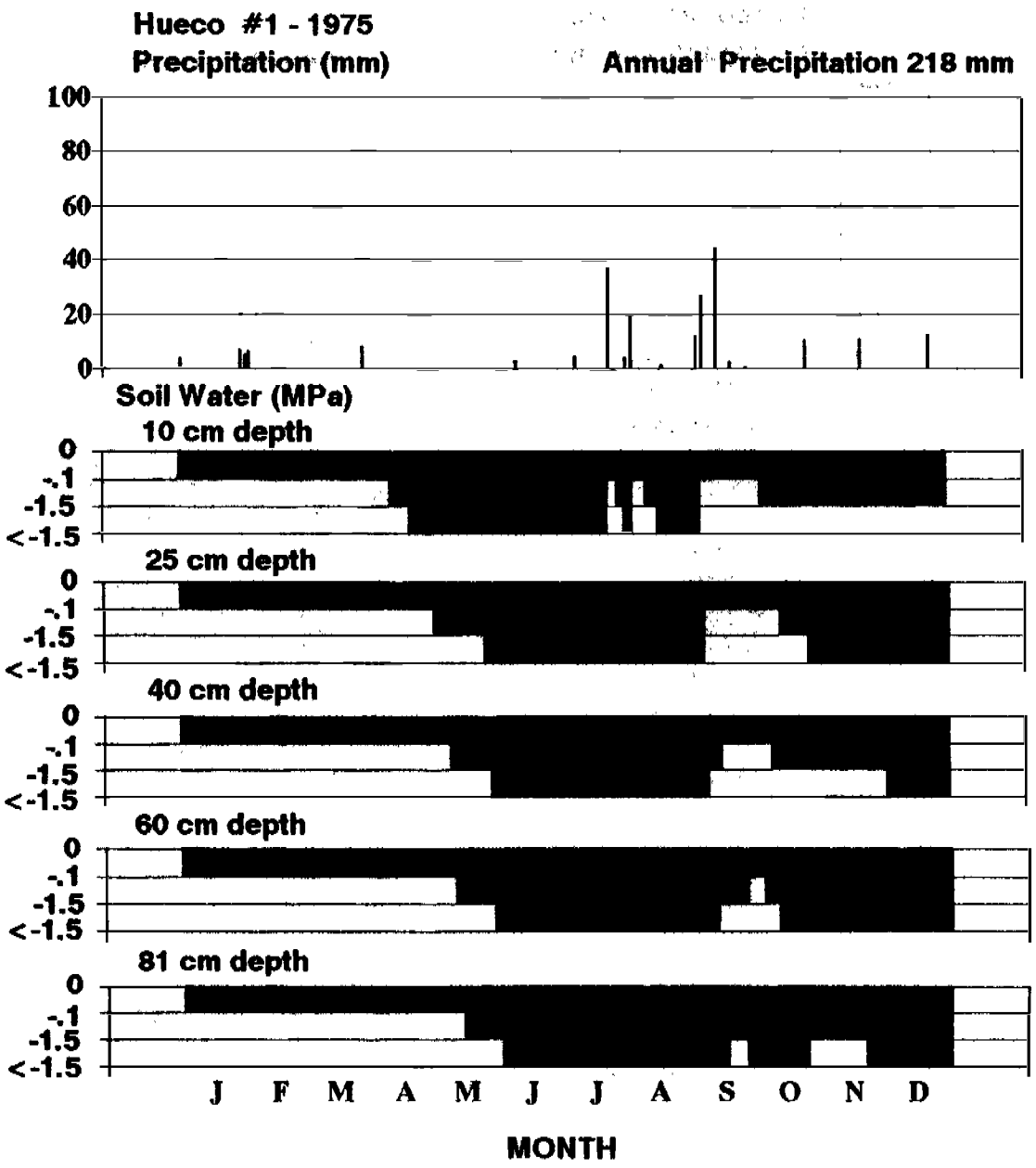


Figure 71. Annual precipitation (218 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1975.

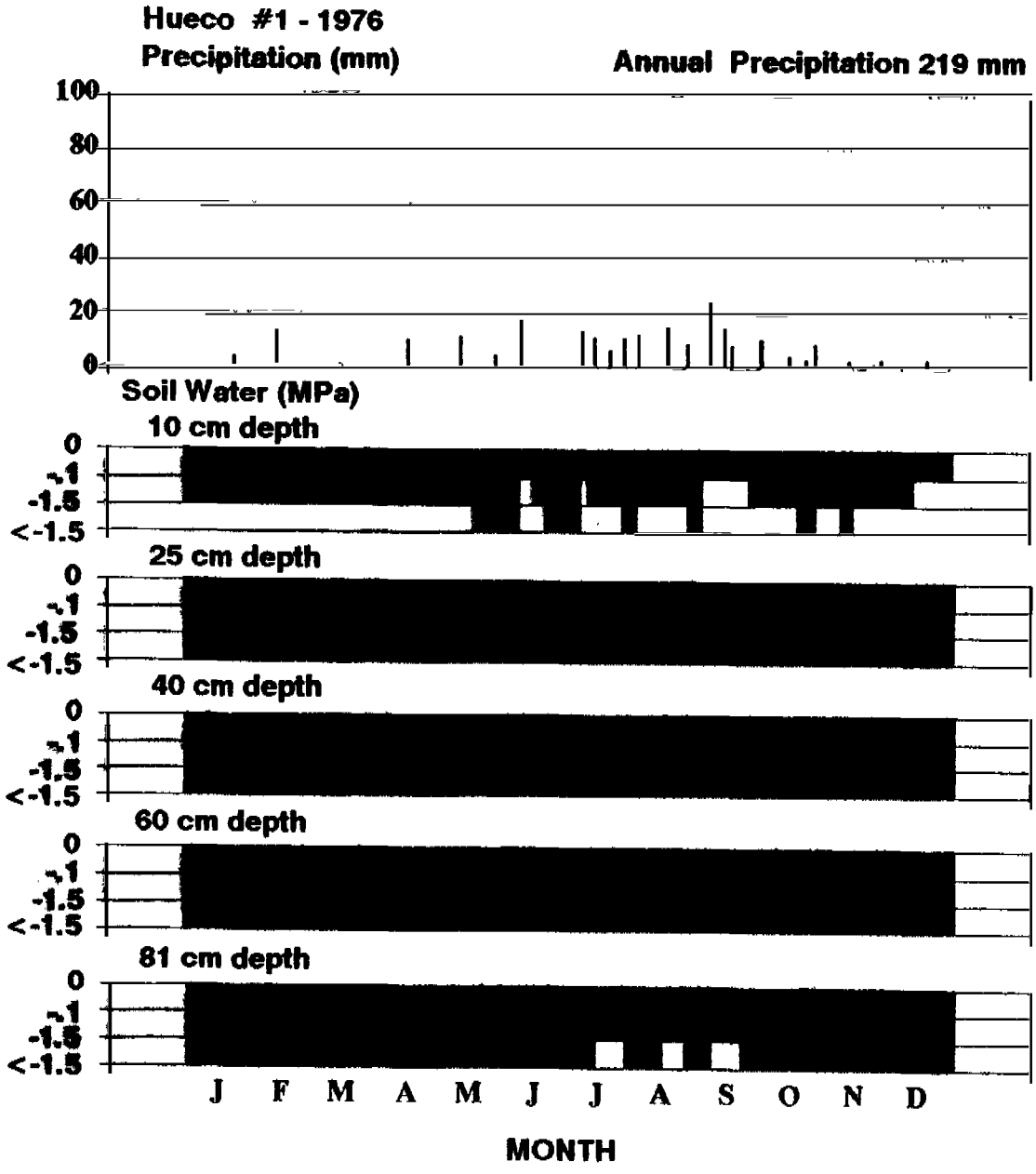


Figure 72. Annual precipitation (219 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site for 1976.

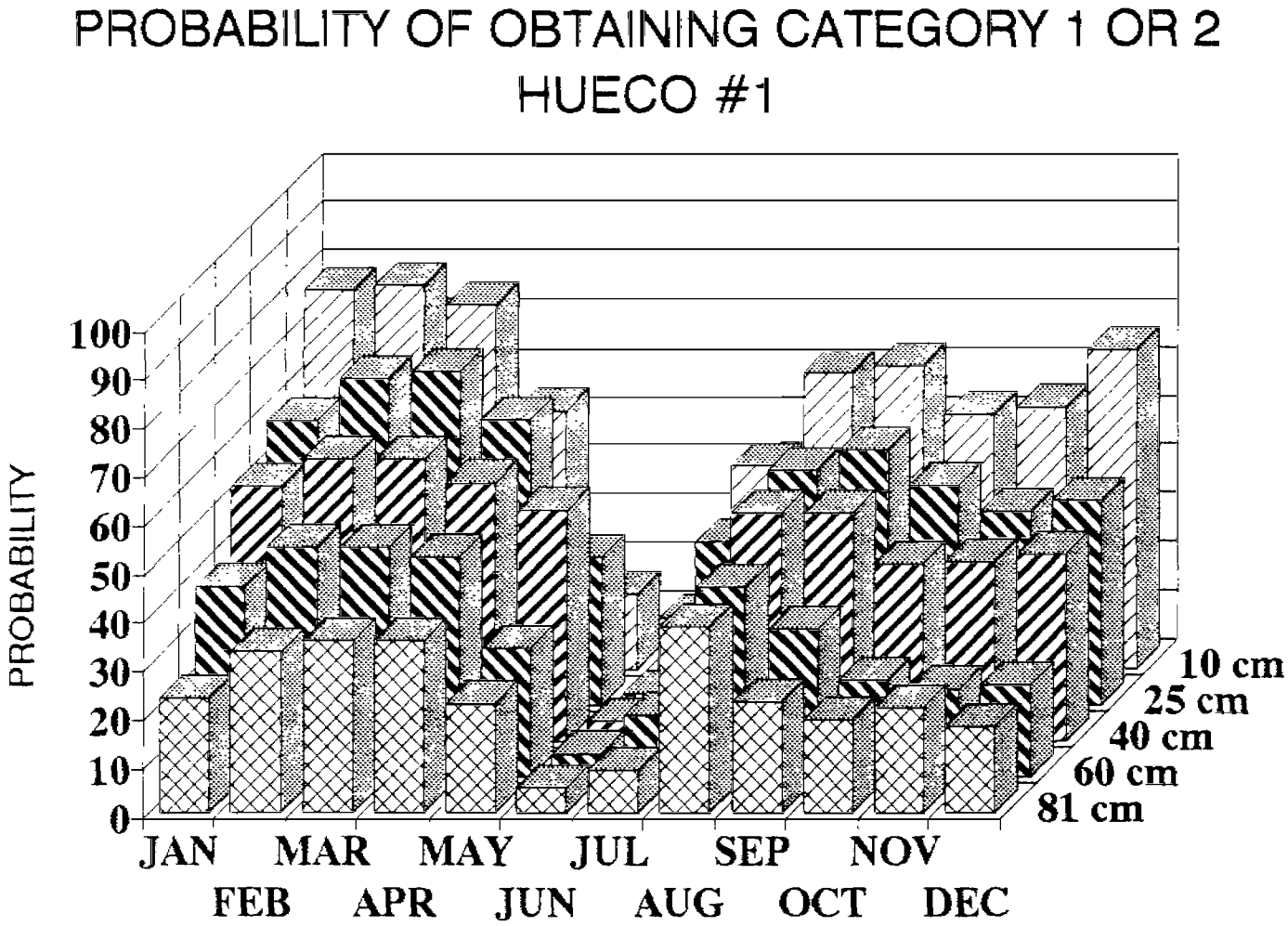


Figure 73. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 60, and 81 cm at the Hueco #1 site.

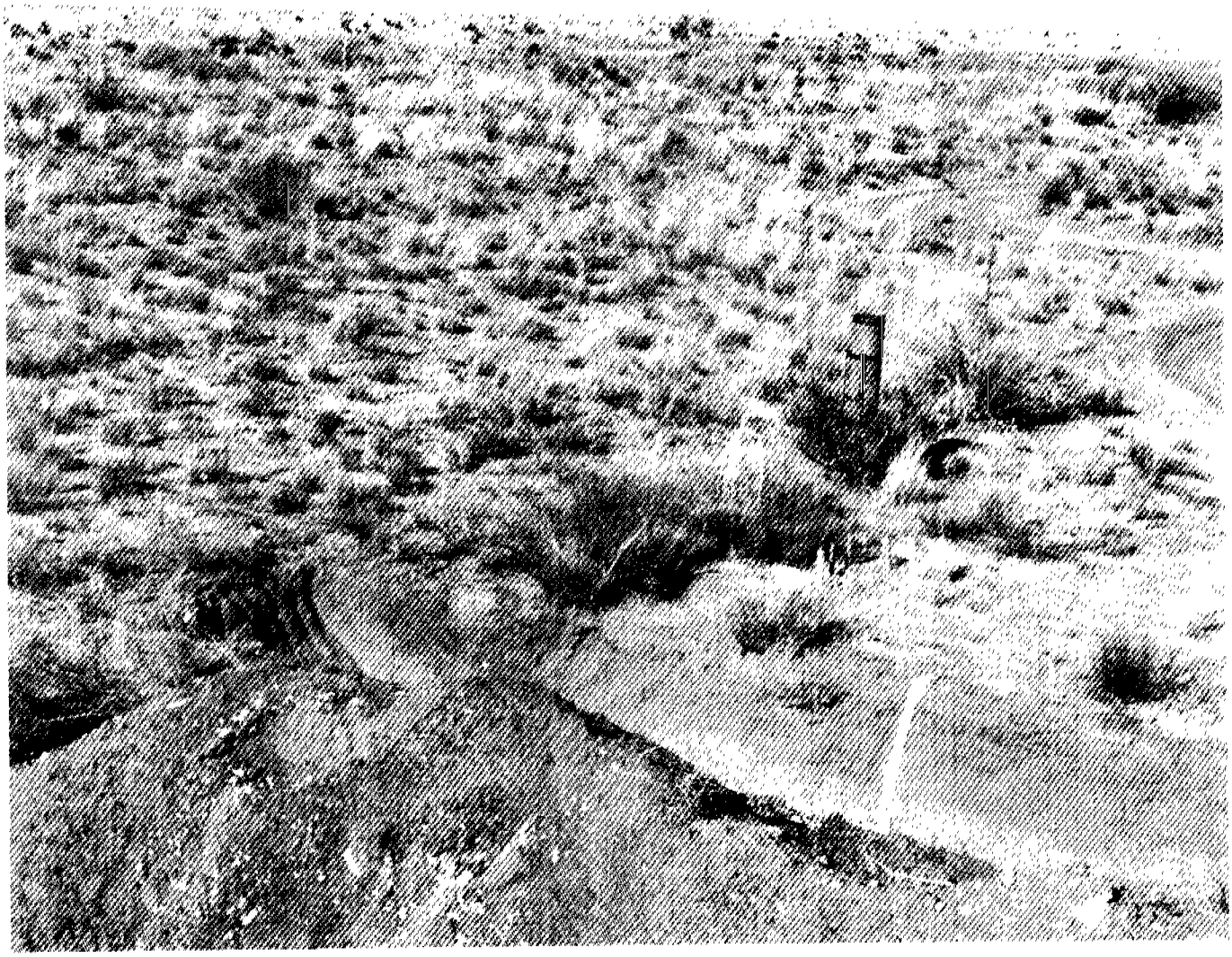


Figure 74. Landscape at Site H2 (fig. 4) and the Petrocalcic Paleargid Hueco #2, in the Co-op exclosure on the Jornada Experimental Range. Stakes and wires to the soil water blocks are beyond the study trench. The nonrecording rain gauge is beyond the soil water blocks. The Caballo Mountains are on the skyline. Photographed January 1990.

Figure 75. Profile of upper horizon of the Petrocalcic Paleargid Hueco #2. Note the undulating top of the petrocalcic horizon. A small pipe descends into the petrocalcic horizon at right; a larger one is at far left. Scale is in feet.

snakeweed, soaptree yucca, mesa dropseed, longleaf ephedra, four-wing saltbush (*Atriplex canescens* [Pursh] Nutt.), and threeawns (*Aristida* spp. L.).

Soils. The soil water blocks are in the Petrocalcic Paleargid Hueco #2 (fig. 75, tables 3, 8; Hueco #2 description and primary data). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a petrocalcic horizon. Silicate clay, carbonate, and organic carbon data (tables 3, 8) confirm the presence of these horizons and support the classification. Hueco #2 is on La Mesa surface of middle Pleistocene age and has formed in sandy fluvial sediments of the Camp Rice Formation. The area is level.

The top of the petrocalcic horizon has prominent undulations (fig. 75). A small pipe occurs just east of the sampled pedon; the east end of a much larger, deeper pipe is on the west end of the trench. The moisture blocks extend to 90 cm depth and must be in a small pipe because the auger showed these depths to the petrocalcic horizon around the blocks: 87 cm south of the blocks, 58 cm; 35 cm west, 69 cm; 35 cm east, 64 cm; and 64 cm north, 48 cm.

Hueco #2 is similar to Hueco #1 in having a noncalcareous zone underlain by carbonate filaments; it differs in having a thin K1 horizon above the petrocalcic horizon. The K1 consists of calcrete fragments with fine earth between them. These fragments (derived from the top of the petrocalcic horizon by action of water and soil biota) are common along the top of many shallow petrocalcic horizons (Gile et al. 1981, p. 69, 70). The soil is noncalcareous to 41 cm depth, illustrating the zone of common wetting and leaching of carbonates. This is confirmed by soil water data (figs. 76-95). Soil water data also show that moisture occasionally reaches the petrocalcic horizon, indicating that its uppermost subhorizon is slowly forming at the present time. The uppermost subhorizon has pisoliths characteristic of stage V morphology (Birkeland et al., 1991).

Soil Water and Precipitation. The gypsum resistance blocks were installed at the soil depths of 10, 25, and 40 cm on August 1, 1957, and the 60- and 90-cm depths July 29, 1959 within a livestock exclosure at Co-op Well. A rain gauge was established at Co-op Well in 1937. The soil water at 10 cm was >-0.1 MPa August 1-September 18, 1957, from 16 mm rainfall July 25-26 and 94 mm rainfall during August (fig. 76). The soil water at the 10-cm depth was between -0.1 and -1.5 MPa September 19-24, and <-1.5 MPa September 25-October 6. Rainfall of 11 mm on October 5 resulted in changing the soil water at 10 cm to >-0.1 MPa and with subsequent precipitation, it stayed at that level through May 5, 1958 (figs. 76, 77). There was a major storm of 64 mm rainfall on October 9, 1957. The soil water at the 25- and 40-cm depths was between -0.1 and -1.5 MPa in early August and again in late September and early October. The rest of 1957 until the latter part of May, 1958, had soil water >-0.1 MPa. Therefore, the soil water of the control section (25-cm soil depth) was >-1.5 MPa from August 1-October 21, 1957 (82 days) and also October 21-December 31, 1957 (70 days, fig. 76).

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Hueco
Classification: Coarse-loamy, mixed, thermic Petrocalcic Paleargid
NSSL ID#: 90P0494
Soil Survey #: S90NM-013-003
Location: The SE1/4SE1/4SW1/4 section 33, T.19S., R.1E., in the Co-op Well exclosure on the Jornada Experimental Range. The south side of the exclosure is about 3.7 m north of the north edge of the road to West Well. The sampled pedon is 4.3 m south of the nonrecording rain gauge, and 1.7 m southeast of wires to the moisture blocks.
Elevation: 4360 ft, 1329 m
Landform: Level basin floor
Geomorphic Surface: La Mesa
Parent Material: Upper Camp Rice Formation (fluvial facies) sand
Vegetation: Snakeweed, soaptree yucca, dropseed, Mormon tea, four-wing saltbush, and threeawn
Described By: L.H. Gile
Date: Feb 4, 1990

Soil Surface: Alternating areas of smooth crust and thin, loose sand.

C--0 to 11 cm; stratified reddish brown (5YR 5/4) sand; reddish brown (5YR 4/4) moist; massive but with horizontal cleavage to thin and medium lenses; generally soft, with some lenses separated by soft fine granules or loose, single grain material; very few fine roots; 90P2726; noncalcareous; abrupt smooth boundary.

Eb--11 to 18 cm; reddish brown (6YR 5/3) loamy sand; dark reddish brown (6YR 3.5/3) moist; weak medium subangular blocky structure; slightly hard, friable; very few fine roots; 90P2727; noncalcareous; abrupt wavy boundary.

Bt1b--18 to 29 cm; yellowish red (5YR 5/5) loamy sand; yellowish red (5YR 3.5/5) moist; weak medium and coarse subangular blocky structure; hard and very hard, friable; very few fine roots; 90P2728; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt2b--29 to 41 cm; yellowish red (5YR 5/5) loamy sand; yellowish red (5YR 4/5) moist; weak medium subangular blocky structure; hard and very hard, friable; very few fine roots; 90P2729; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Btk1b--41 to 53 cm; yellowish red (5YR 5/5) fine sandy loam; yellowish red (5YR 4/5) moist; weak medium subangular blocky structure; hard, friable; very few fine roots; 90P2730; sand grains coated with oriented clay; few carbonate filaments; slightly effervescent; abrupt wavy boundary.

Btk2b--53 to 66 cm; reddish brown (5YR 5.5/4) fine sandy loam; reddish brown (5YR 4/4) moist; few parts with 5 chroma; weak fine and medium subangular blocky structure; slightly hard and hard, friable; 90P2731; sand grains coated with oriented clay; common carbonate filaments; strongly effervescent; abrupt wavy boundary.

K1b--66 to 76 cm; reddish brown (5YR 5/4) very gravelly sandy loam; reddish brown (5YR 4/4) moist; weak fine granular structure; soft, very friable; very few fine roots; 90P2732; pebbles are carbonate-cemented fragments once part of the petrocalcic horizon; strongly effervescent; abrupt wavy boundary.

K21mb--76 to 80 cm; pinkish white (7.5YR 8/2) carbonate-cemented laminae, pisoliths, and massive material in the upper part of the petrocalcic horizon; pinkish gray to pink (7.5YR 7/3) moist; lesser amount white (7.5YR 9/2, dry); extremely hard; no roots; 90P2733; strongly effervescent.

S90NM-013-003 *** PRIMARY CHARACTERIZATION DATA ***

PRINT DATE 11/29/91

Soil series: HUECO ; COARSE-LOAMY, MIXED, THERMIC PETROCALCIC PALEARGID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 494, SAMPLES 90P2726-2735
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002-.05	TOTAL SAND .05-2	TOTAL FINE LT .0002	CLAY CO3 LT .002 PCT OF <2MM	SILT FINE .002-.02	SILT COARSE .02-.05	SILT VF .05-.10	SAND VF .10-.25	SAND F .25-.50	SAND M .5-1	SAND C 1-2	SAND VC 2-5	COARSE FRACTIONS(MM) WEIGHT 20-75 (3A1)	COARSE FRACTIONS(MM) WEIGHT .1-75	>2MM WT PCT OF WHOLE SOIL
90P2726S	0- 11	C	6.7	4.4	88.9		0.6	1.1	3.3	11.5	38.6	34.9	3.9	TR	--	--	77	--
90P2727S	11- 18	EB	10.3	7.8	81.9			1.2	6.6	11.3	35.8	29.3	4.9	0.6	TR	--	71	TR
90P2728S	18- 29	BT1B	12.2	5.3	82.5			1.5	3.8	12.4	35.9	28.7	4.9	0.6	TR	--	70	TR
90P2729S	29- 41	BT2B	11.6	5.2	83.2			1.8	3.4	11.1	35.8	30.3	5.6	0.4	TR	--	72	--
90P2730S	41- 53	BTK1B	15.2	4.0	80.8			2.5	1.5	13.2	33.3	29.0	4.6	0.7	TR	--	68	TR
90P2731S	53- 66	BTK2B	15.4	7.3	77.3		2.1	3.5	3.8	10.7	31.7	28.2	5.9	0.8	1	TR	67	1
90P2732S	66- 76	K1B	8.7	15.4	75.9		6.9	0.4	7.0	8.8	19.6	21.2	17.7	8.6	--	--	67	--
90P2733S	76- 80	K2MB	9.1	10.3	80.6		5.2	7.4	2.9	9.3	18.1	22.9	21.7	8.6	--	--	71	--
															--	--		--
															--	--		--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B3a <2MM	EXTR TOTAL P 6S3 PPM	TOTAL S 6R3a <- PERCENT	DITH-CIT EXTRACTABLE FE 6C2b	DITH-CIT EXTRACTABLE AL 6G7a OF	DITH-CIT EXTRACTABLE MN 6D2a <2MM -->	RATIO/CLAY 15 CEC 8D1	RATIO/CLAY 15 BAR 8D1	ATTERBERG LIMITS - LL 4F1 PCT	ATTERBERG LIMITS - PI 4F <0.4MM	BULK DENSITY FIELD MOIST 4A3a	BULK DENSITY 1/3 BAR 4A1d <- - G/CC - -	BULK DENSITY OVEN DRY 4A1h	COLE WHOLE SOIL 4D1 CM/CM	WATER CONTENT FIELD MOIST 4B4	WATER CONTENT 1/10 BAR 4B1c	WATER CONTENT 1/3 BAR 4B1c	WATER CONTENT 15 BAR 4B2a <- -PCT OF <2MM - ->	WRD WHOLE SOIL 4C1 CM/CM
0- 11	0.15							0.82	0.33										2.2	
11- 18	0.26							0.84	0.39				1.51	1.52	0.002			10.5	4.0	0.10
18- 29	0.19							0.75	0.37				1.81	1.84	0.005			6.8	4.5	0.04
29- 41	0.17							0.75	0.39										4.5	
41- 53	0.17							0.68	0.36				1.58	1.65	0.015			7.5	5.4	0.03
53- 66	0.24							0.68	0.43				1.51	1.58	0.015			9.7	6.6	0.05
66- 76	0.21							0.39	1.24										10.8	
76- 80	0.26							0.27	0.89					1.98					8.1	

AVERAGES, DEPTH 18- 68: PCT CLAY 13 PCT .1-75MM 69

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA 5B5a 6N2e	NH4OAC EXTRACTABLE BASES MG 5B5a 6O2d	NH4OAC EXTRACTABLE BASES NA 5B5a 6P2b	NH4OAC EXTRACTABLE BASES K 5B5a 6Q2b	NH4OAC EXTRACTABLE BASES SUM BASES	ACIDITY 6H5a	CEC SUM CATS 5A3a	CEC NH4-OAC 5A8b	EXCH NA 5B5b PCT	SAR 5E	BASE SATURATION SUM 5C3	BASE SATURATION NH4OAC 5C1	CARBONATE AS CACO3 <2MM 6E1g	CARBONATE AS CACO3 <20MM 6E4	CASO4 AS GYPSUM <2MM 6F1a	CASO4 AS GYPSUM <20MM 6F4	PH SAT PASTE 8C1b	PH CACL2 .01M 8C1f	PH H2O 8C1f
	<- - - - - - - - - -MEQ / 100 G - - - - - - - - - ->								PCT		<- -PCT- >		<- -PCT ->		<- -PCT ->			1:2	1:1
0- 11	5.5	1.0	TR	0.5	7.0		7.0	5.5	1		100	100	TR					7.0	7.1
11- 18	7.7	1.3	--	0.6	9.6	0.6	10.2	8.6	TR		94	100	TR					7.5	7.8
18- 29	8.2	1.4	--	0.6	10.2	0.6	10.8	9.2	TR		94	100	TR					7.5	8.1
29- 41	7.9	1.4	--	0.5	9.8	0.5	10.3	8.7	TR		95	100	TR					7.4	8.2
41- 53		2.0	TR	0.3		--		10.4	TR		100	100	1					7.6	8.1
53- 66		3.5	0.1	0.3				10.5	1		100	100	4					7.8	8.5
66- 76		2.0	0.2	0.1				3.4	4	2	100	100	80				8.2	8.0	8.6
76- 80		1.7	0.4	TR				2.5	8	3	100	100	82		--		8.2	8.2	8.4

DEPTH (CM)	WATER EXTRACTED FROM SATURATED PASTE CA 6N1b	MG 6O1b	NA 6P1b	K 6Q1b	CO3 6I1b	HCO3 6J1b	CL 6K1c	SO4 6L1c	NO3 6M1c	H2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A3a MMHOS /CM
	< - - - - - - - - - -MEQ / LITER - - - - - - - - - - >									<- -PCT ->		
0- 11												0.11
11- 18												0.12
18- 29												0.12
29- 41												0.12
41- 53												0.14
53- 66												0.16
66- 76	2.2	1.0	2.0	0.1	--	1.8	1.3	1.8	--	41.2	TR	0.47
76- 80	5.7	2.7	5.7	0.1	--	1.3	5.9	6.2	--	37.0	TR	1.44

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 1, 2, 3, 4, 5, 6,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

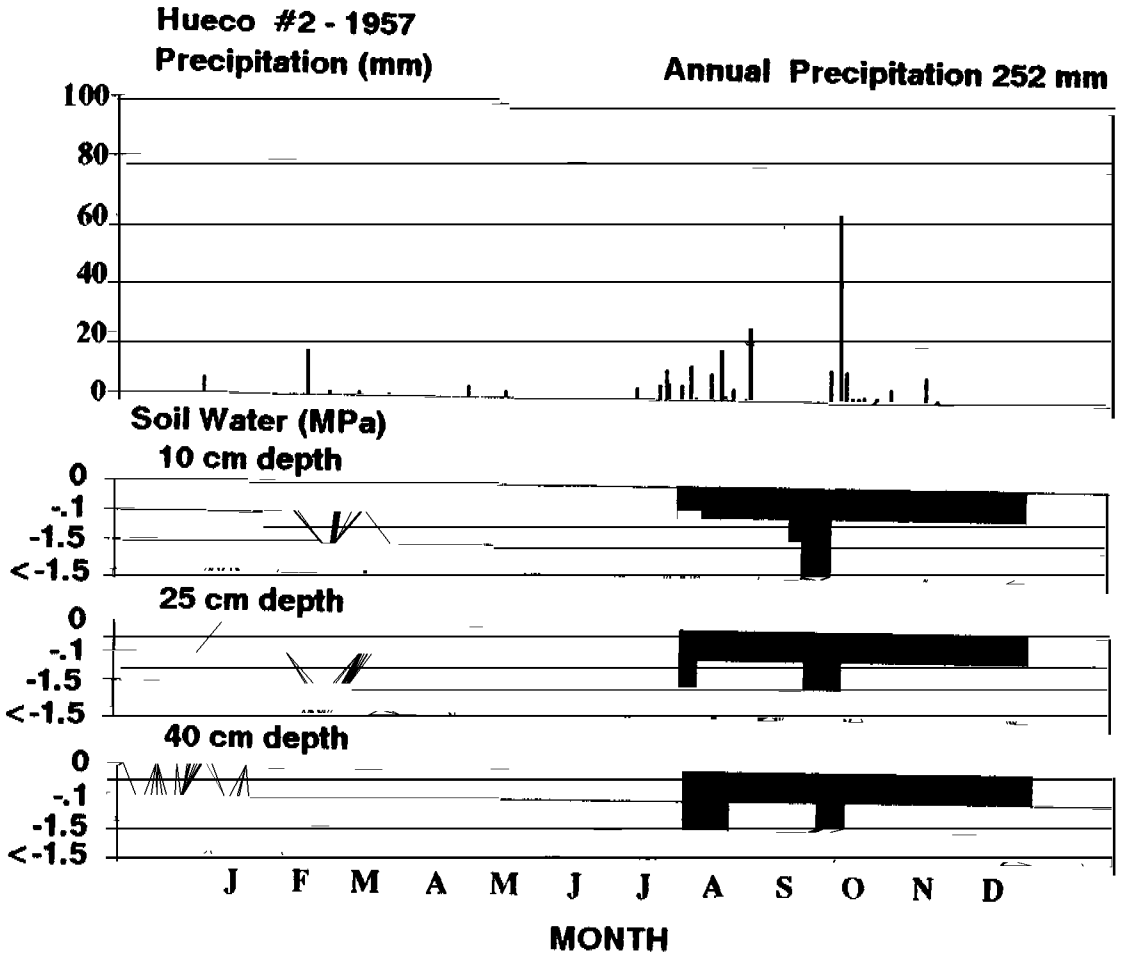


Figure 76. Annual (252 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 1-December 31, 1957 at the Hueco #2 site.

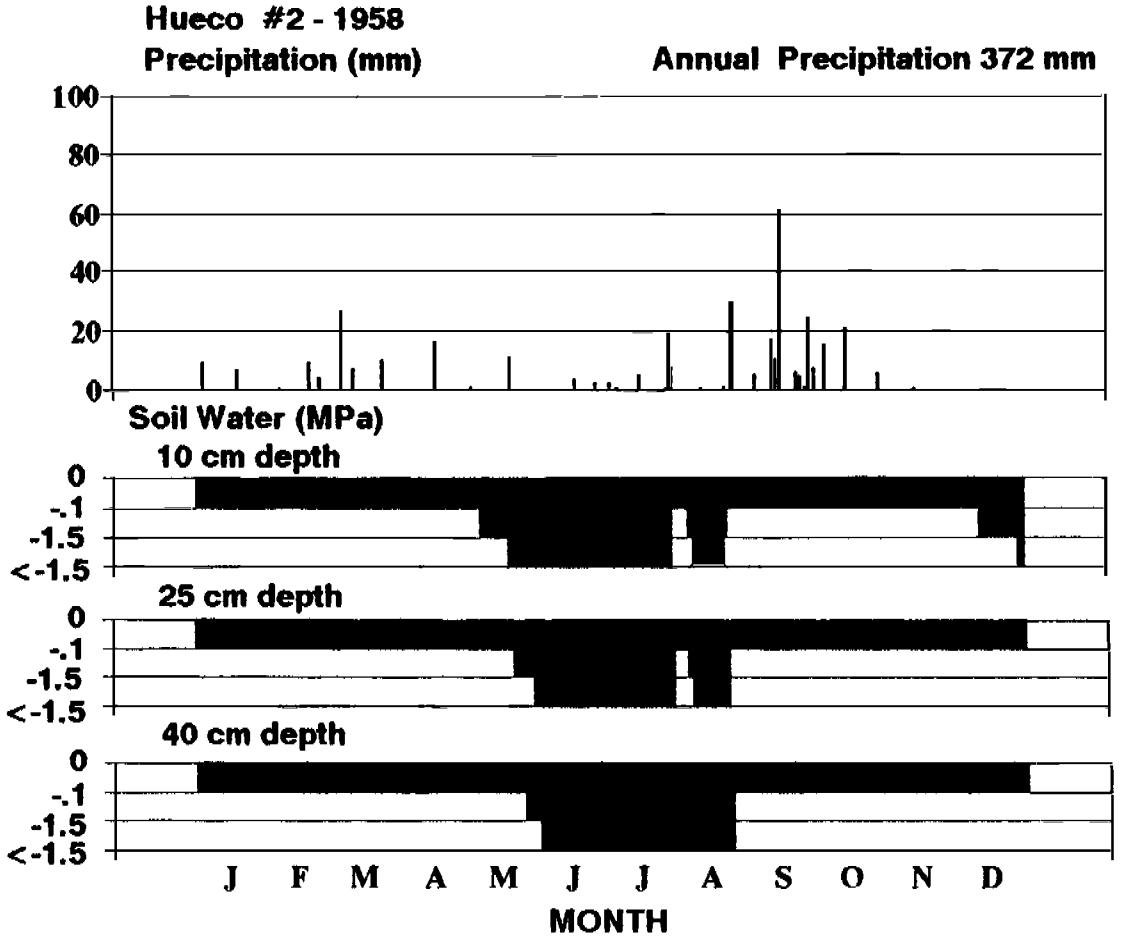


Figure 77. Annual precipitation (372 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Hueco #2 site for 1958.

In 1958, soil water at 10, 25, and 40 cm below the soil surface was <-1.5 MPa from late May or early June until July 30 when 27 mm rainfall on July 29-30 raised the soil water at the 10- and 25-cm depths to >-0.1 MPa (fig. 77). Both of these depths and the 40-cm depth had soil water <-1.5 MPa August 8-24 when 47 mm rainfall on August 24-25 and subsequent precipitation gave soil water >-0.1 MPa for the remainder of the year except the soil water was <-0.1 MPa December 12-31 at a depth of 10 cm (fig. 77). During the high rainfall of 1958, the control section (25 cm) had soil water >-1.5 MPa January 1-May 29 (147 days), July 31-August 7, and August 24-December 31 (fig. 77).

Most of the precipitation in 1959 was concentrated in July and August (fig. 78). The soil water was >-1.5 MPa at 25 cm January 1-April 30 and at the 40-cm depth January 1-May 1, both from 1958 precipitation. The soil water was also >-1.5 MPa at the 10-cm depth July 10-September 15, 25-cm depth July 21-September 20 (61 days), 40-cm depth July 27-September 23, 60-cm depth July 29-September 23, and the 90-cm depth July 29-August 23 and August 26-September 23 (fig. 78). The soil water was <-1.5 MPa for the balance of the year.

The year, 1960, with 154 mm precipitation may be characterized as a droughty year. There was some soil water >-1.5 MPa at 10-, 25-, and 40-cm depths in winter and early spring (fig. 79). The control section had soil water >-1.5 MPa January 18-May 12 (116 days), August 15-November 29 (68 days June 21-October 21), and December 10-31. Soil water at the 60- and 90-cm depths was <-1.5 MPa for the entire year (fig. 79).

Annual precipitation of 304 mm in 1961 (fig. 80) and 291 mm in 1962 (fig. 81) characterized both years as wet. The 25-cm depth (control section) had soil water >-1.5 MPa January 1-June 11, 1961 (fig. 80); July 7-November 4, 1961 (107 days between June 21 and October 21); November 9, 1961-May 22, 1962 (figs. 80, 81); July 11-August 16, 1962 (37 days); and September 26-December 31, 1962 (fig. 81).

Each year, 1963-67, was droughty. During September 6-October 8, 1963, the control section (25-cm depth) had soil water >-1.5 MPa for 33 continuous days during June 21-October 21 (fig. 82); for 49 and 30 days in 1964 (fig. 83); 25 continuous days in 1965 (fig. 84); 7, 21, and 25 days in 1966 (fig. 85); and 32 and 13 continuous days June 21-October 21, 1967 (fig. 86). In addition, there was some scattered soil water >-1.5 MPa at other depths and times during these five years (figs. 82-86).

Precipitation in 1968 was above-average but most of the soil water >-1.5 MPa was in the winter and spring (fig. 87). The control section had soil water >-1.5 MPa January 1-May 29, July 6-16, July 28-August 22, September 6-25, and November 19-December 31 (fig. 87).

The annual precipitation for 1969-71 was below average. The control section (25-cm depth) had soil water >-1.5 MPa January 1-May 20, 1969 (fig. 88); July 11-August 5, 1969; October 25, 1969-May 7, 1970 (figs. 88, 89); July 25-August 25, 1970; August 19-September 15, 1971 (fig. 90); and October 26-December 31, 1971. In

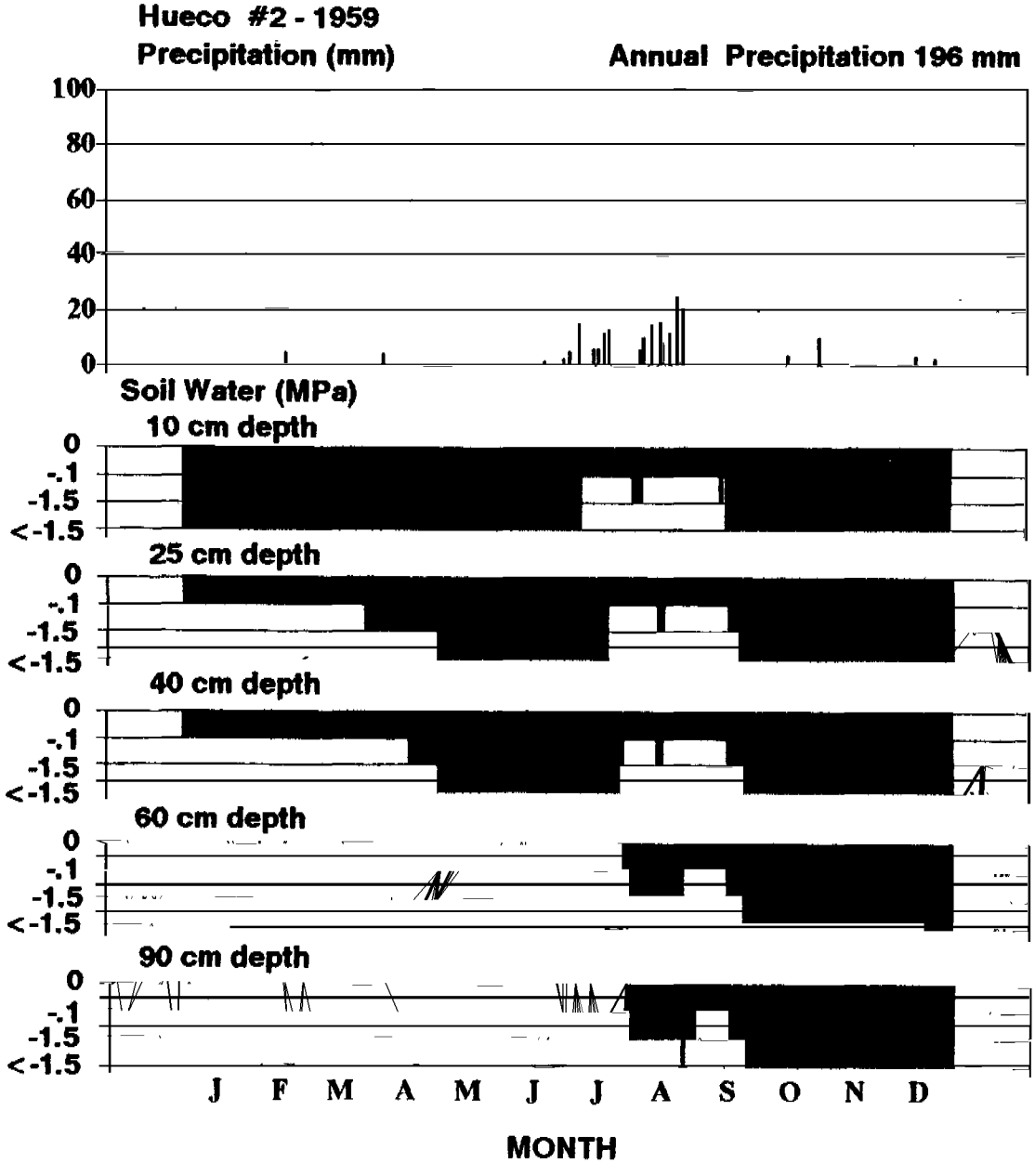


Figure 78. Annual precipitation (196 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Hueco #2 site for 1959. Also shown is the soil water at depths of 60 and 90 cm July 29-December 31, 1959.

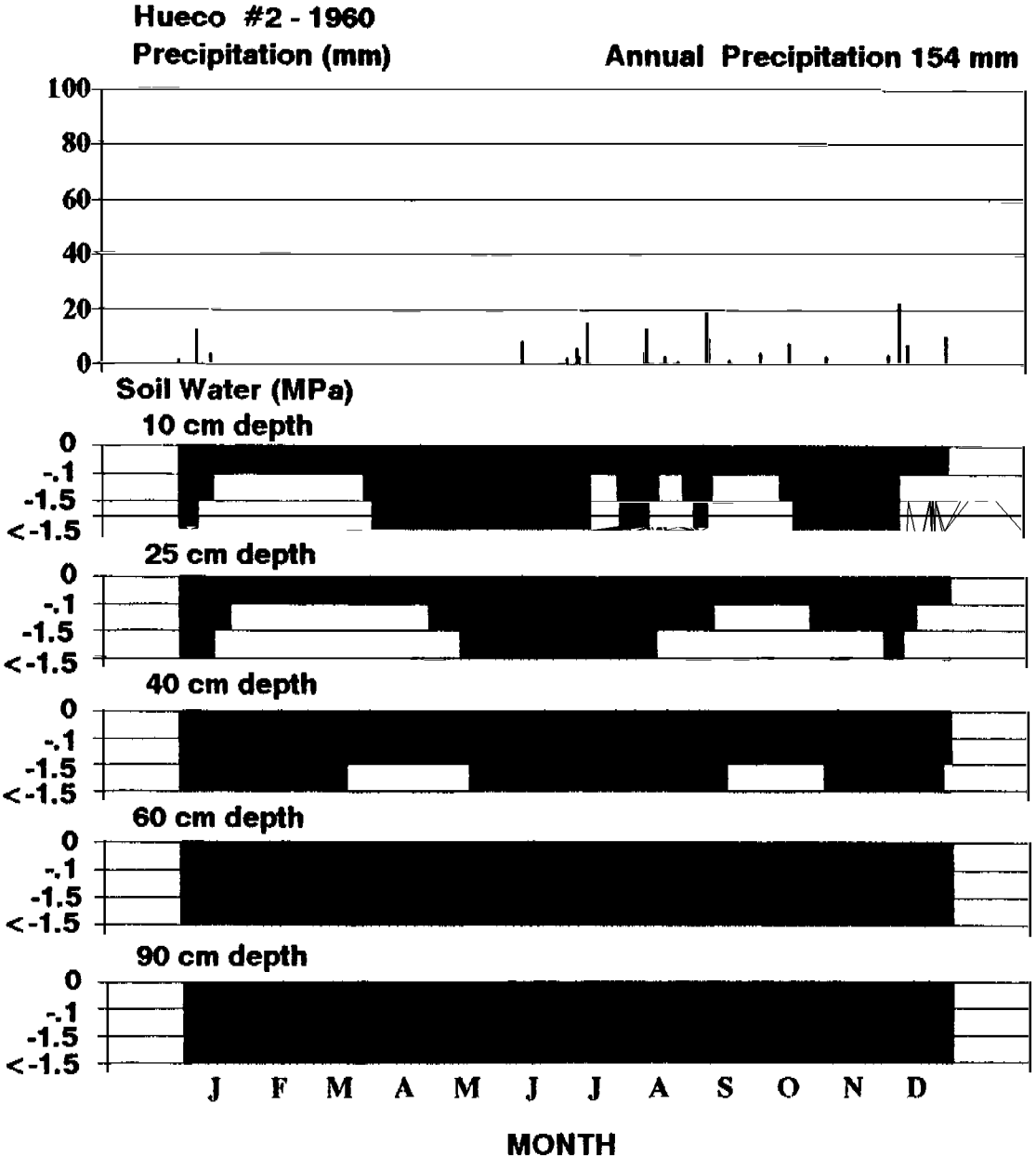


Figure 79. Annual precipitation (154 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1960.

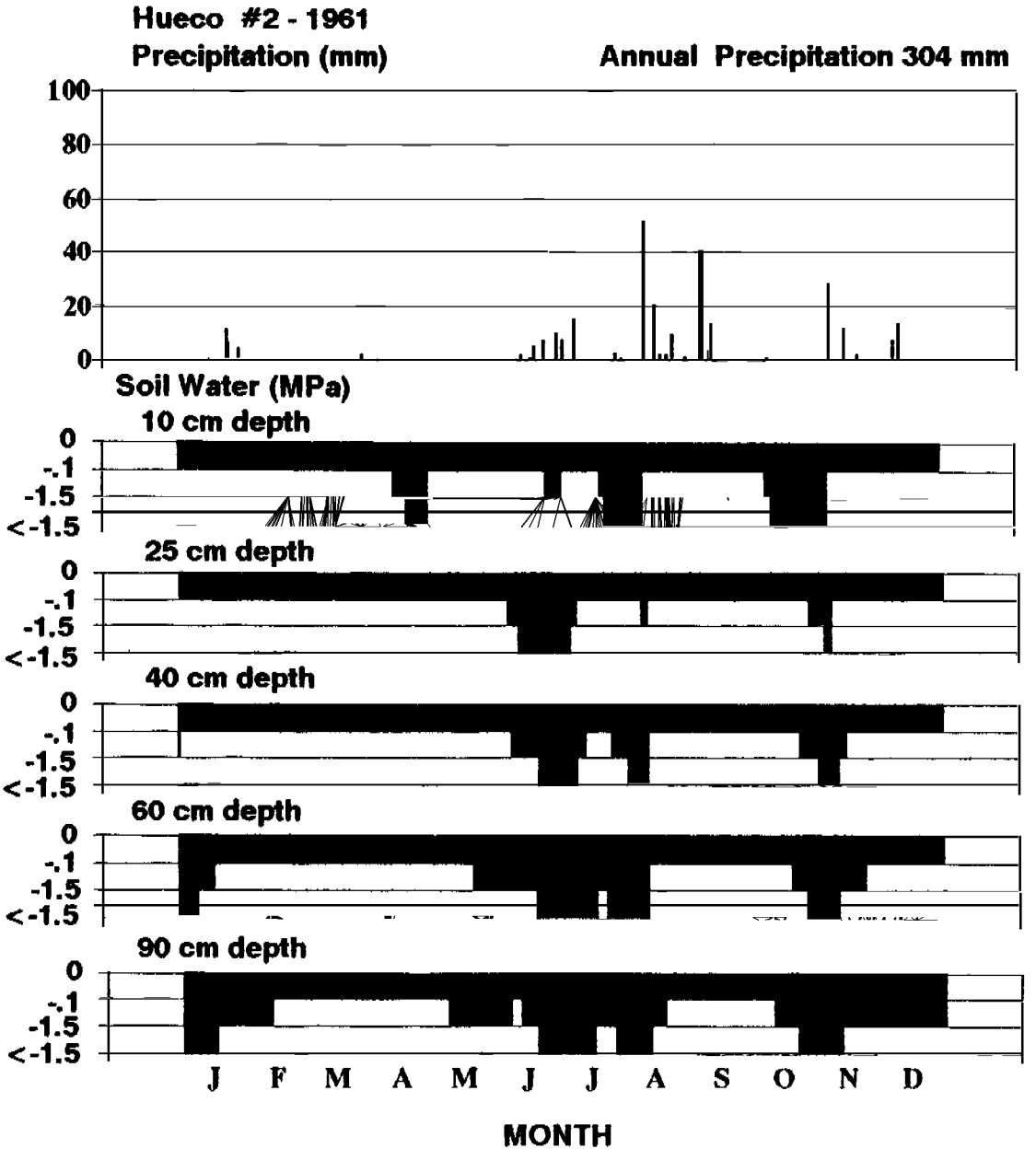


Figure 80. Annual precipitation (304 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1961.

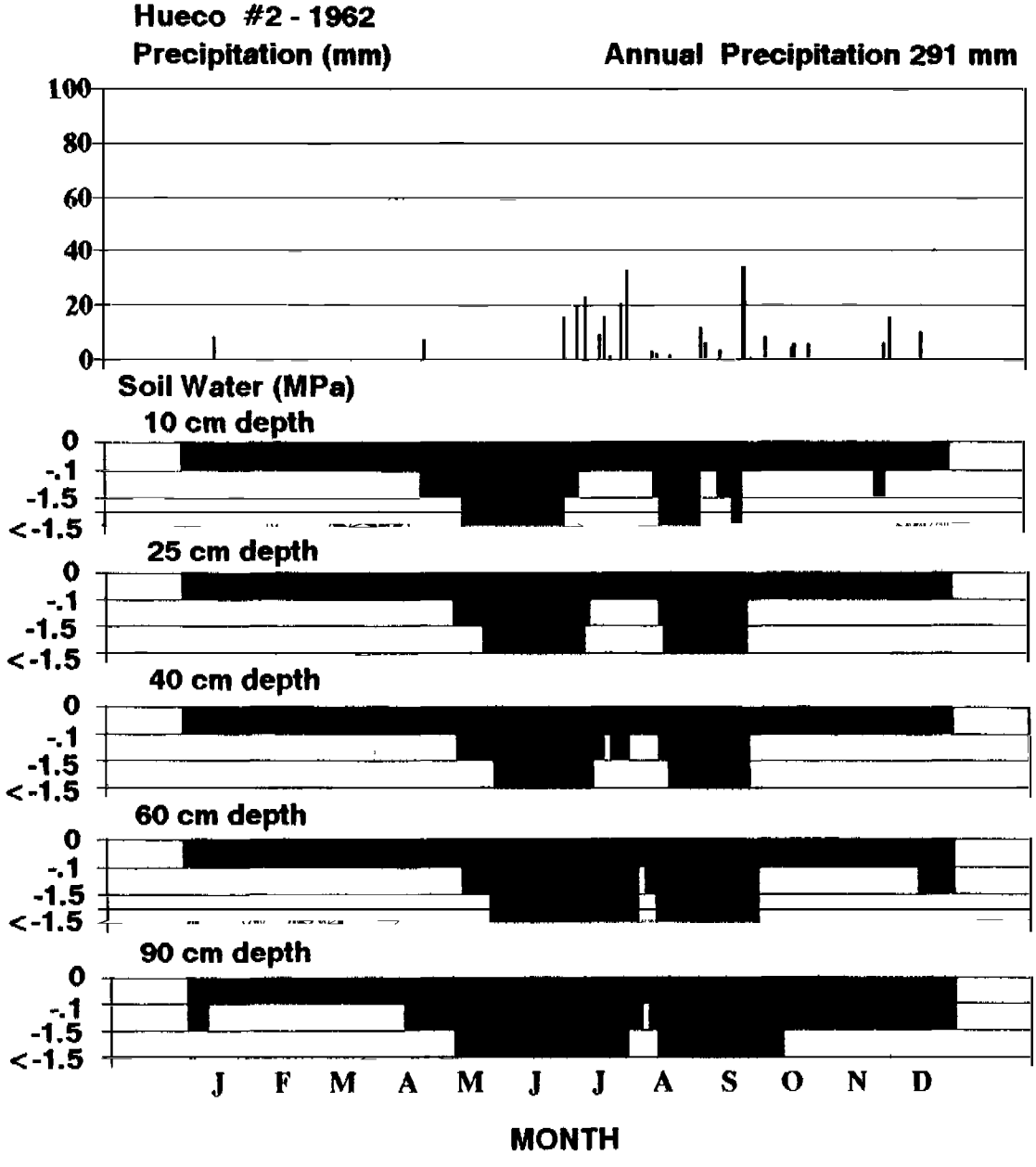


Figure 81. Annual precipitation (291 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1962.

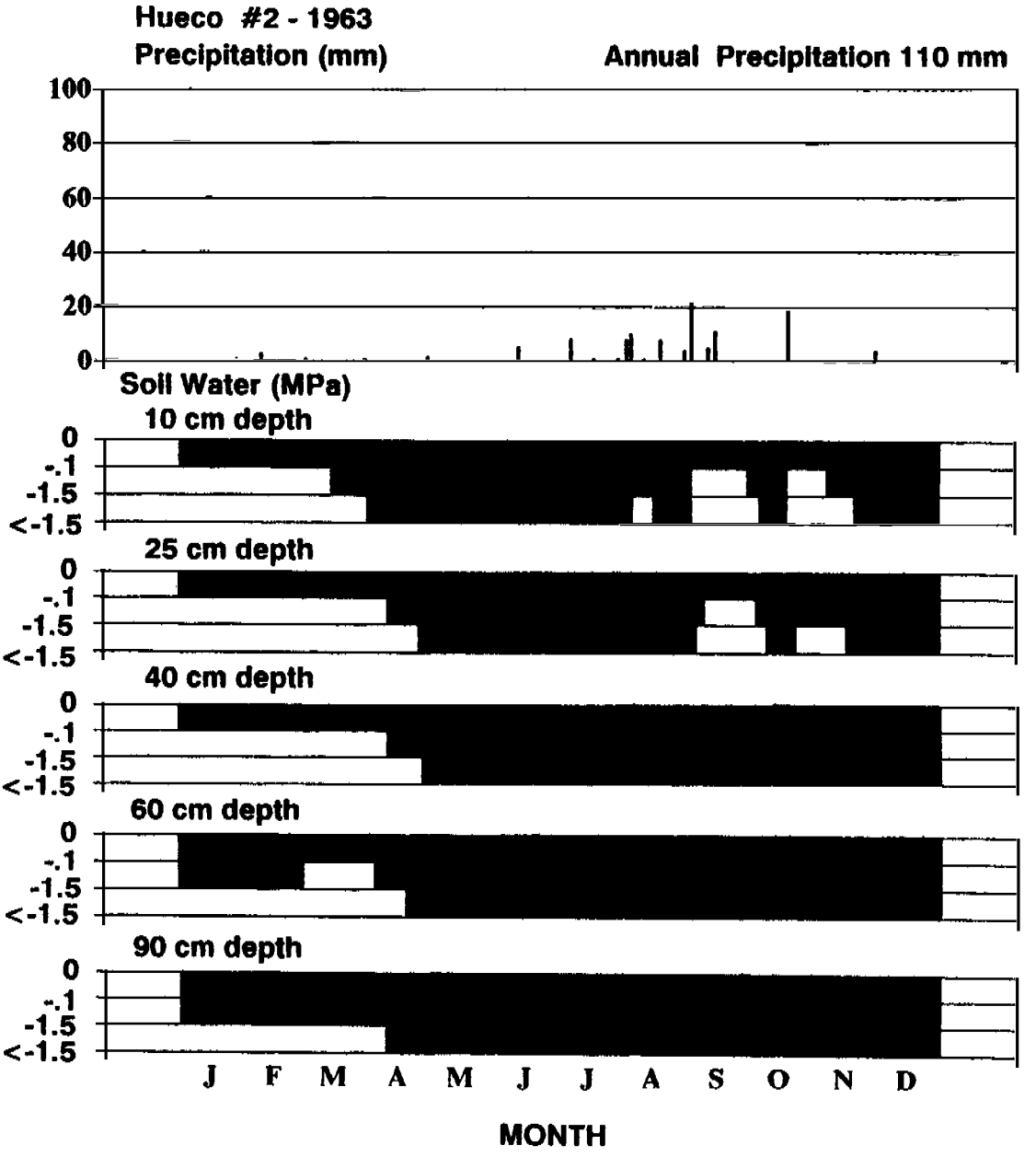


Figure 82. Annual precipitation (110 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1963.

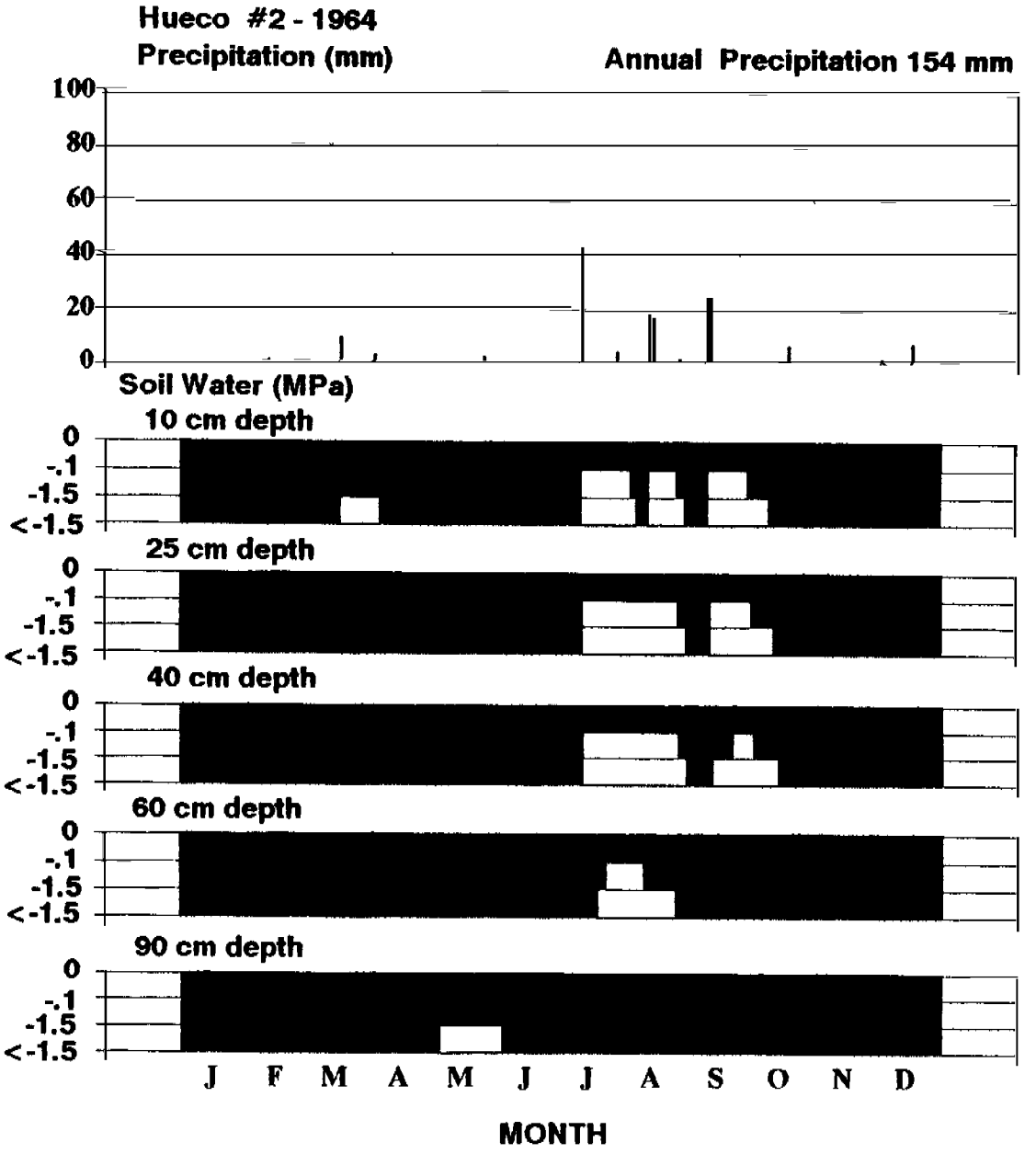


Figure 83. Annual precipitation (154 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1964.

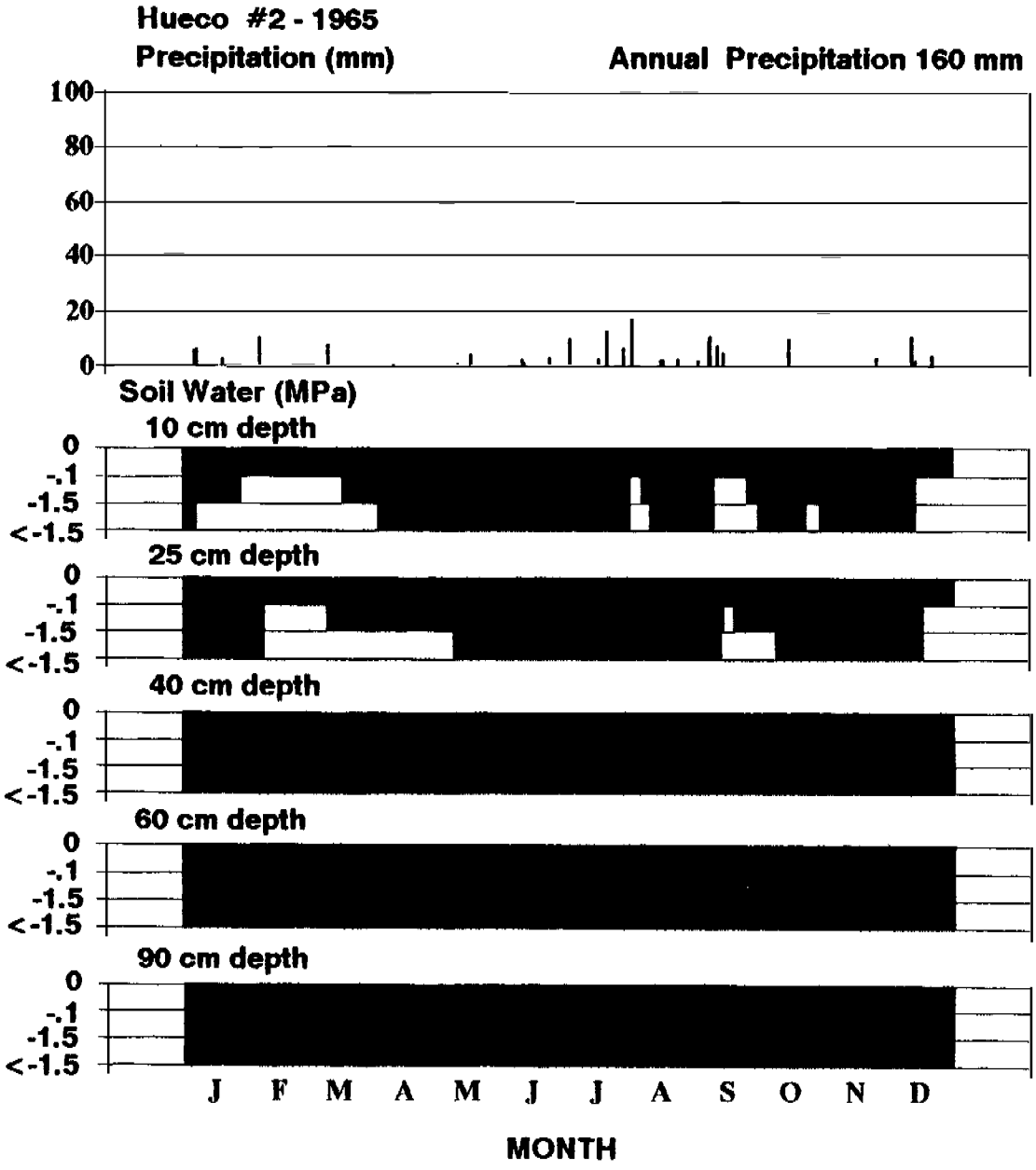


Figure 84. Annual precipitation (160 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1965.

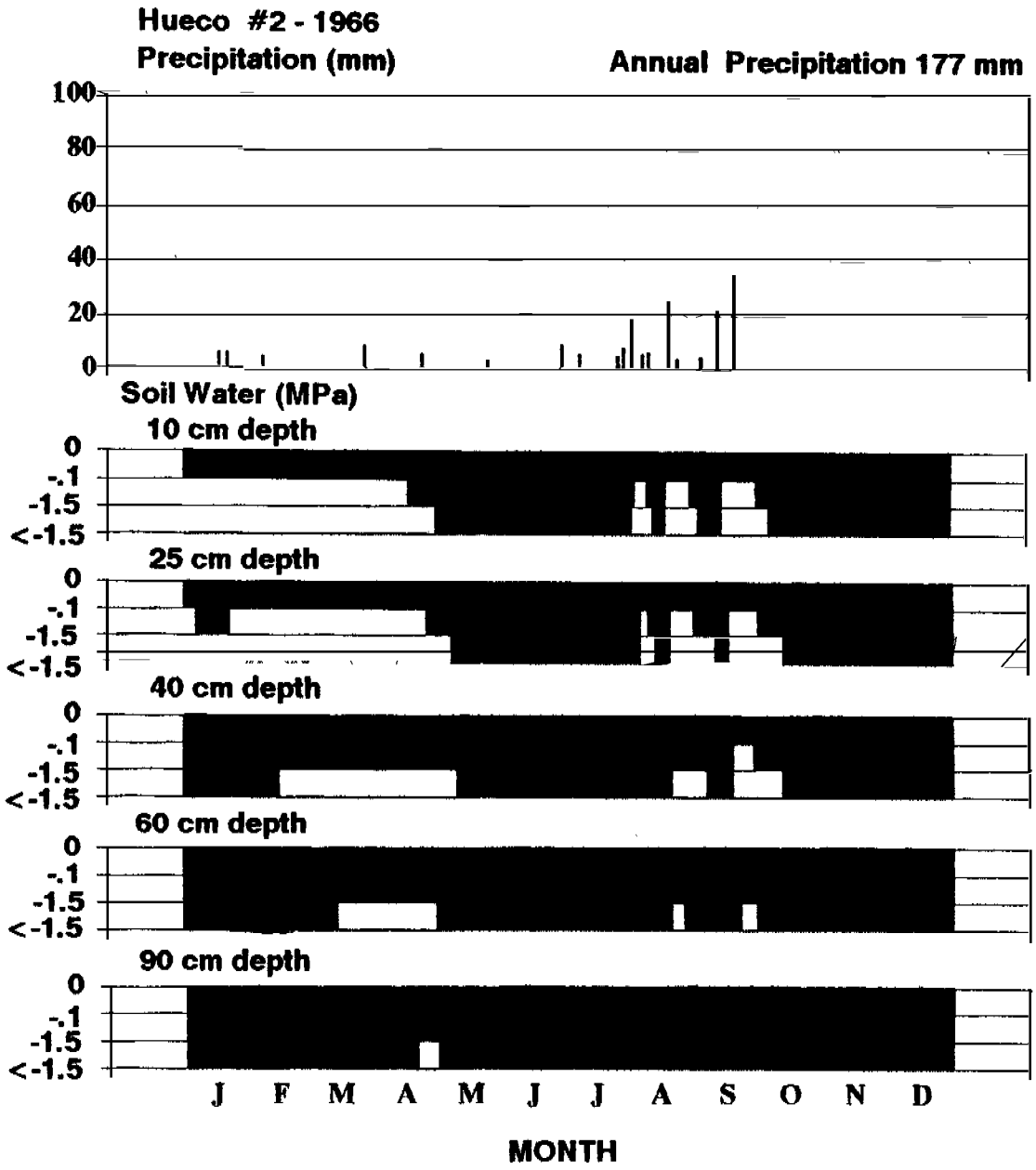


Figure 85. Annual precipitation (177 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1966.

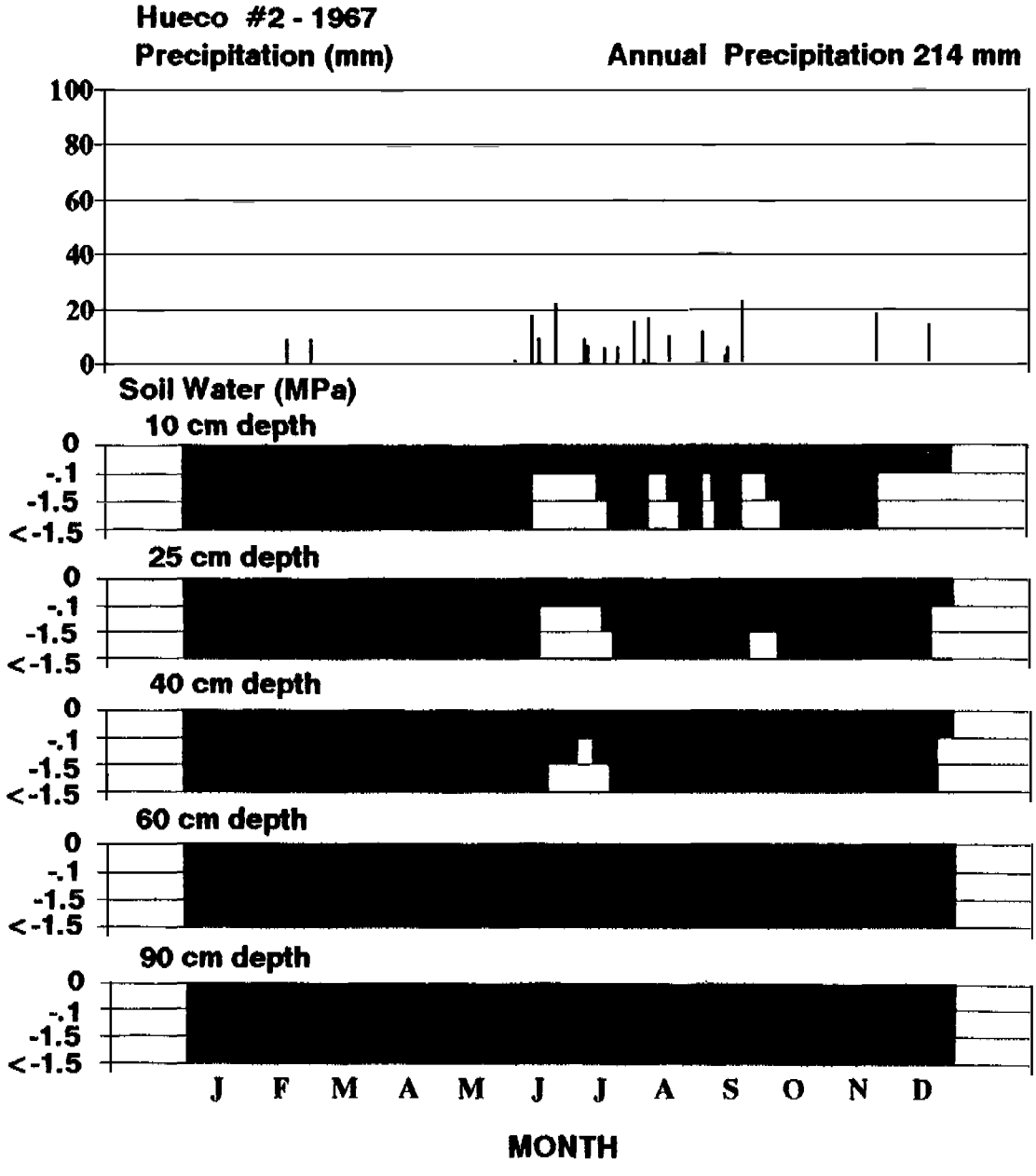


Figure 86. Annual precipitation (214 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1967.

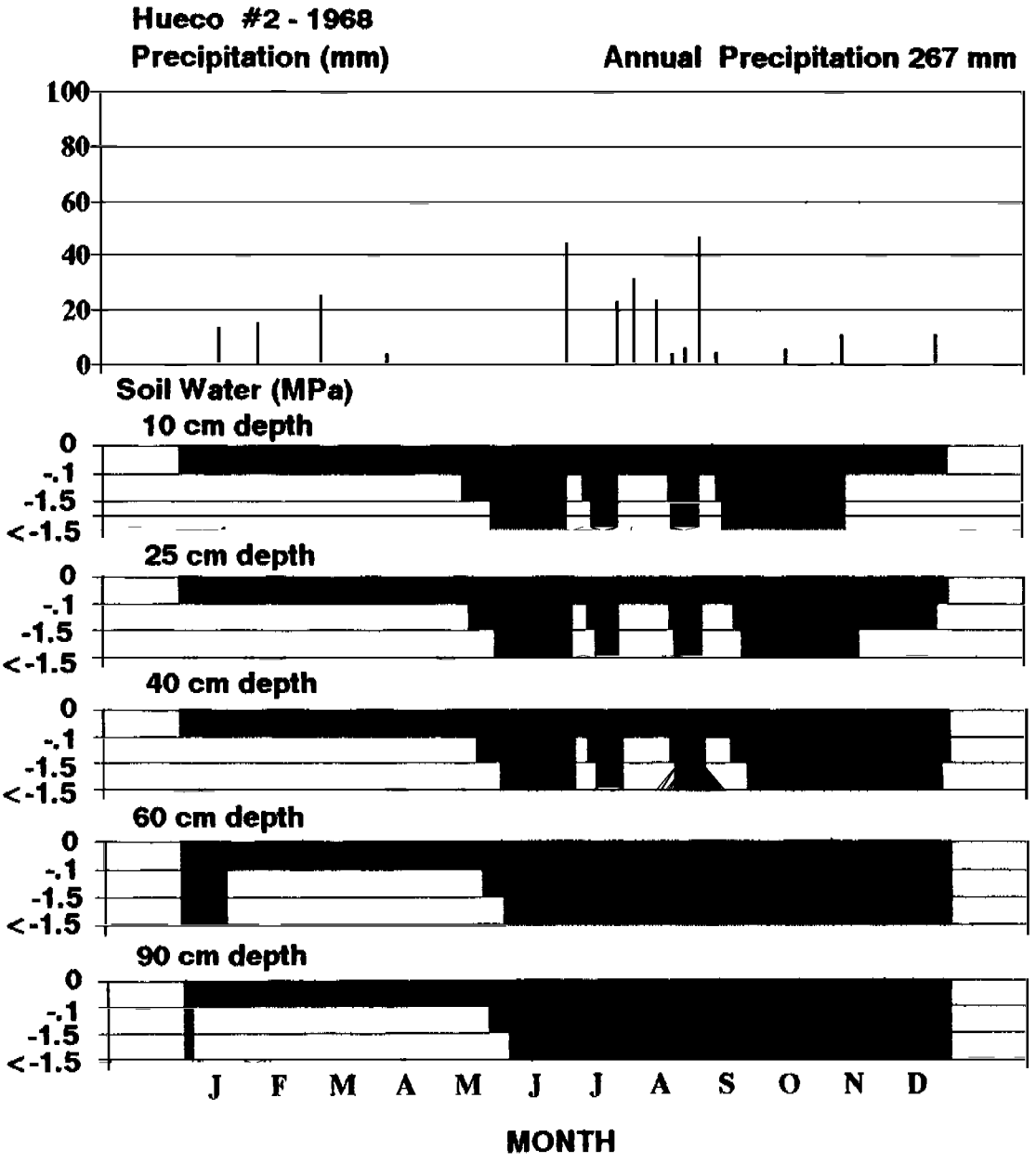


Figure 87. Annual precipitation (267 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1968.

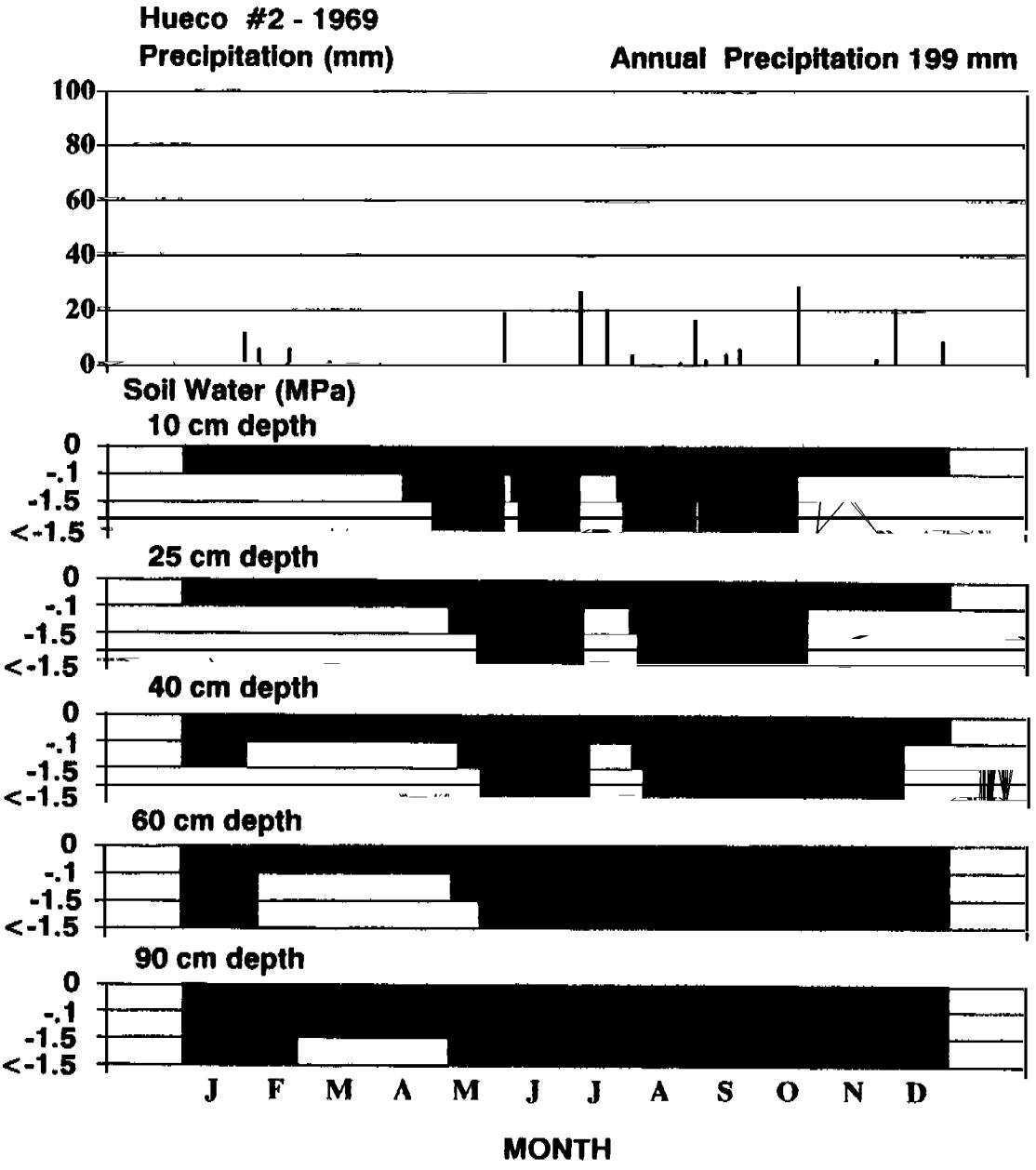


Figure 88. Annual precipitation (199 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1969.

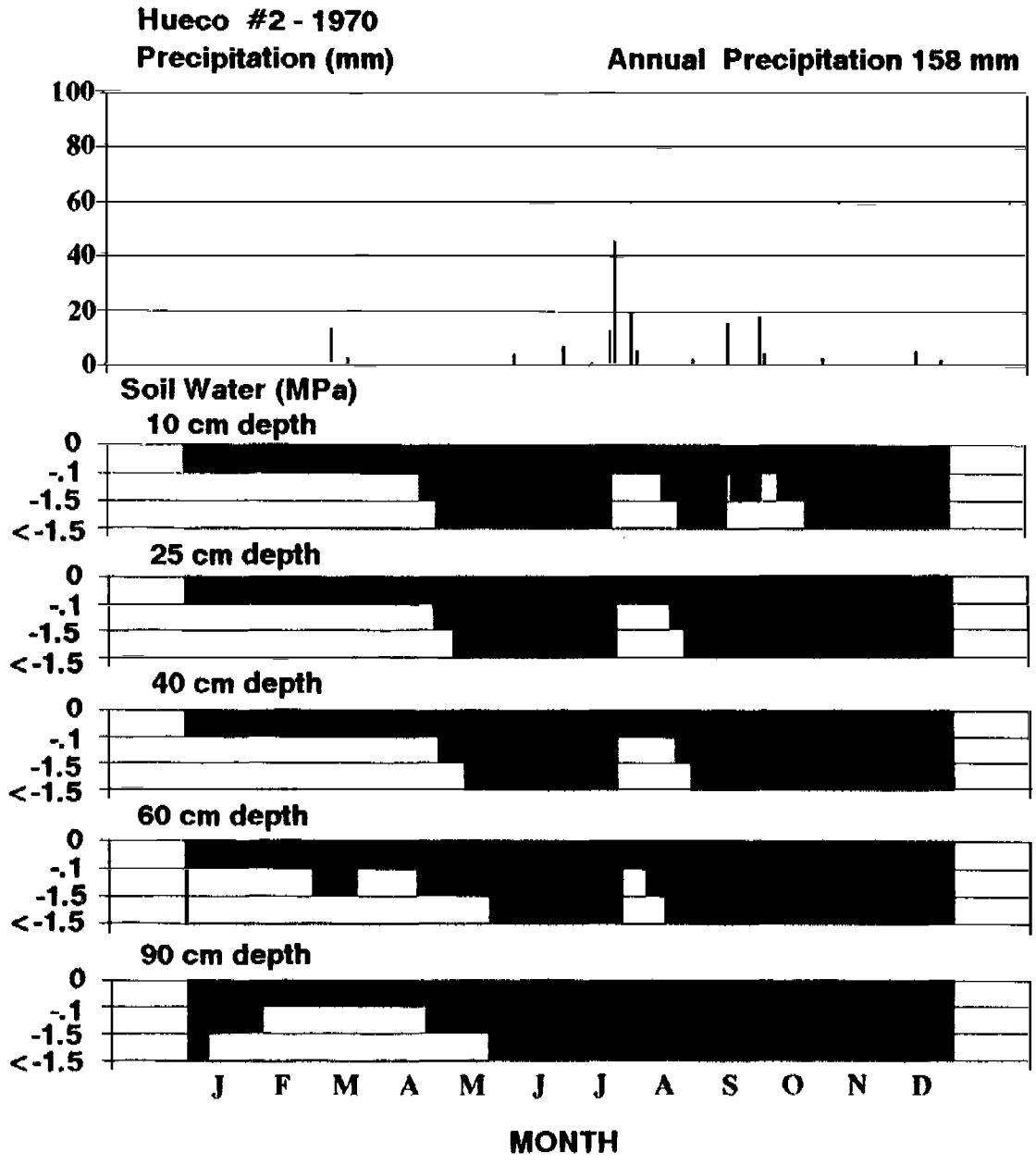


Figure 89. Annual precipitation (158 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1970.

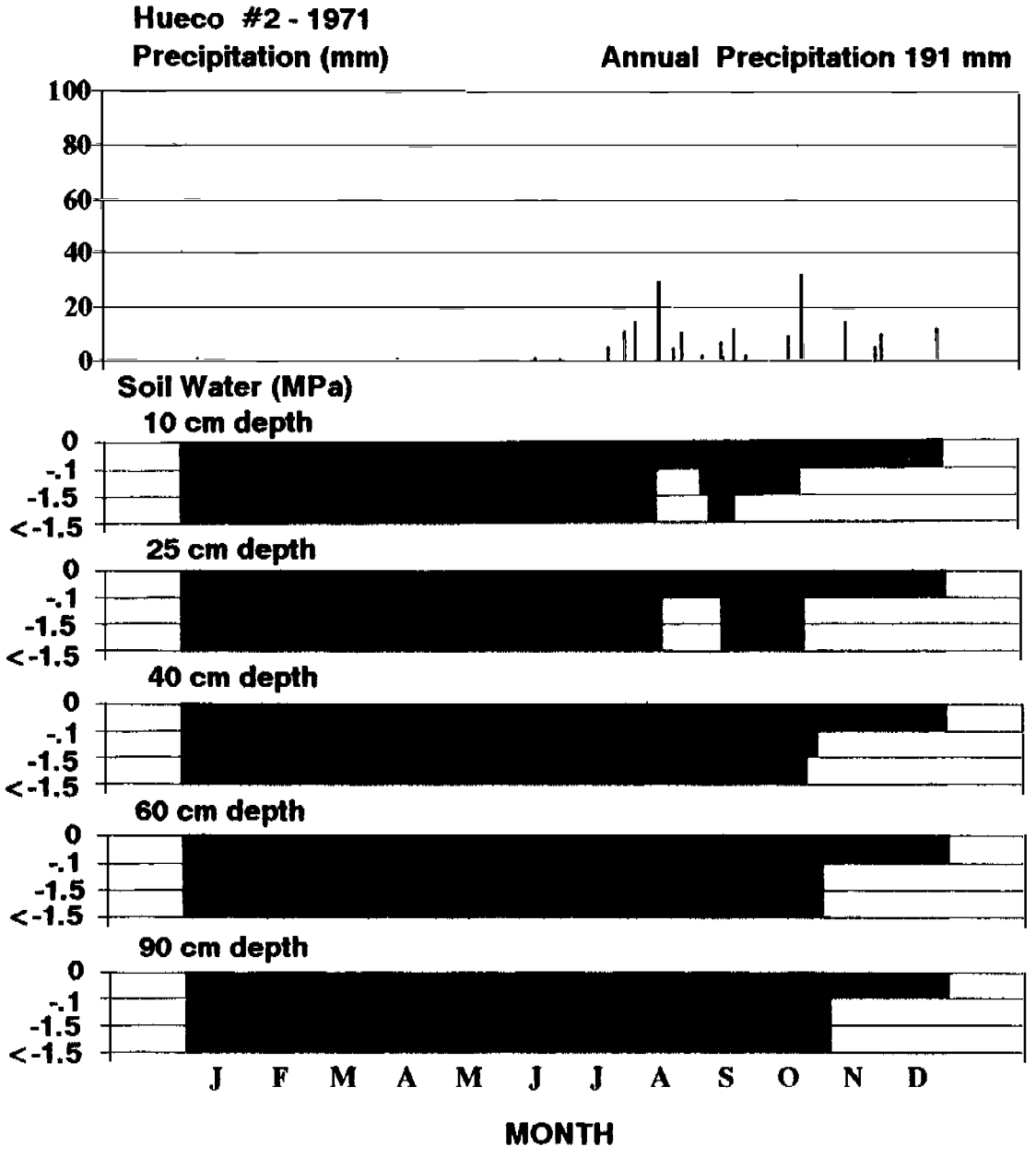


Figure 90. Annual precipitation (191 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1971.

addition, there was some soil water >-1.5 MPa at other depths and times during these three years (figs. 88-90).

The annual precipitation in 1972 was above average but the ohmmeter was inoperative August 1-December 31, 1972. The control section had soil water >-1.5 MPa January 1-April 28 from wet conditions during fall 1971, and also June 13-20 (fig. 91). The significant rainfall August-December, 1972, was 20 mm August 7-8, 29 mm on August 28, 15 mm on September 3, and 49 mm October 21-22.

The precipitation in 1973 was below average. The 25-cm depth had soil water >-1.5 MPa January 6-June 8, June 16-July 3, July 20-August 11, and August 30-September 7 (fig. 92). The fall was quite dry.

The annual precipitation in 1974 was considerably above average but the winter-spring was quite dry except for 18 mm precipitation on January 10 (fig. 93). The significant rainfall after that was 60 mm July 15, 43 mm July 31, 29 mm August 4, 44 mm September 21, 84 mm October 29, 25 mm November 30, and 17 mm December 25. The control section had soil water >-1.5 MPa July 15-September 6 (54 days) and September 23-December 31 (fig. 93).

The annual precipitation for both 1975 and 1976 was about average but the soil water pattern was much different. There was considerable soil water >-1.5 MPa during the winter-spring of 1975 (fig. 94). The control section had soil water >-1.5 MPa January 1-April 2, July 19-August 11, and September 7-October 21, 1975 (fig. 94). In 1976, there was some soil water -0.1 to -1.5 MPa in the winter and spring (fig. 95). The control section (25-cm depth) had soil water -0.1 to -1.5 MPa February 23-April 23, September 14-October 4, November 30-December 6, and December 14-31 (fig. 95). The storm of 46 mm on July 17, 1975 and the storms in early September 1975 resulted in soil water >-0.1 MPa whereas the lighter but more frequent storms in 1976 did not. Also illustrated in fig. 95 is the movement of soil water in 1976 between the 90-cm soil depth and deeper soil depths. The soil water determinations were terminated December 31, 1976.

The average precipitation for the study period, August 1, 1957 through December 31, 1976, excluding August 1-December 31, 1972, was 222 mm. An average of 137 mm of this precipitation occurred July-September. Figure 96 shows the probability of soil water ≥-1.5 MPa at the five depths during the study period. The probability of soil water ≥-1.5 MPa at the 25-cm depth averaged 68.5% for December-April, 21.7% for May-June, 47.2% for July-September, and 46.8% for October-November.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, nine of 20 years had soil water <-1.5 MPa more than half the time at 10 cm; 11 of 20 years at 25 and 40 cm; 14 of 18 years at 60 cm, and 15 of 18 years at a depth of 90 cm. Six of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 5 of 20 years at 25 cm; 7 of 20 years at 40 cm; 8 of 18 years at 60 cm; and 9 of 18 years at a soil depth of

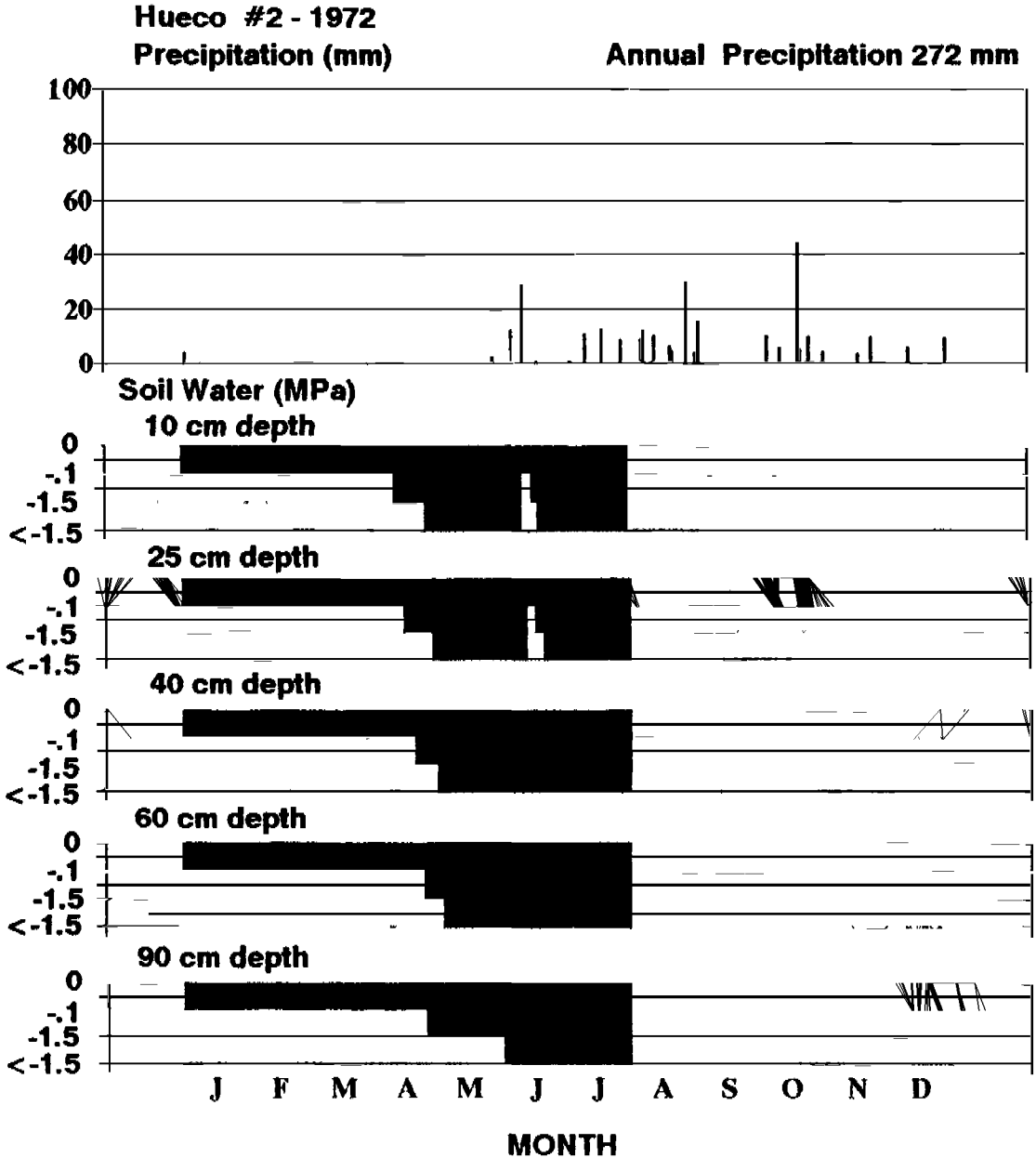


Figure 91. Annual (272 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm for January 1-August 1, 1972 at the Hueco #2 site.

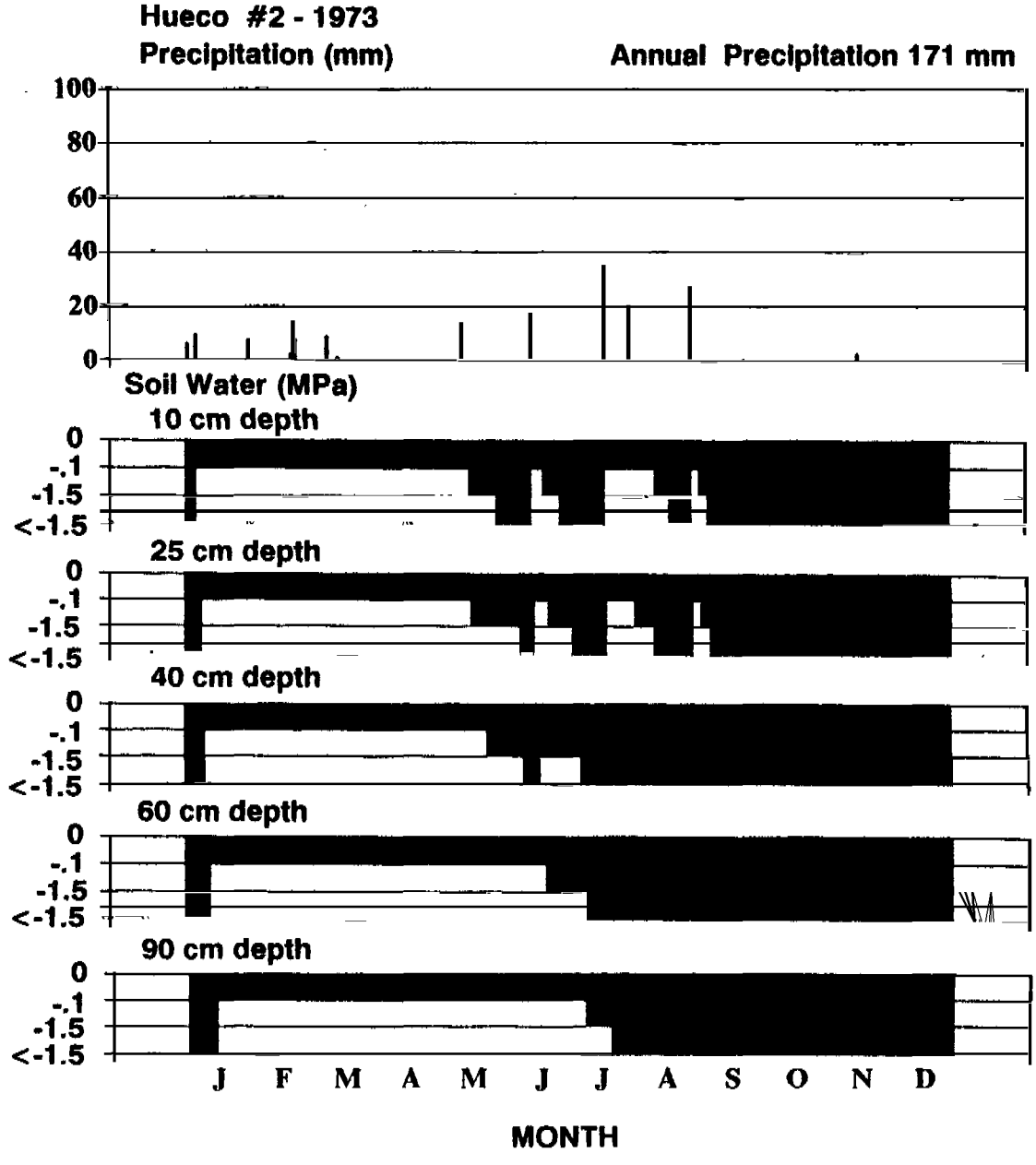


Figure 92. Annual precipitation (171 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1973.

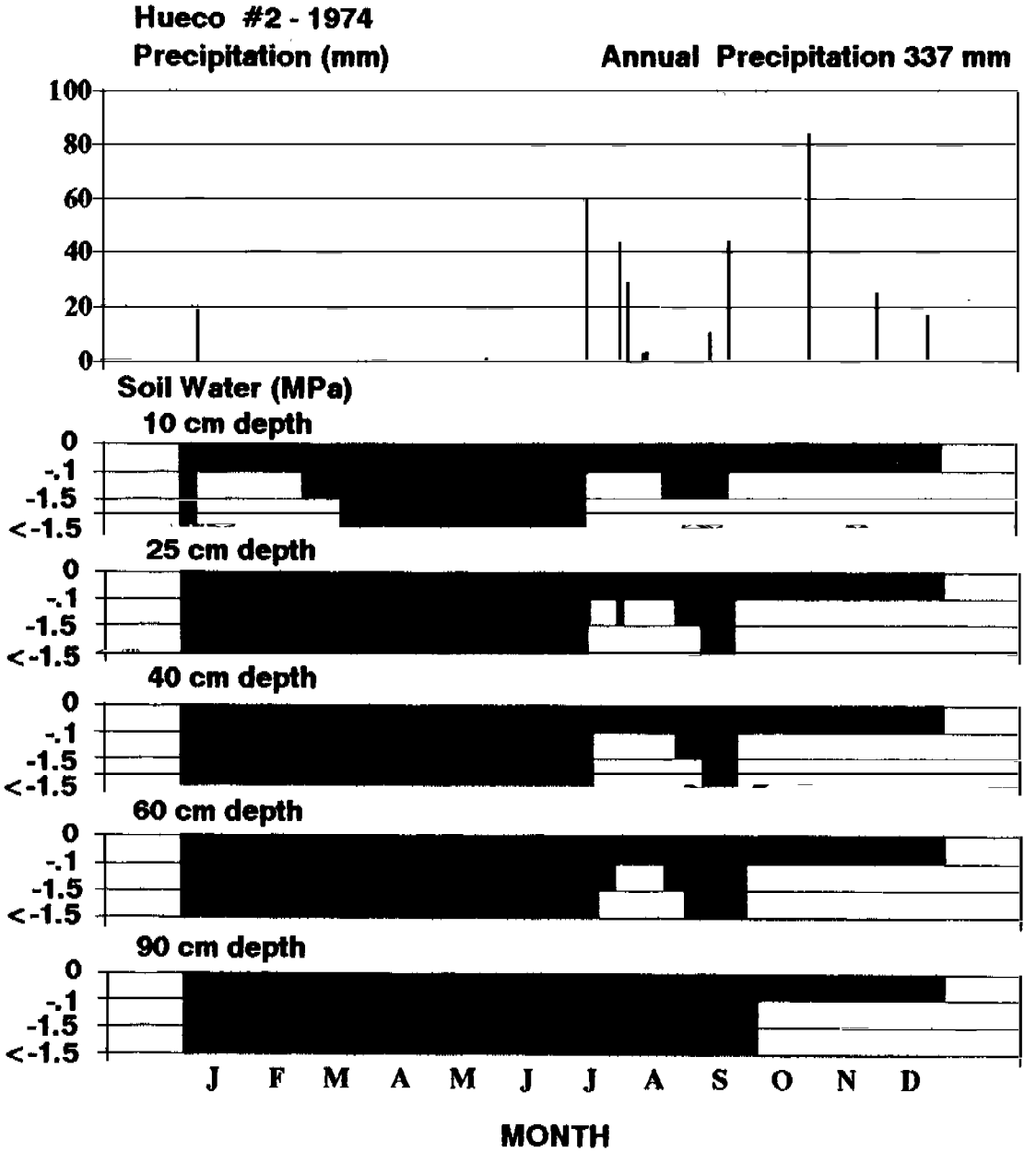


Figure 93. Annual precipitation (337 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1974.

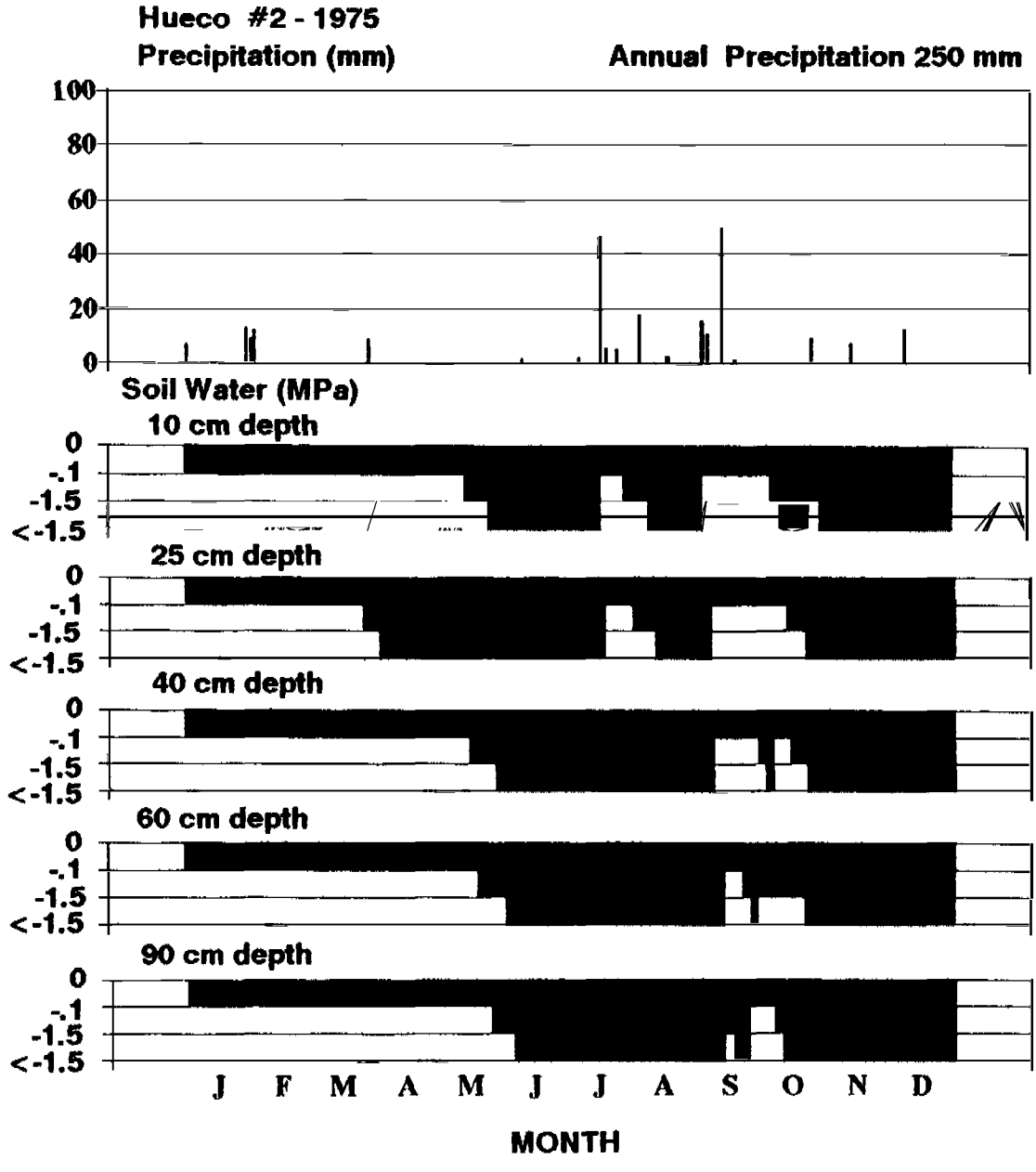


Figure 94. Annual precipitation (250 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1975.

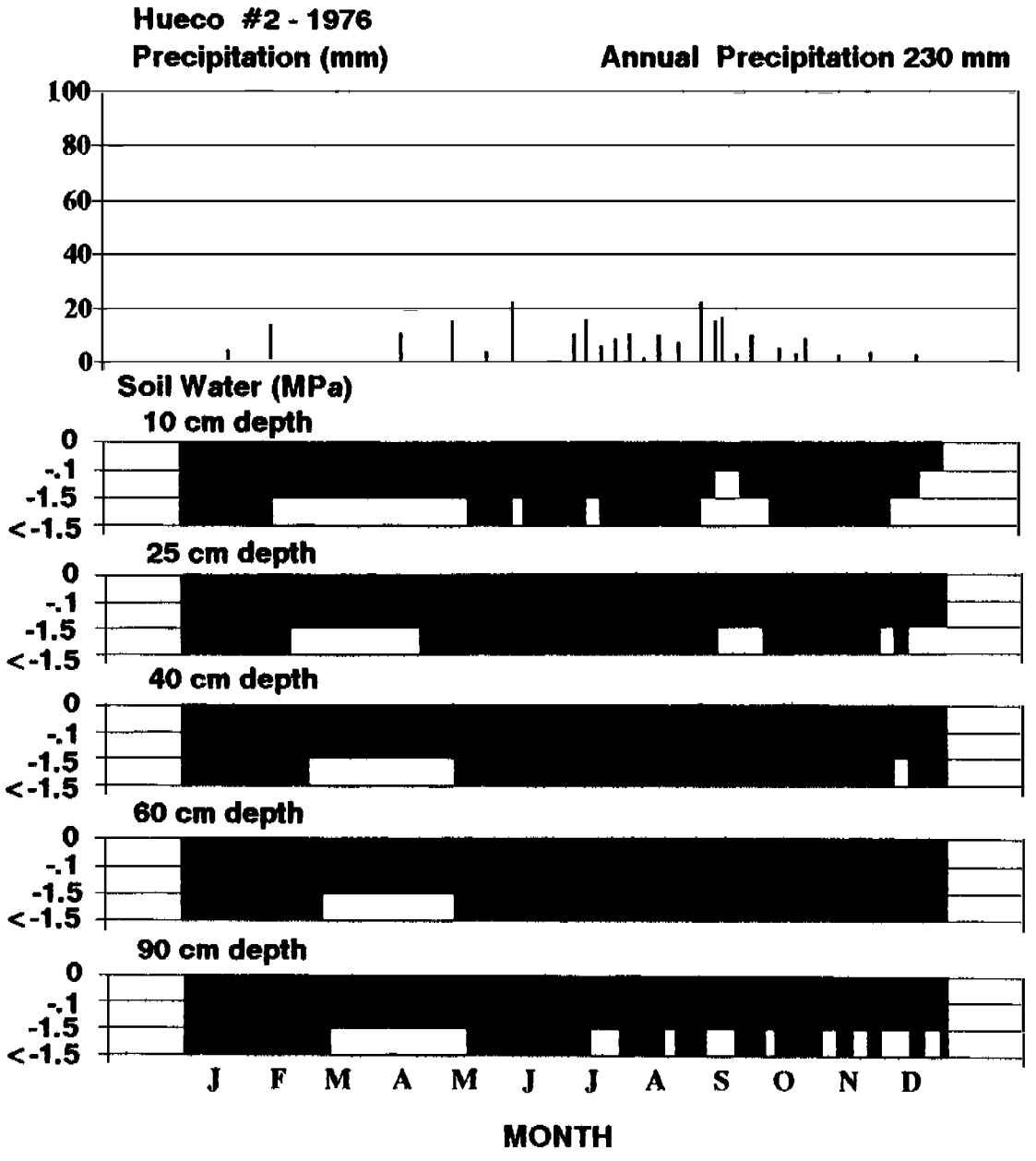


Figure 95. Annual precipitation (230 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site for 1976.

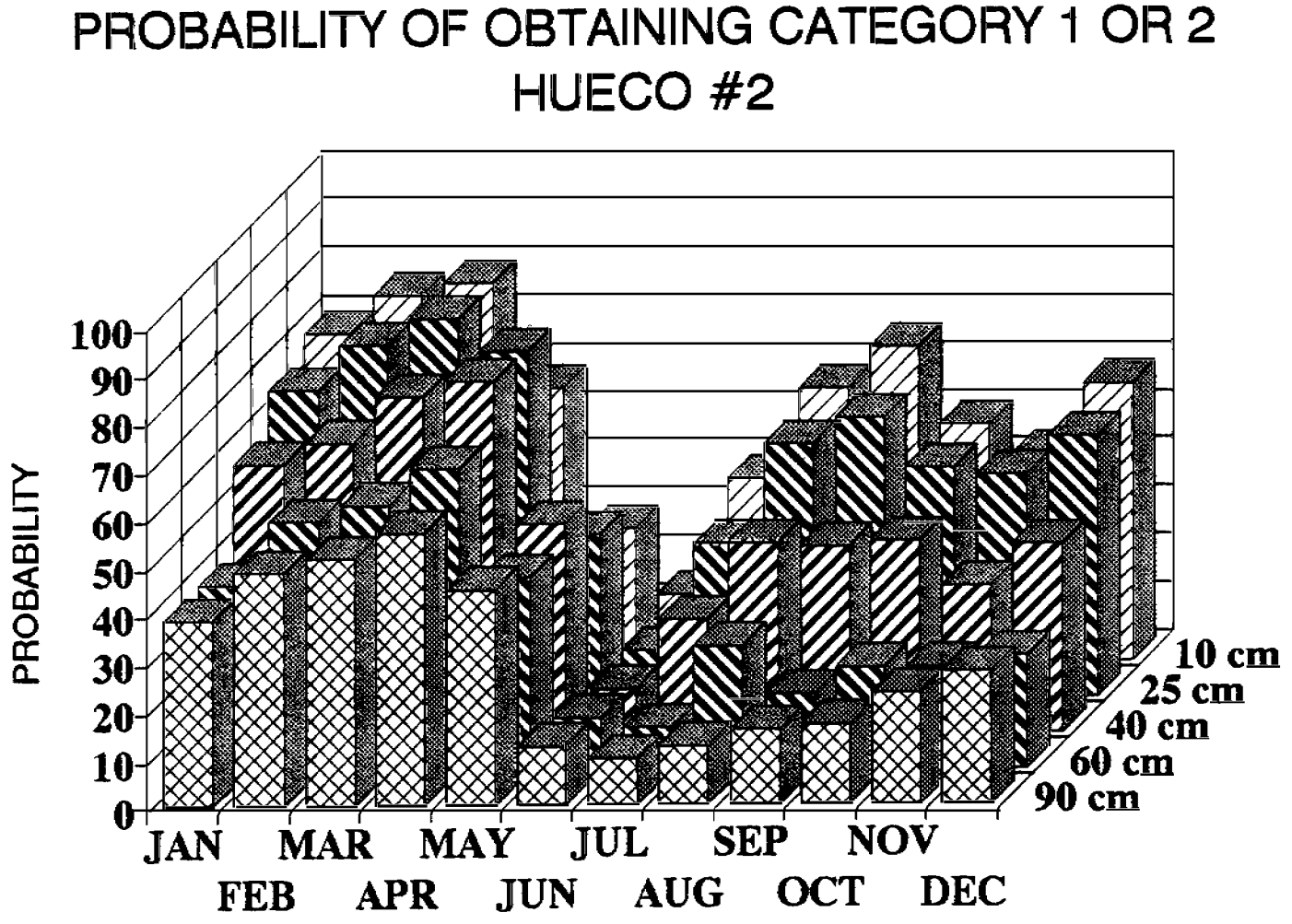


Figure 96. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 60, and 90 cm at the Hueco #2 site.

90 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 17 of 20 years and >30 consecutive days within 4 months after June 21, 12 of 20 years.

Site Hueco #3 (H3)

Site H3 (figs. 4, 97, 98, table 8) is in the Ber exclosure on th Jornada Experimental Range. The sampled pedon is 1.2 m east of th east fence of the exclosure, and near the soil water blocks (fig. 97). The perennial vegetation is mainly black grama, fluffgrass (*Erioneuron pulchellum* [H. B. K.] Tateoka), broom snakeweed, mesa dropseed, mesquite, and soaptree yucca.

Soils. The soil water blocks are in the Petrocalcic Paleargid Hueco #3 (fig. 98, table 8). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a petrocalcic horizon. Hueco #3 is on La Mesa surface of middle Pleistocene age (table 1) and has formed in sandy fluvial sediments of the Camp Rice Formation. The site occurs on a very slight ridge, and is virtually level.

A large pipe (cf. Gile et al., 1981, study area 6, for a diagram and discussion of one of the pipes in these ancient soils of La Mesa surface) was found near the moisture blocks with an auger. The moisture blocks extend to a depth of 68 cm where they rest on the petrocalcic horizon. All around the blocks, at distances ranging from about 1/2 to 1 m away from them, depth to the petrocalcic horizon is greater than 125 cm. Thus the soil moisture blocks apparently rest on a high in the microrelief of the pipe. The soil in the pipe has a fine sandy loam Bt horizon and is in the Sonoita series (see also Site S). The black grama is well developed, and there appears to be little or no difference in the vegetation of soils in the pipe and soils adjacent to the pipe. As with shallow and moderately deep petrocalcic horizons, the fine sandy loam Bt horizon tends to retain soil water for use by grasses, and prevents its loss to deeper horizons.

The soil is noncalcareous to 36 cm depth and is wetted fairly frequently to that depth. Carbonate is currently accumulating in the Btkb horizon and probably the horizons below, including the top of the petrocalcic horizon, because soil water reaches them at times (figs. 99-115). Pebbles in the very gravelly K1b horizon consist of calcrete fragments, derived by weathering from the underlying petrocalcic horizon.

Soil Water, Precipitation, and Yields. The gypsum resistance blocks were installed at the soil depths of 10, 25, 40, 53, and 69 cm on September 12, 1960 within a livestock exclosure at Ber Rain Gauge. The annual precipitation for 1960 was 143 mm. The average annual yield of perennial grasses was 177 kg/ha (n=15, s.e.=21 kg/ha). The grass stand in this area was about 85% black grama. There was soil water >-1.5 MPa at the 25-cm depth in September and October (fig. 99). Rainfall of 32 mm on December 11, 1960 and subsequent precipitation in January, 1961 gave soil water >-1.5 MPa at the 25-cm depth until June 12, 1961 (figs. 99, 100).

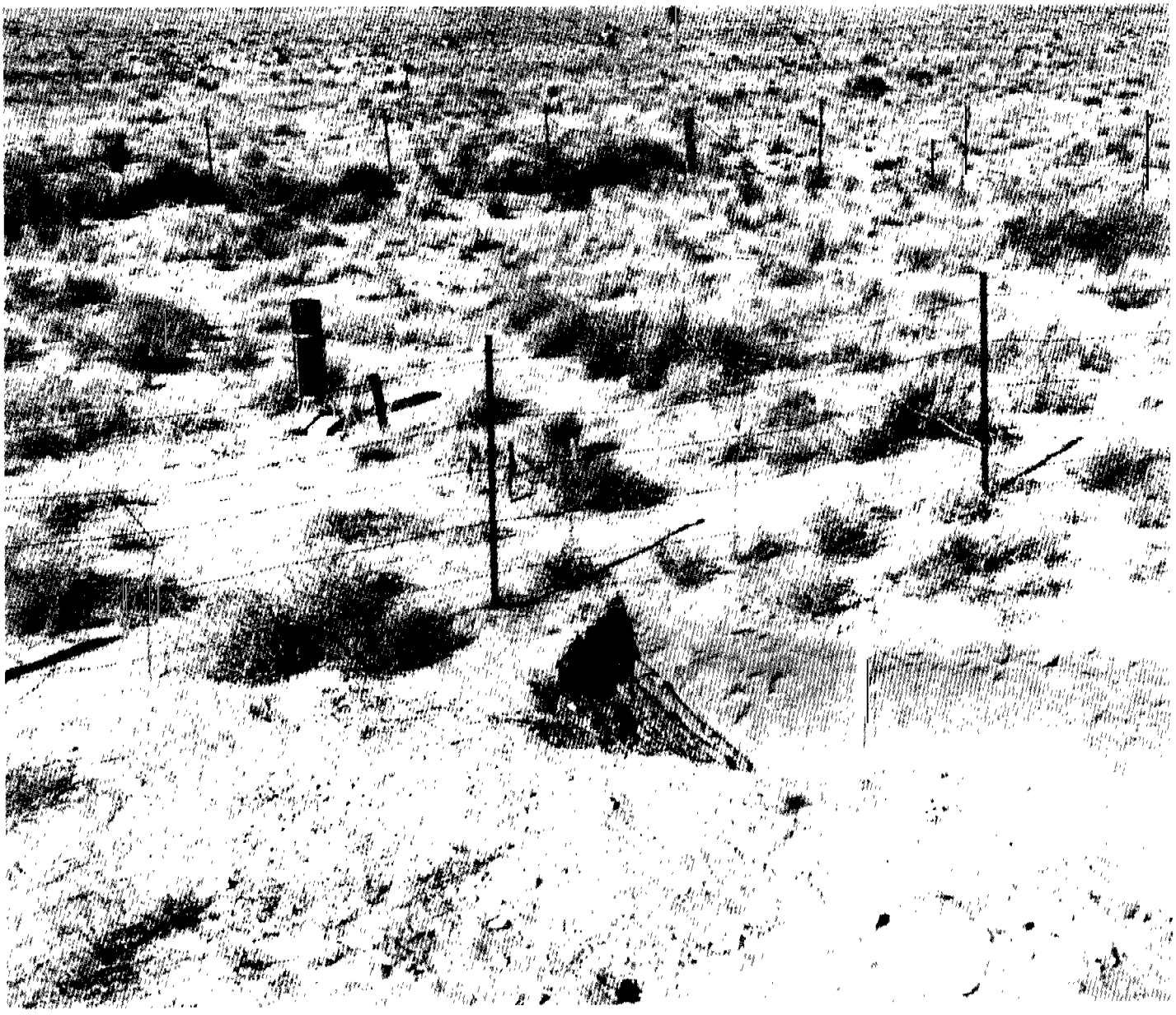


Figure 97. Landscape at Site H3 (fig. 4) and the Petrocalcic Paleargid Hueco #3, in the Ber exclosure on the Jornada Experimental Range. The nonrecording rain gauge and stakes and wires to the soil water blocks are inside the fence. Photographed November 1970.

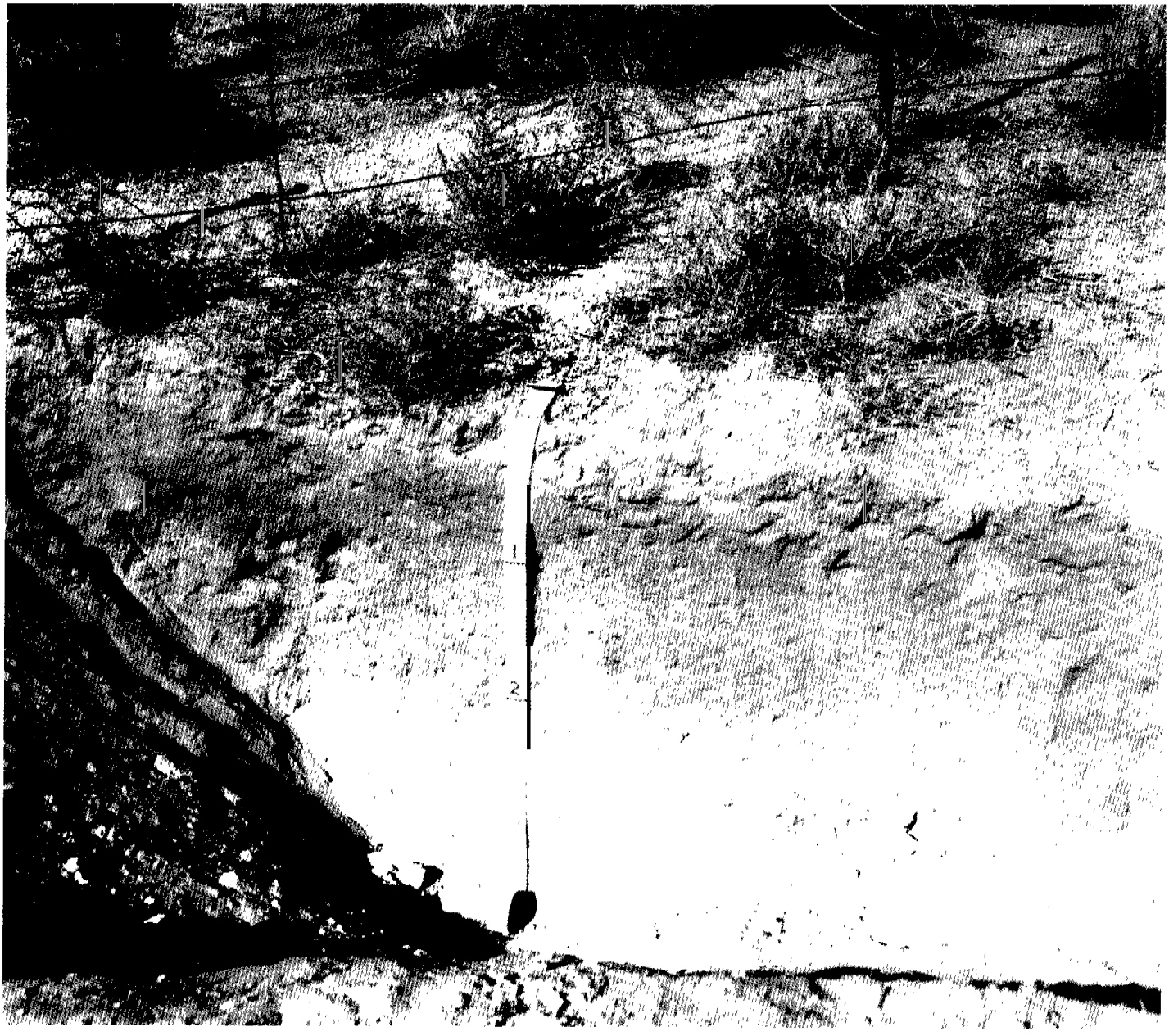


Figure 98. Profile of upper horizons of the Petrocalcic Paleargid Hueco #3. The pedon is thought to be on the margin of a large pipe (see text discussion). Scale is in feet.

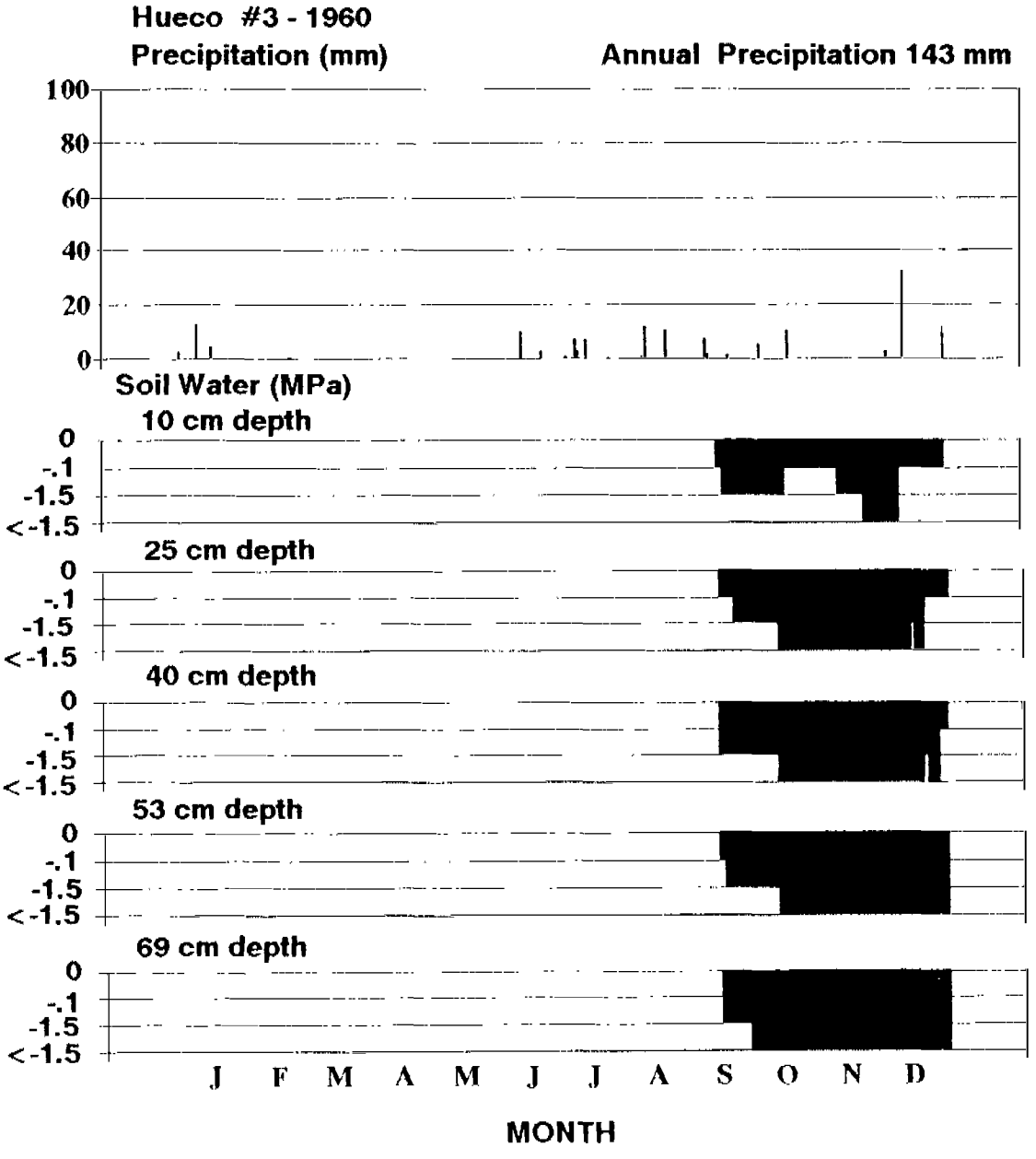


Figure 99. Annual (143 mm) and daily (mm) precipitation for 1960, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm for September 12-December 31, 1960 at the Hueco #3 site.

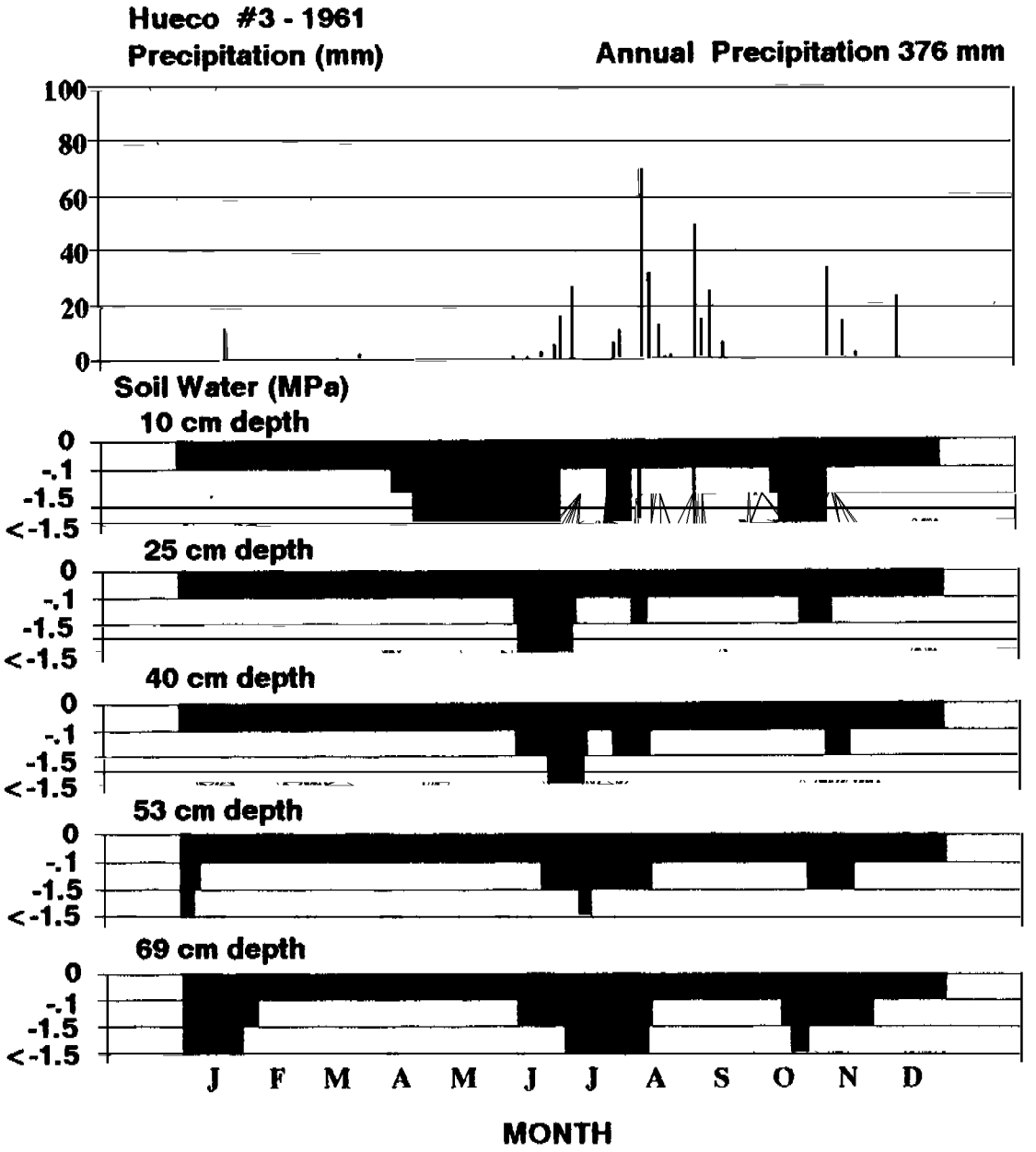


Figure 100. Annual precipitation (376 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1961.

Both 1961 and 1962 could be characterized as wet years. Production of perennial grasses averaged 644 kg/ha in 1961 (n=15, s.e.=44 kg/ha) and 797 kg/ha in 1962 (n=15, s.e.=58 kg/ha). There was continuous soil water >-1.5 MPa at the 25-cm depth July 8, 1961-June 11, 1962 (figs. 100, 101); July 6-29; August 3-9; and September 27, 1962-April 29, 1963 (figs. 101, 102).

Precipitation for the next four years, 1963-66, was below average. Production of perennial grasses averaged 336 kg/ha in 1963 (n=15, s.e.=47 kg/ha), 302 kg/ha in 1964 (n=20, s.e.=39 kg/ha), 182 kg/ha in 1965 (n=20, s.e.=20 kg/ha), and 477 kg/ha in 1966 (n=20, s.e.=40 kg/ha). There was soil water >-1.5 MPa at the 25-cm depth August 14-September 30, 1963 (fig. 102); October 21-November 9, 1963; March 19-April 15, 1964 (fig. 103); July 13-August 30, 1964; September 12-October 8, 1964; February 9-April 30, 1965 (fig. 104); September 19-November 4, 1965; December 10, 1965-May 14, 1966 (figs. 104, 105); and August 8-October 2, 1966. The reduction in perennial grass yields in 1965 was due to no soil water >-1.5 MPa at the 25-cm or deeper depths in July or August (fig. 104).

Precipitation in 1967 was 240 mm (fig. 106) but perennial grass yields were only 145 kg/ha (n=20, s.e.=21 kg/ha). These low yields are due to dry conditions in the winter and spring and sporadic soil water >-1.5 MPa in the summer (fig. 106).

Production of perennial grasses in 1968 was 181 kg/ha (n=20, s.e.=18 kg/ha). There was soil water >-1.5 MPa at the 25-cm depth November 29, 1967-May 25, 1968 (figs. 106, 107); July 5-27; and July 30-August 22, 1968. These soil water conditions are opposite to those of 1965 but estimates of yields are similar. Growing conditions in 1967 adversely affected perennial grass yields in 1968.

There was soil water >-1.5 MPa at the 25-cm depth November 14, 1968-June 24, 1969 (figs. 107, 108); July 11-August 5; and September 3-25, 1969. Average yield of perennial grasses in 1969 was 372 kg/ha (n=20, s.e.=29 kg/ha). These yields are similar to those obtained in 1963 when there was soil water >-1.5 MPa in the winter and spring and 47 days in August and September (fig. 102).

Yields of perennial grasses averaged 174 kg/ha (n=20, s. .=20 kg/ha) in 1970 and 249 kg/ha (n=20, s.e.=31 kg/ha) in 1971. There was soil water >-1.5 MPa at the 25-cm depth October 22, 1969-May 22, 1970 (figs. 108, 109); July 26-August 29, 1970; October 6-November 9, 1970; and August 10, 1971-May 1, 1972 (figs. 110, 111). These 1970-71 production figures are similar to those obtained in 1964, 1965, 1967, and 1968. Three of the four latter years had some soil water >-1.5 MPa at the 25-cm depth in the spring but all four had sporadic soil water >-1.5 MPa at the 25-cm depth and none or only a few days at deeper depths in the summer.

No soil water data were collected August 1-December 31, 1972 because the ohmmeter was inoperative. Production of perennial grasses determined in October 1972 was 473 kg/ha (n=20, s.e.=57 kg/ha). Production estimates obtained in 1966 and 1972 were similar even though precipitation values were considerably different (figs. 105, 111).

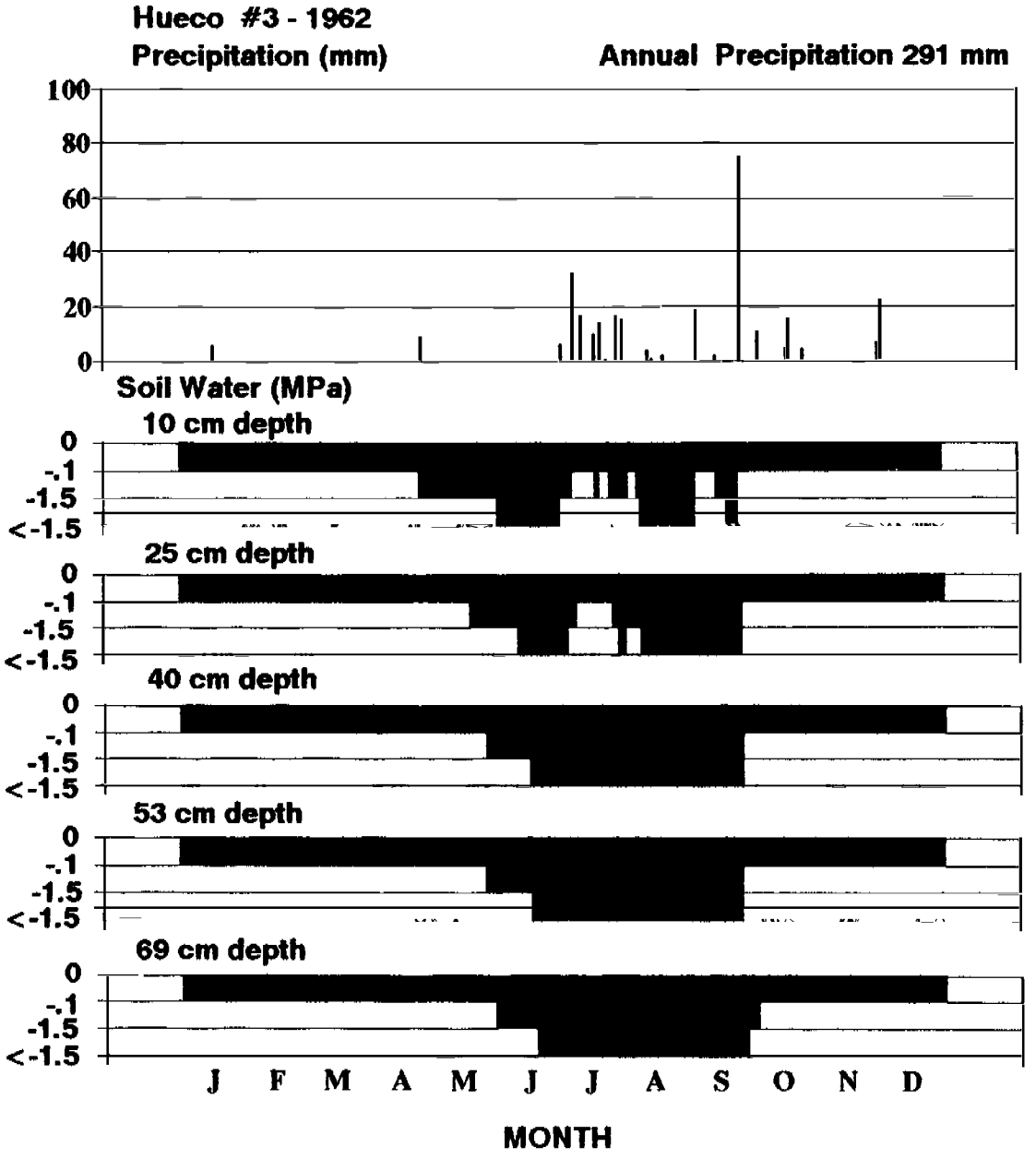


Figure 101. Annual precipitation (291 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1962.

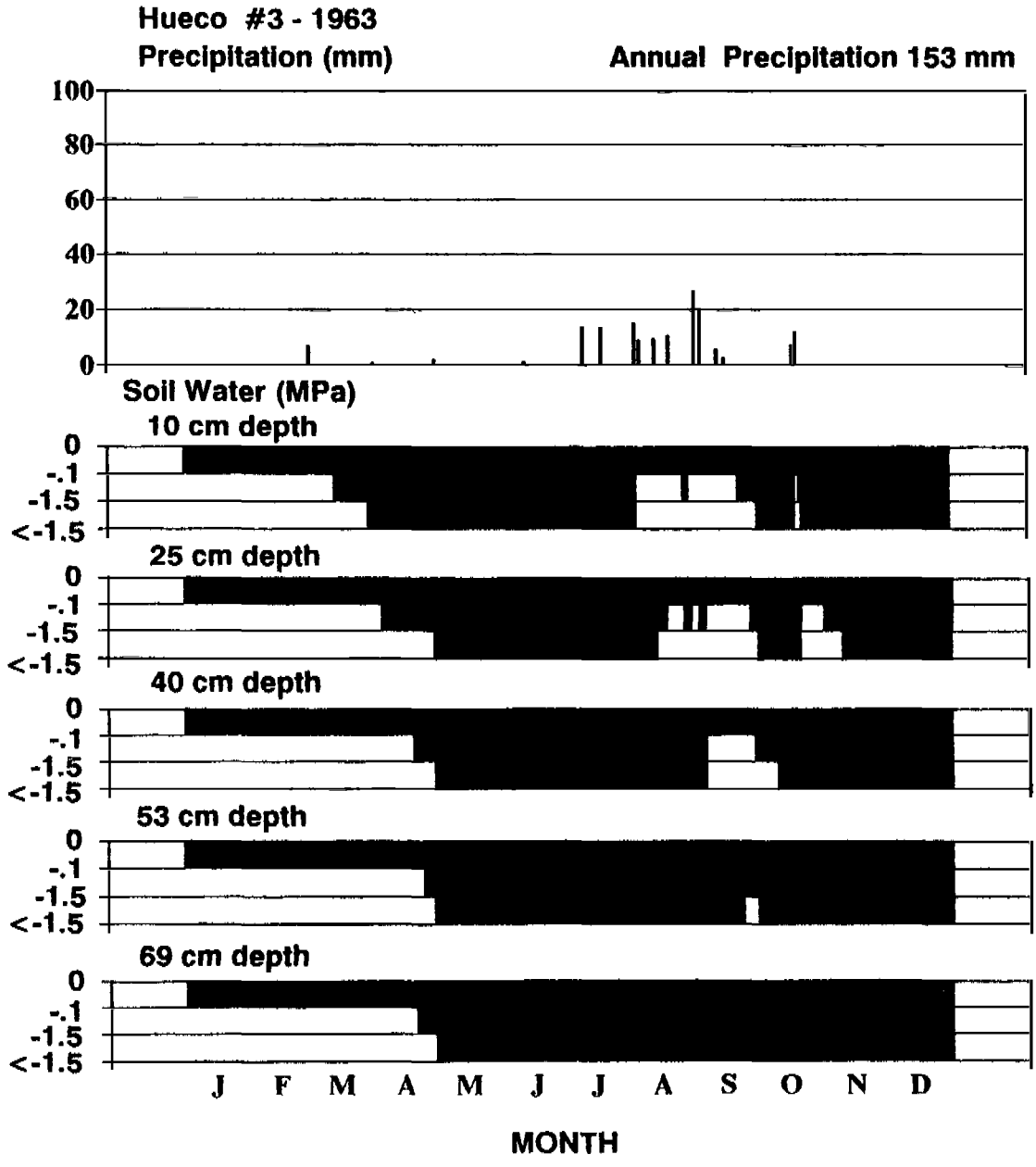


Figure 102. Annual precipitation (153 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1963.

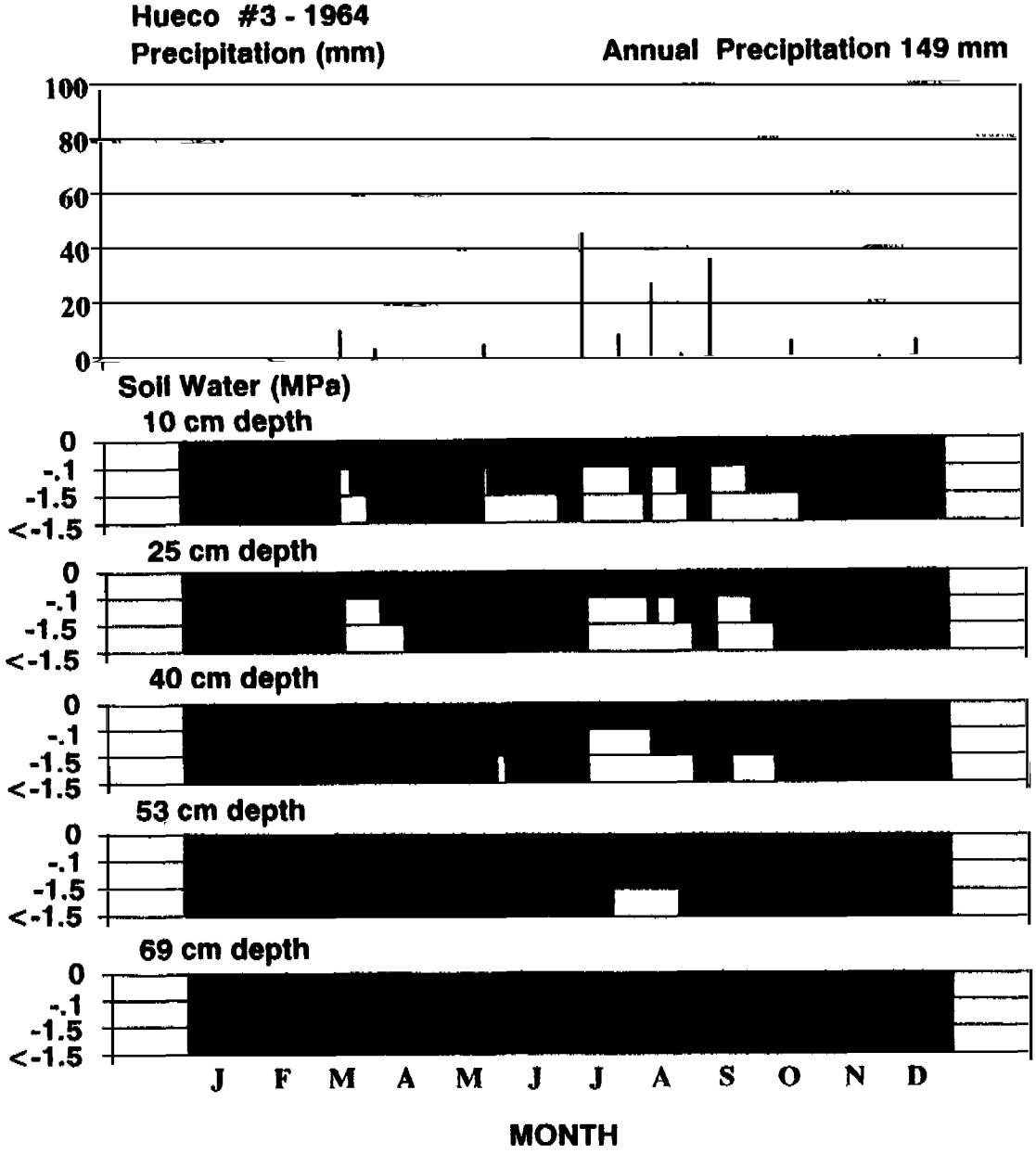


Figure 103. Annual precipitation (149 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1964.

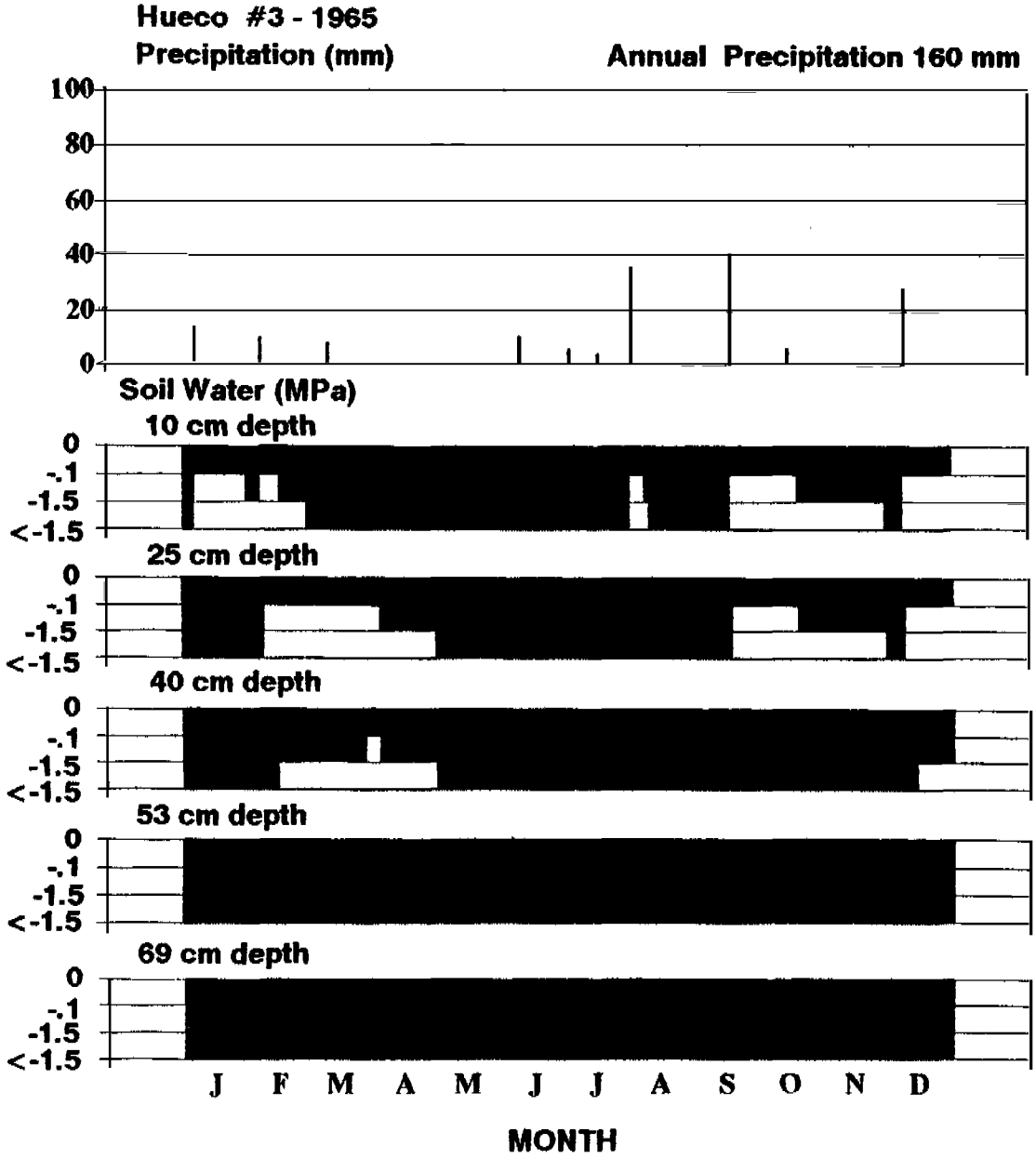


Figure 104. Annual precipitation (160 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1965.

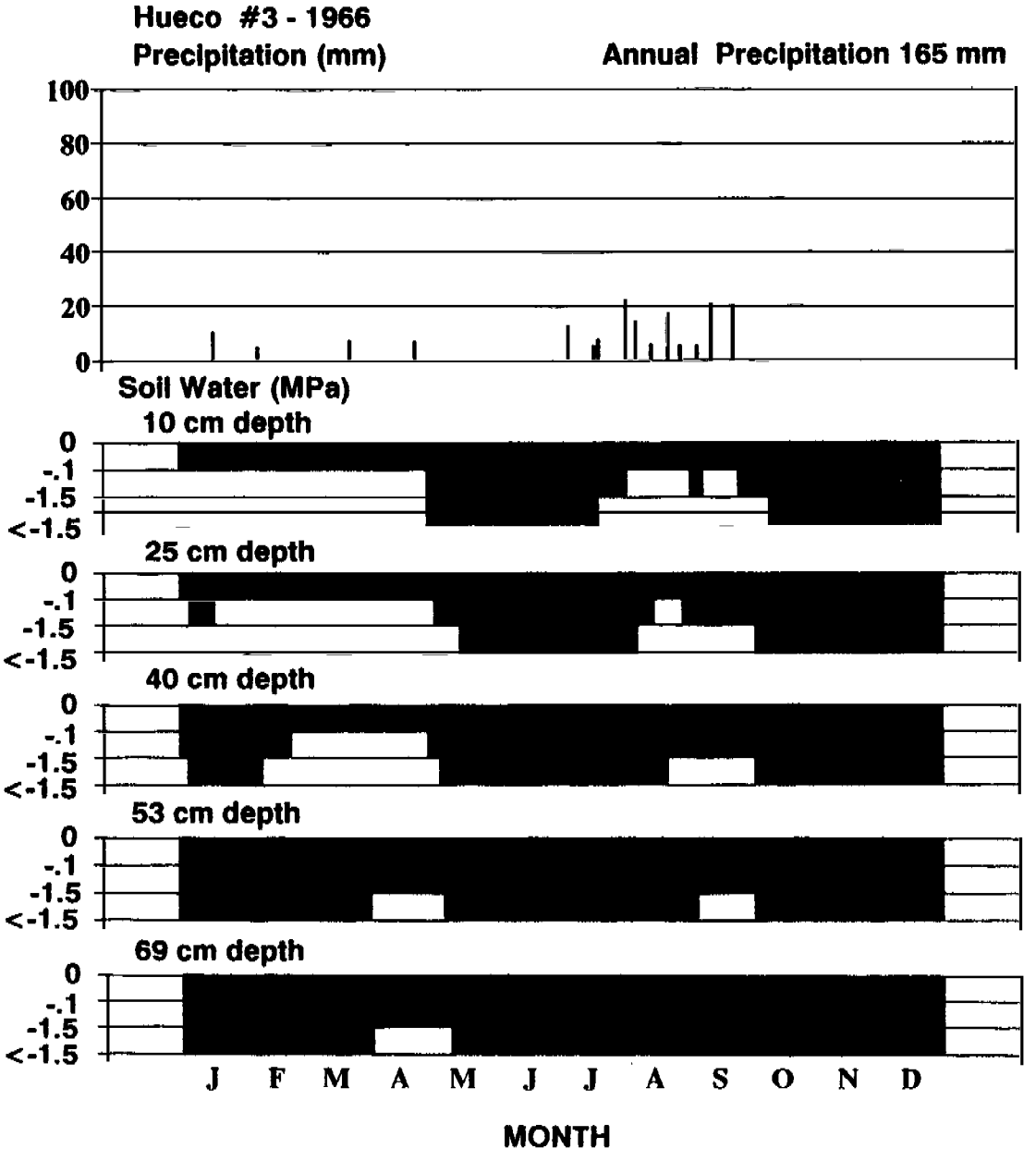


Figure 105. Annual precipitation (165 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1966.

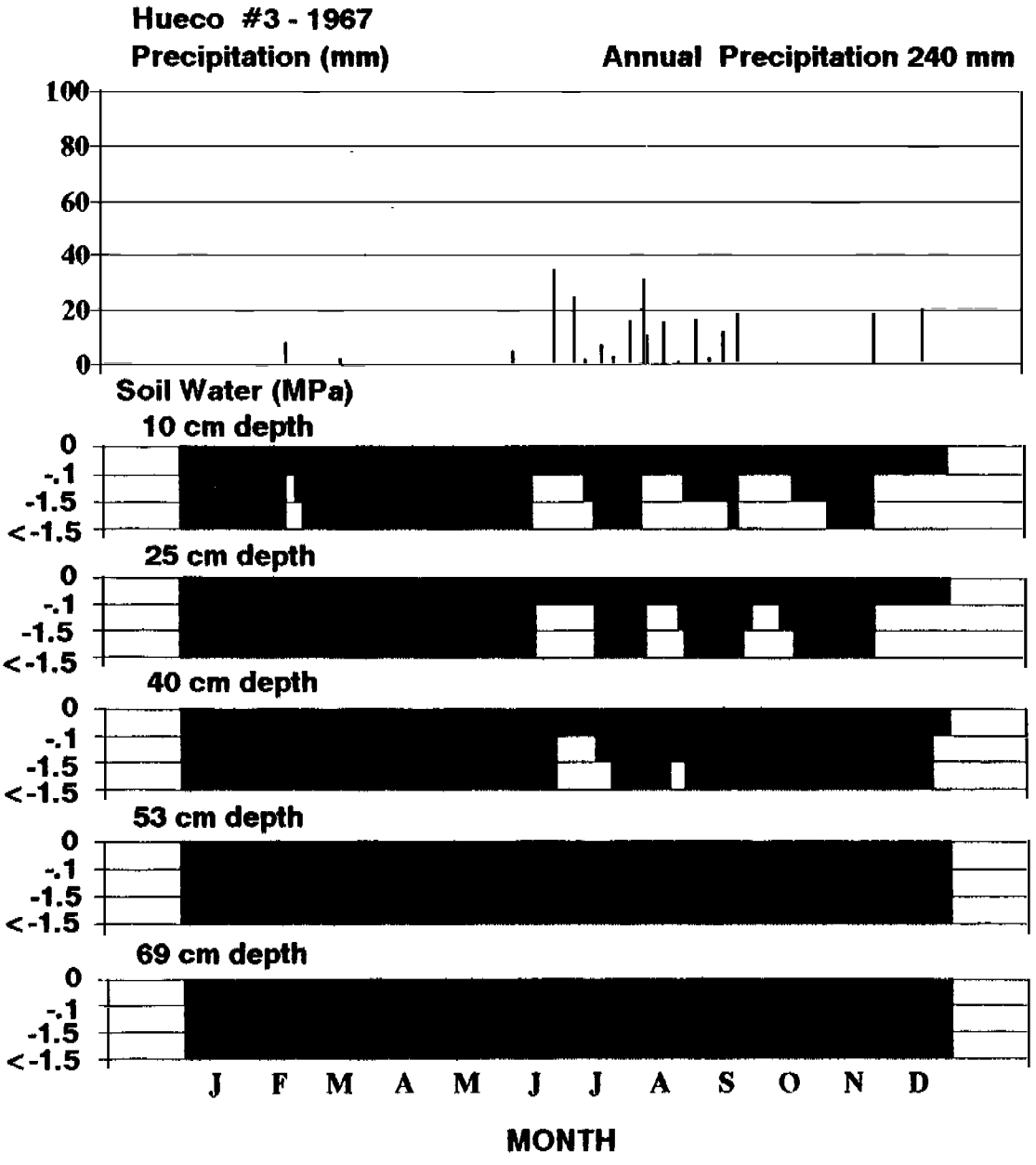


Figure 106. Annual precipitation (240 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1967.

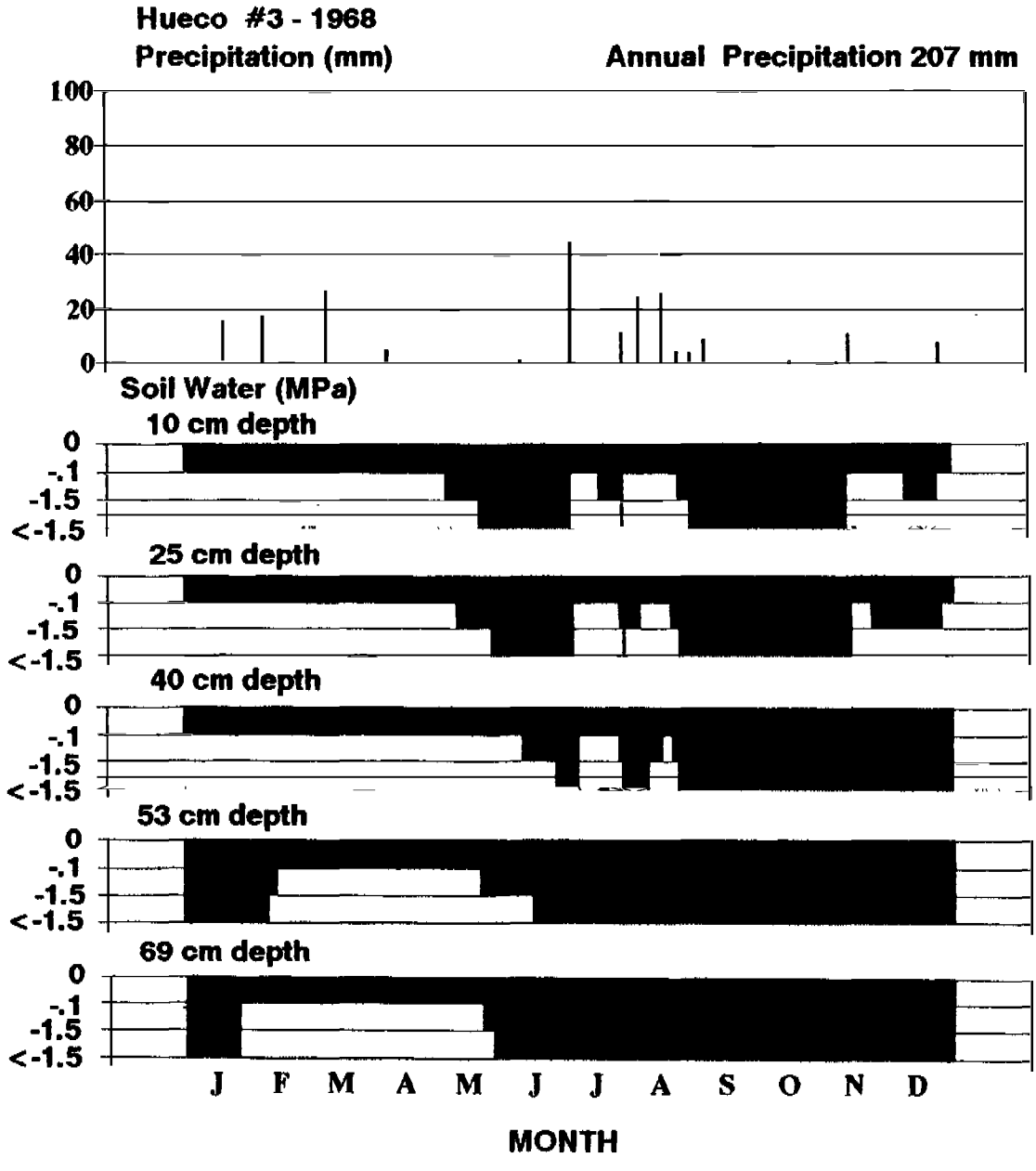


Figure 107. Annual precipitation (207 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1968.

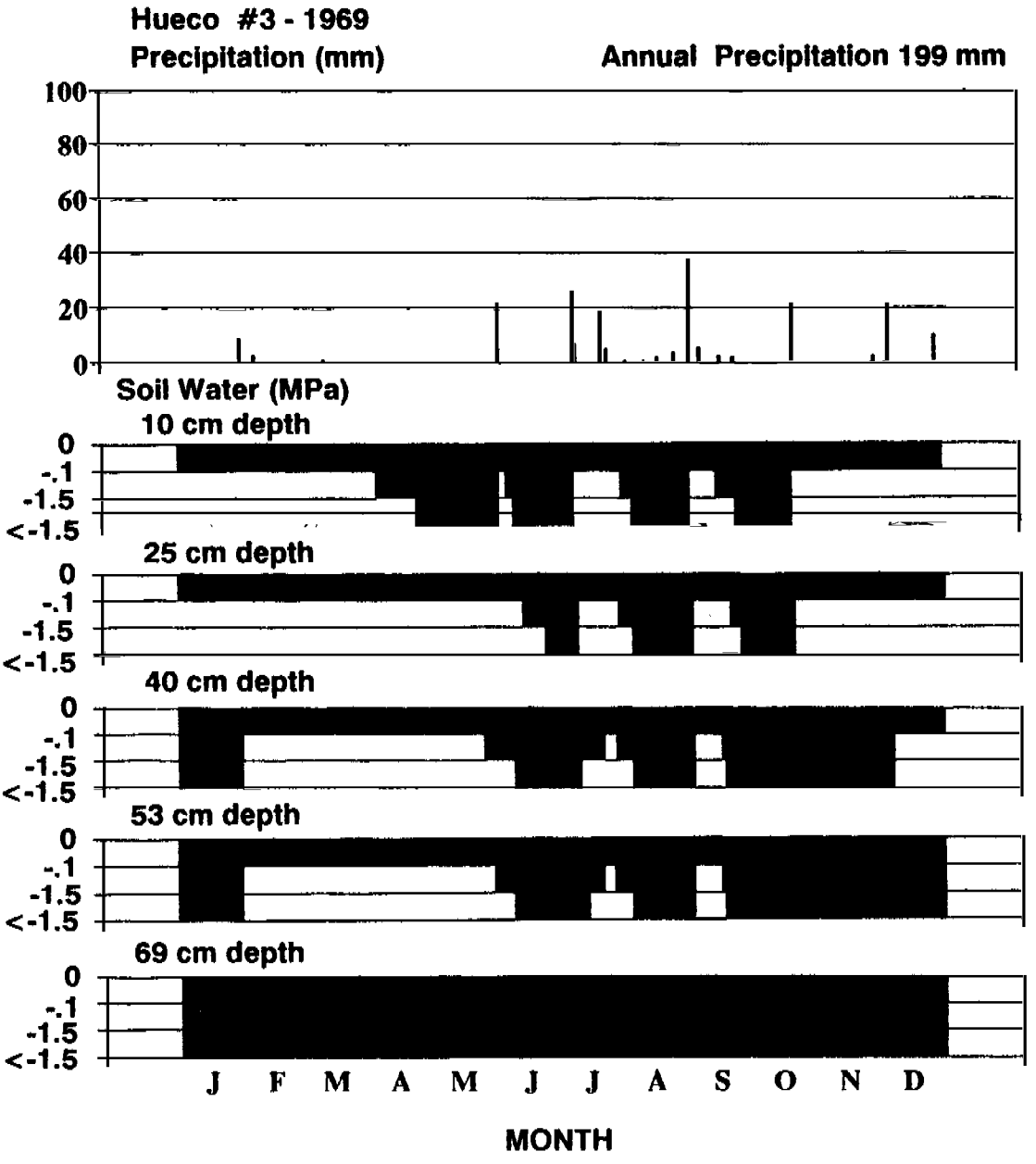


Figure 108. Annual precipitation (199 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1969.

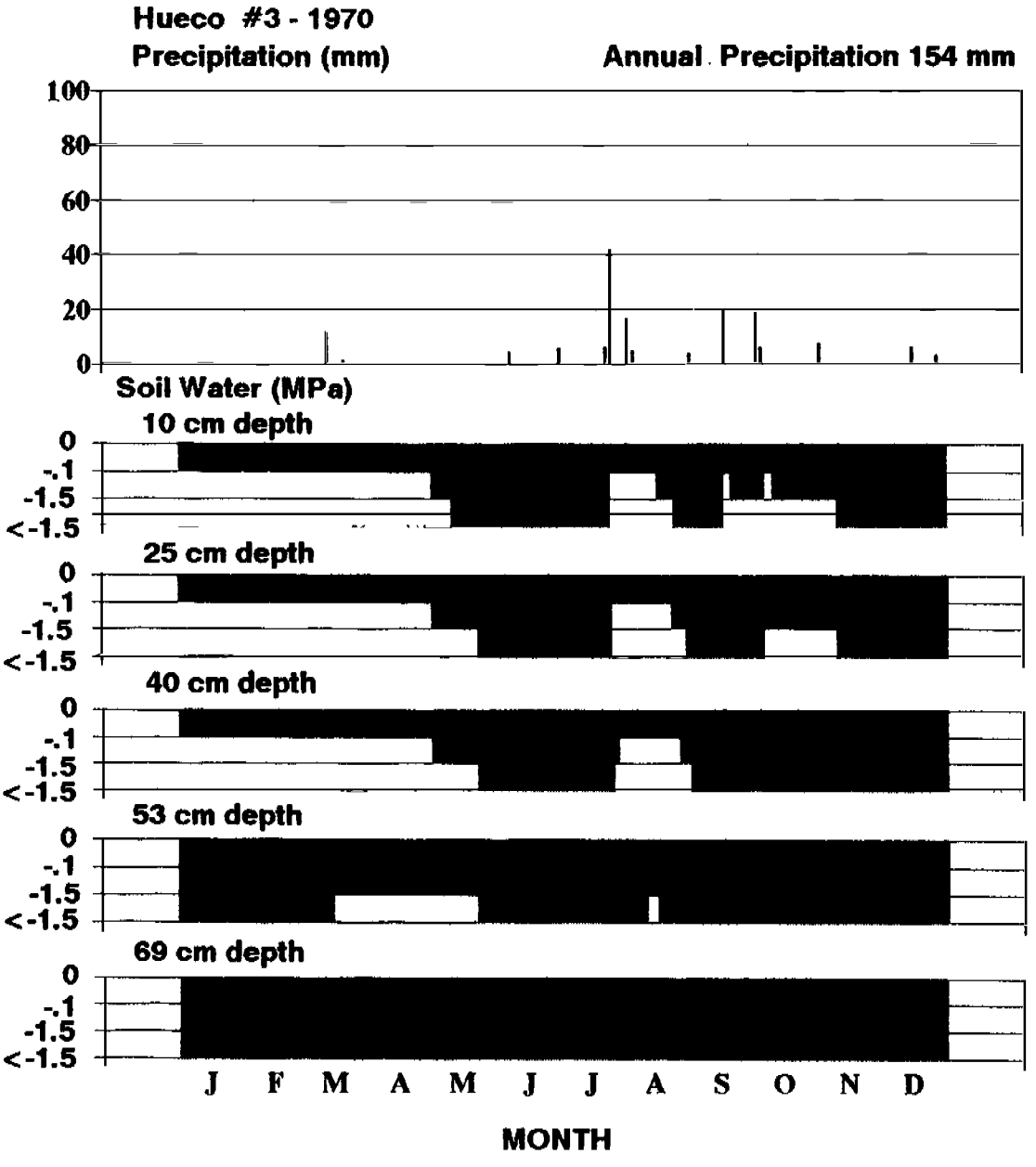


Figure 109. Annual precipitation (154 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1970.

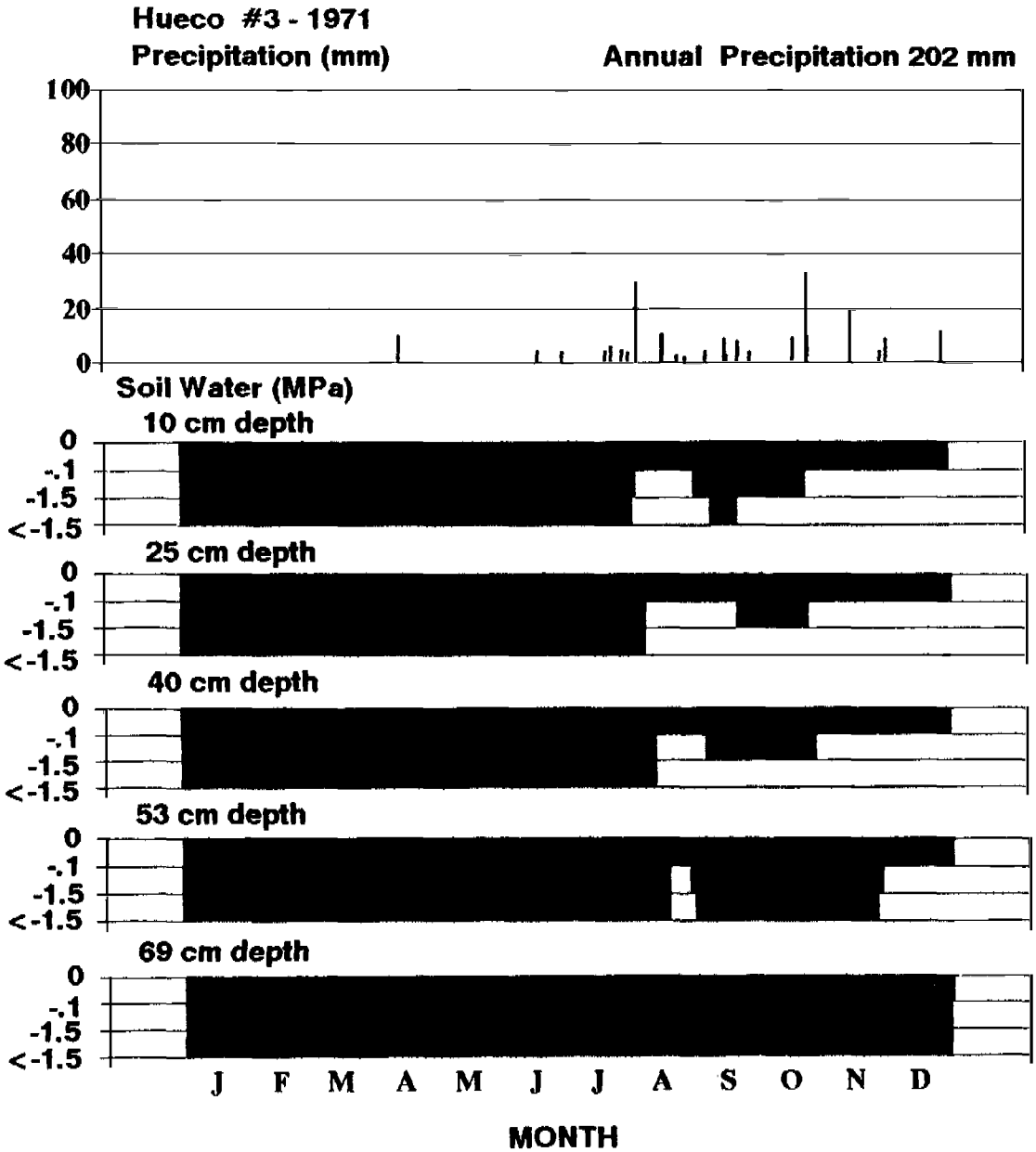


Figure 110. Annual precipitation (202 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1971.

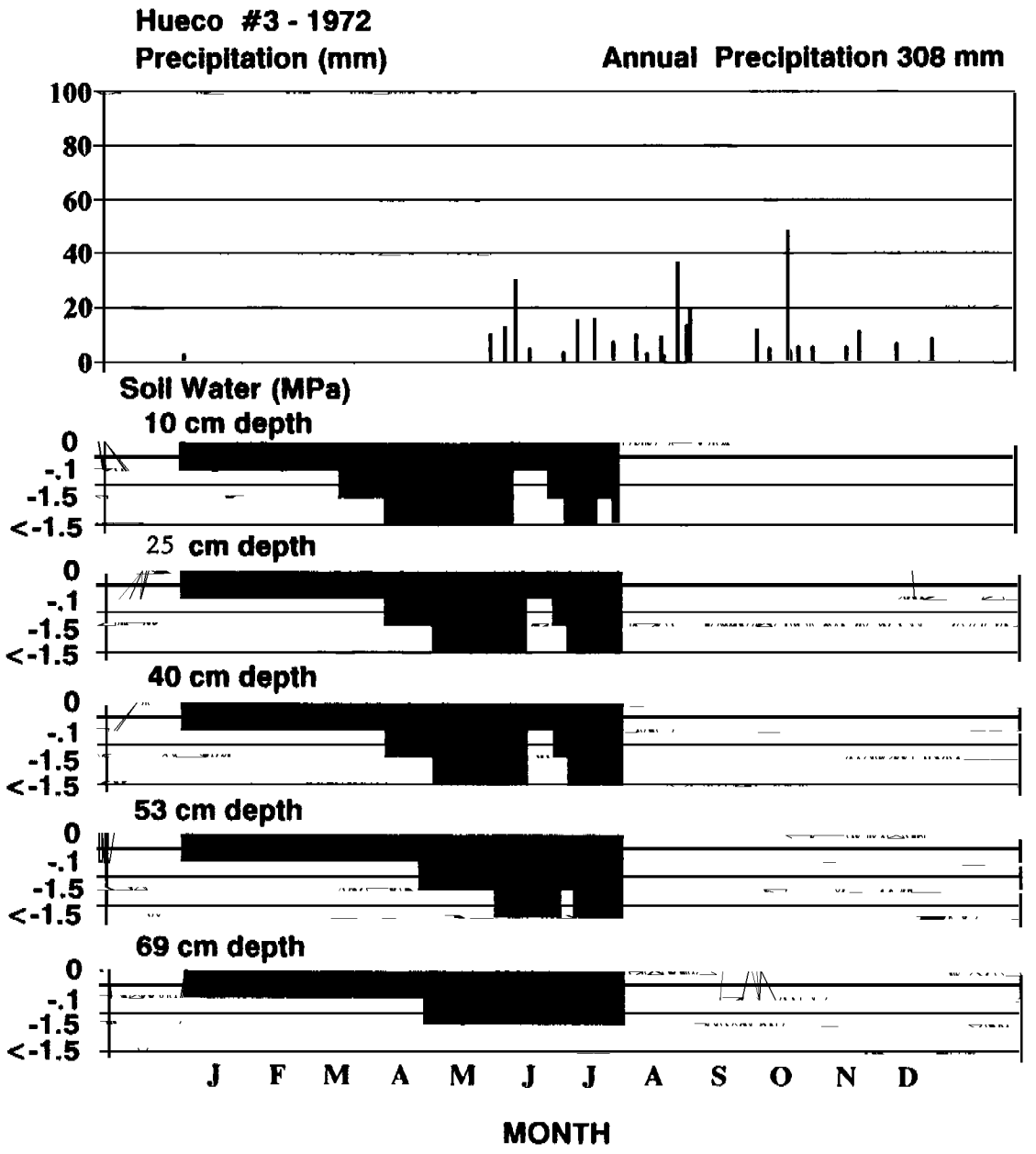


Figure 111. Annual (308 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm for January 1-August 1, 1972 at the Hueco #3 site.

Production of perennial grasses was 195 kg/ha (n=20, s.e.=25 kg/ha) in 1973 and 190 kg/ha (n=20, s.e.=20 kg/ha) in 1974. There was soil water >-1.5 MPa at the 25-cm depth January 9-May 22, 1973 (fig. 112); June 14-July 4; July 21-August 9; August 31-September 7, 1973; January 11-April 24, 1974 (fig. 113); and July 15-August 22, 1974. Even though annual precipitation in 1974 was much higher than in 1973, 146 mm occurred after September 20 (fig. 113). Both 1973 and 1974 had limited soil water >-1.5 MPa during the summer growing season (figs. 112, 113).

There was soil water >-1.5 MPa at the 25-cm depth September 24, 1974-May 25, 1975 (figs. 113, 114); July 21-28; September 9, 1975-February 24, 1976 (figs. 114, 115); July 11-August 3; and December 7-31, 1976. Production of perennial grasses was 344 kg/ha (n=20, s.e.=48 kg/ha) in 1975 and 354 kg/ha (n=20, s.e.=18 kg/ha) in 1976. Production was similar in 1963, 1969, 1975, and 1976. Those years had some winter-spring soil water >-1.5 MPa, 24-48 days of soil water >-1.5 MPa at the 25-cm depth July-September, and soil water <-1.5 MPa at the 69-cm depth July-September (figs. 102, 108, 114, 115). The average annual precipitation for 1960-76 was 230 mm. The average rainfall for July-September was 148 mm. Figure 116 shows the probability of soil water >-1.5 MPa at the five depths during the study period. The probability of soil water >-1.5 MPa at the 25-cm depth averaged 74.2% for December-April, 37.4% for May-June, 49.6% for July-September, and 53.5% for October-November.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, nine of 17 years had soil water <-1.5 MPa more than half the time at 10 and 25 cm; 11 of 17 years at 40 cm; and 14 of 17 years at the 53- and 69-cm soil depths. Four of 17 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 5 of 17 years at 25 cm; 6 of 17 years at 40 cm; 8 of 17 years at 53 cm; and 9 of 17 years at a soil depth of 69 cm. For the bordering ustic moisture regime, the moisture control section (25-cm depth) at Hueco #3 had soil water >-1.5 MPa >60 consecutive days in 1961, 1962, 1963, 1965, 1966, 1968, 1969, 1970, 1971, 1972 (data incomplete), 1973, 1974, and 1975 (13 of 17 years). During June 21-October 21, the 25-cm depth had soil water >-1.5 MPa >30 consecutive days in 1961, 1963, 1964, 1965, 1966, 1971, 1974, and 1975 (8 of 17 years).

Site Hueco #4 (H4)

Site H4 (figs. 4, 117, 118, table 8) is in the Rabbit exclosure on the Jornada Experimental Range. The sampled pedon is 2.3 m southeast of the nonrecording rain gauge and 50 cm southeast of wires leading to the soil water blocks. The perennial vegetation is mostly mesquite, with a few fourwing saltbush plants.

Soils. The soil water blocks are in the Petrocalcic Paleargid Hueco #4 (fig. 118, tables 3, 8; Hueco #4 description and primary data). Work with the soil auger showed considerable local variation in depth to the petrocalcic horizon. The exclosure is

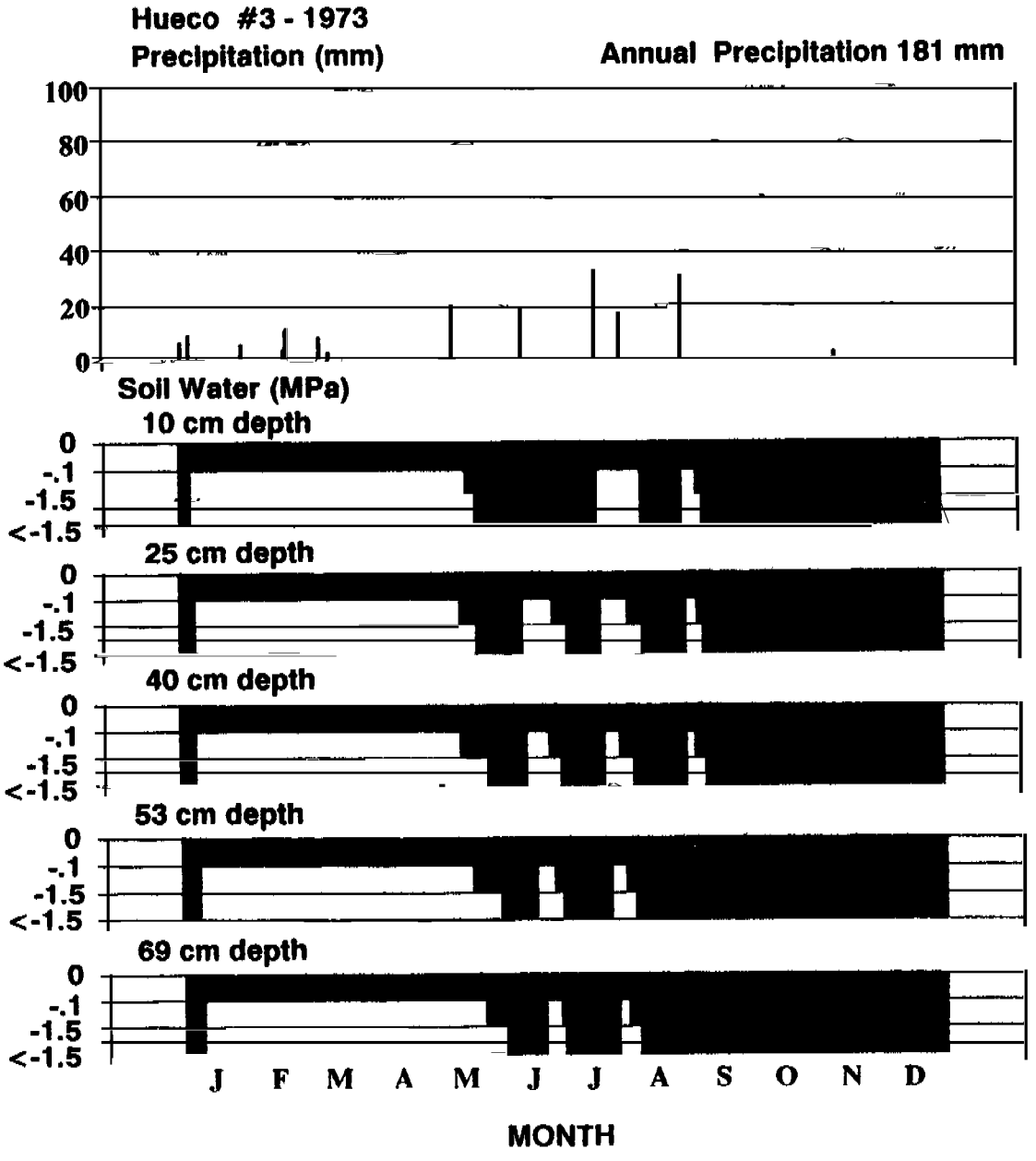


Figure 112. Annual precipitation (181 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1973.

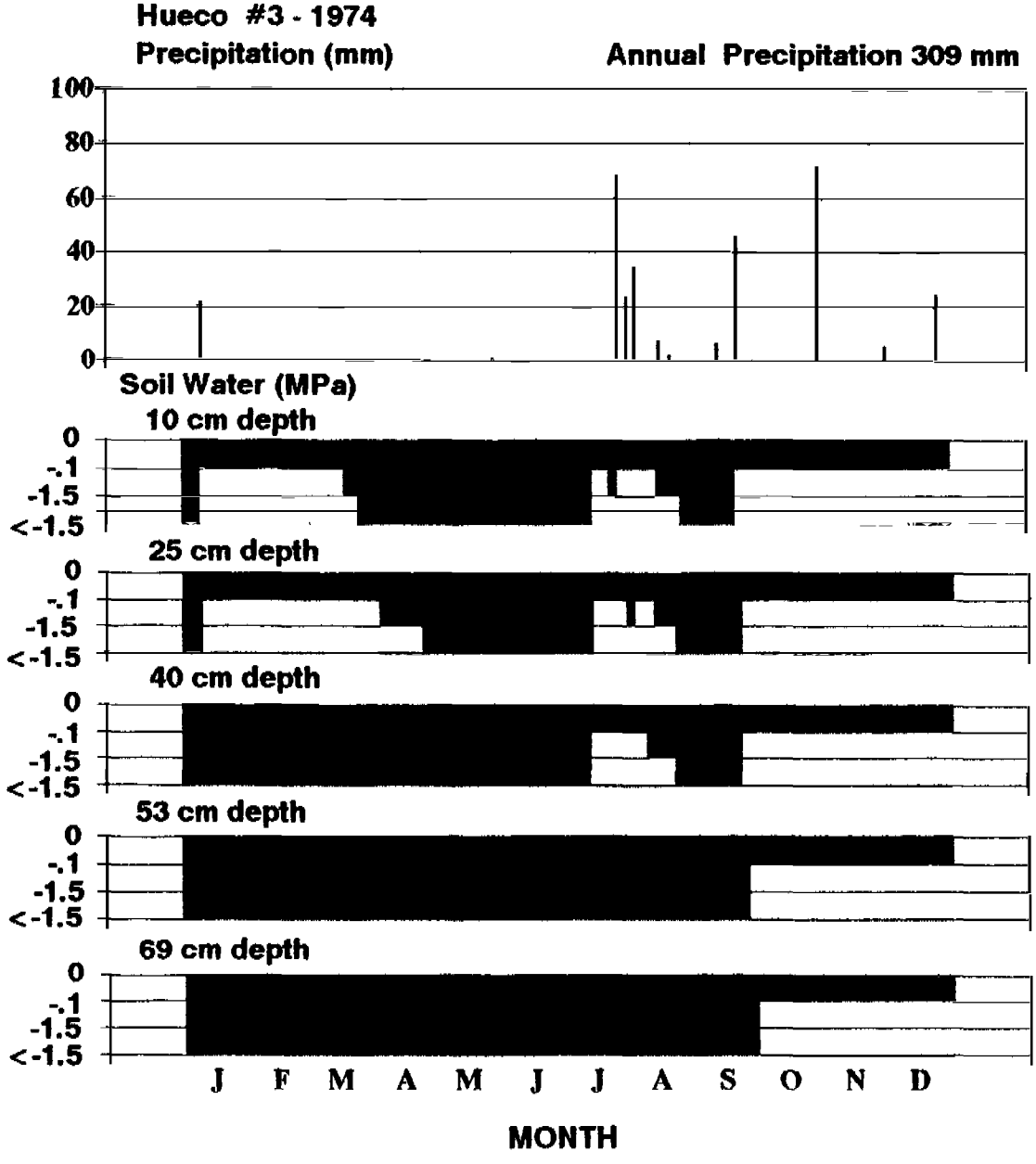


Figure 113. Annual precipitation (309 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1974.

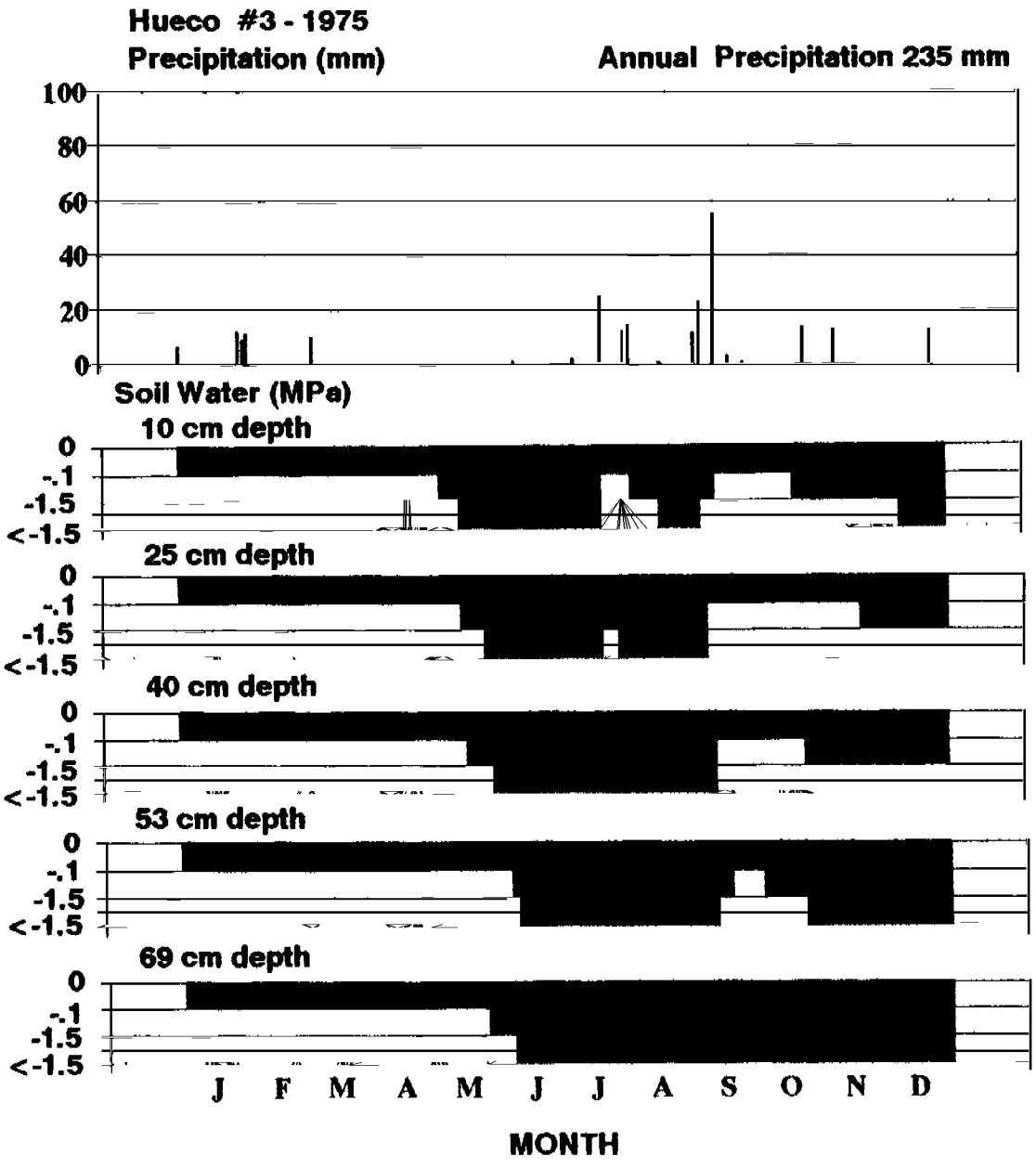


Figure 114. Annual precipitation (235 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1975.

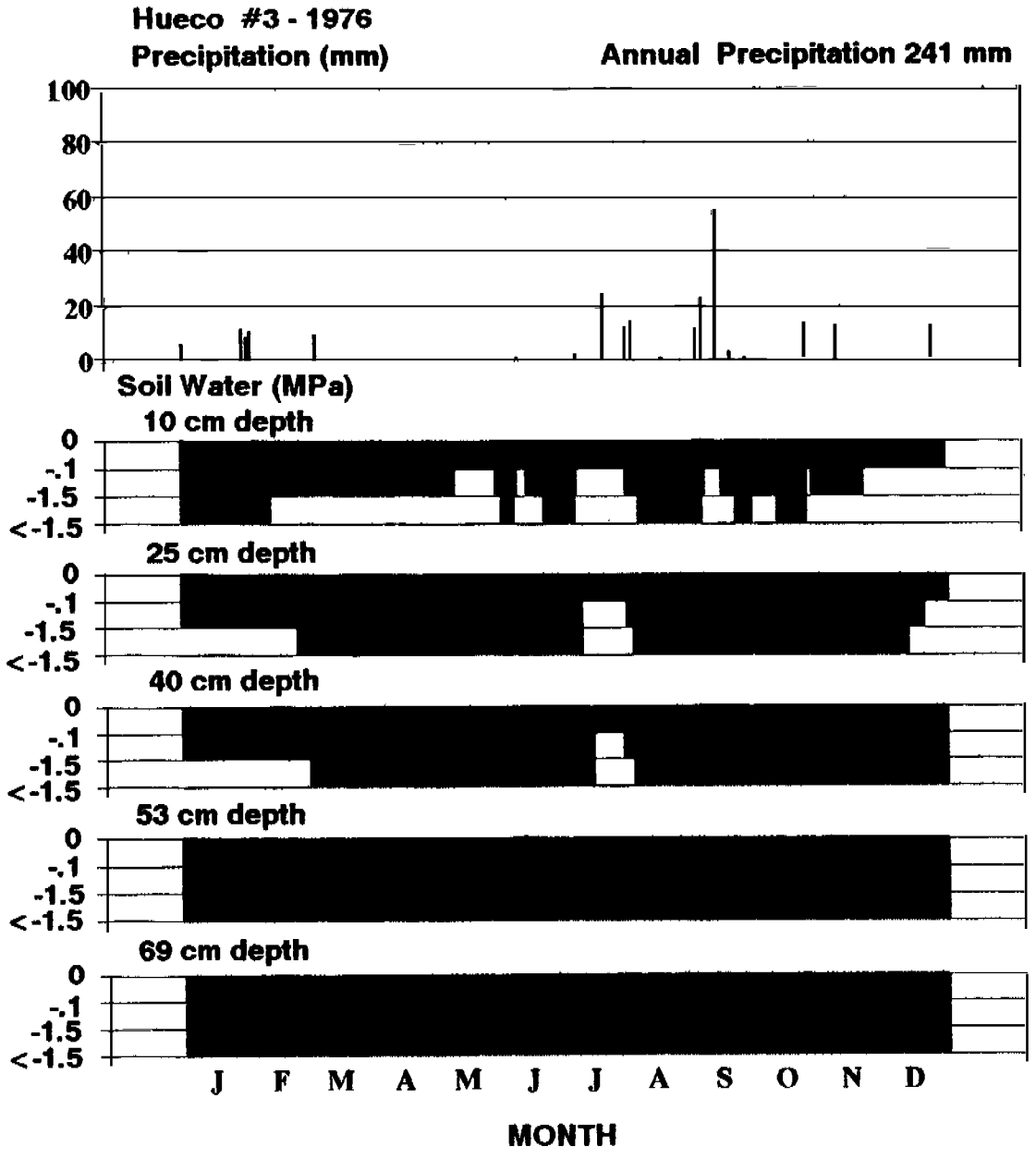


Figure 115. Annual precipitation (241 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site for 1976.

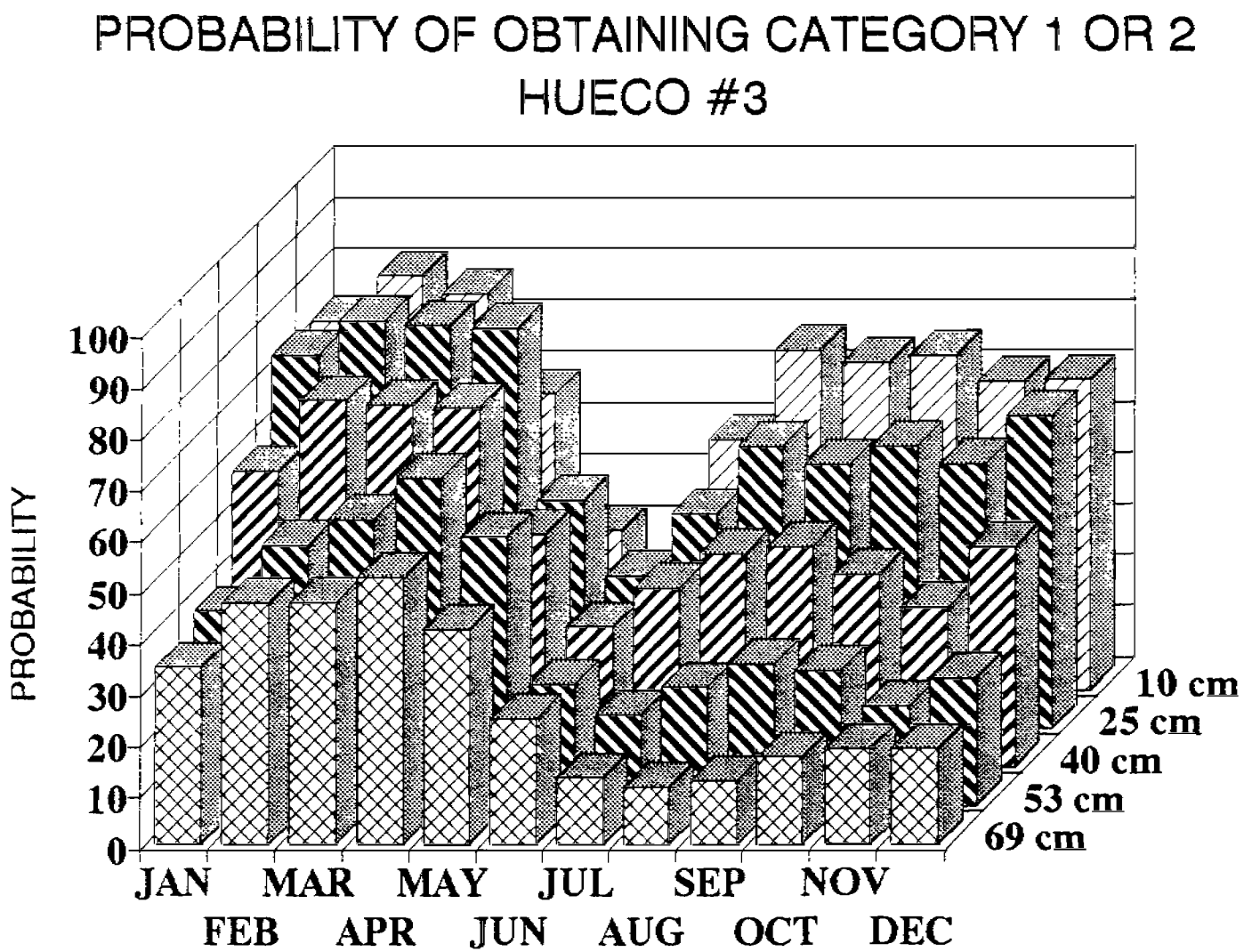


Figure 116. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 53, and 69 cm at the Hueco #3 site.

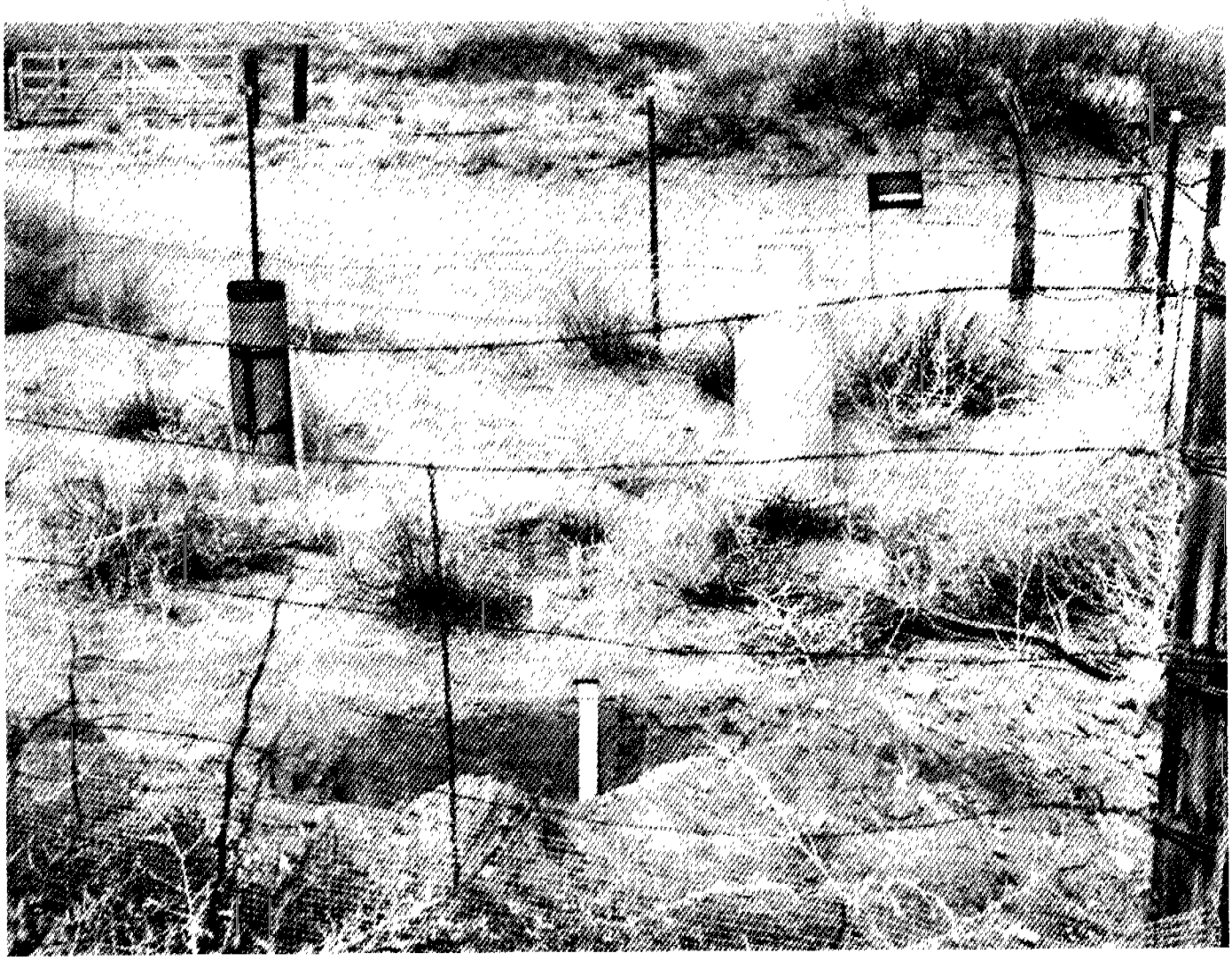


Figure 117. Landscape at Site H4 (fig. 4) and the Petrocalcic Paleargid Hueco #4, in the Rabbit exclosure in the Jornada Experimental Range. Both rain gauges and wires to the soil water blocks are beyond the foreground fence. The road to the Jornada Experimental Range Headquarters is just beyond the exclosure; dunes may be seen beyond the road. The Caballo Mountains are on the skyline. Photographed February 1990.

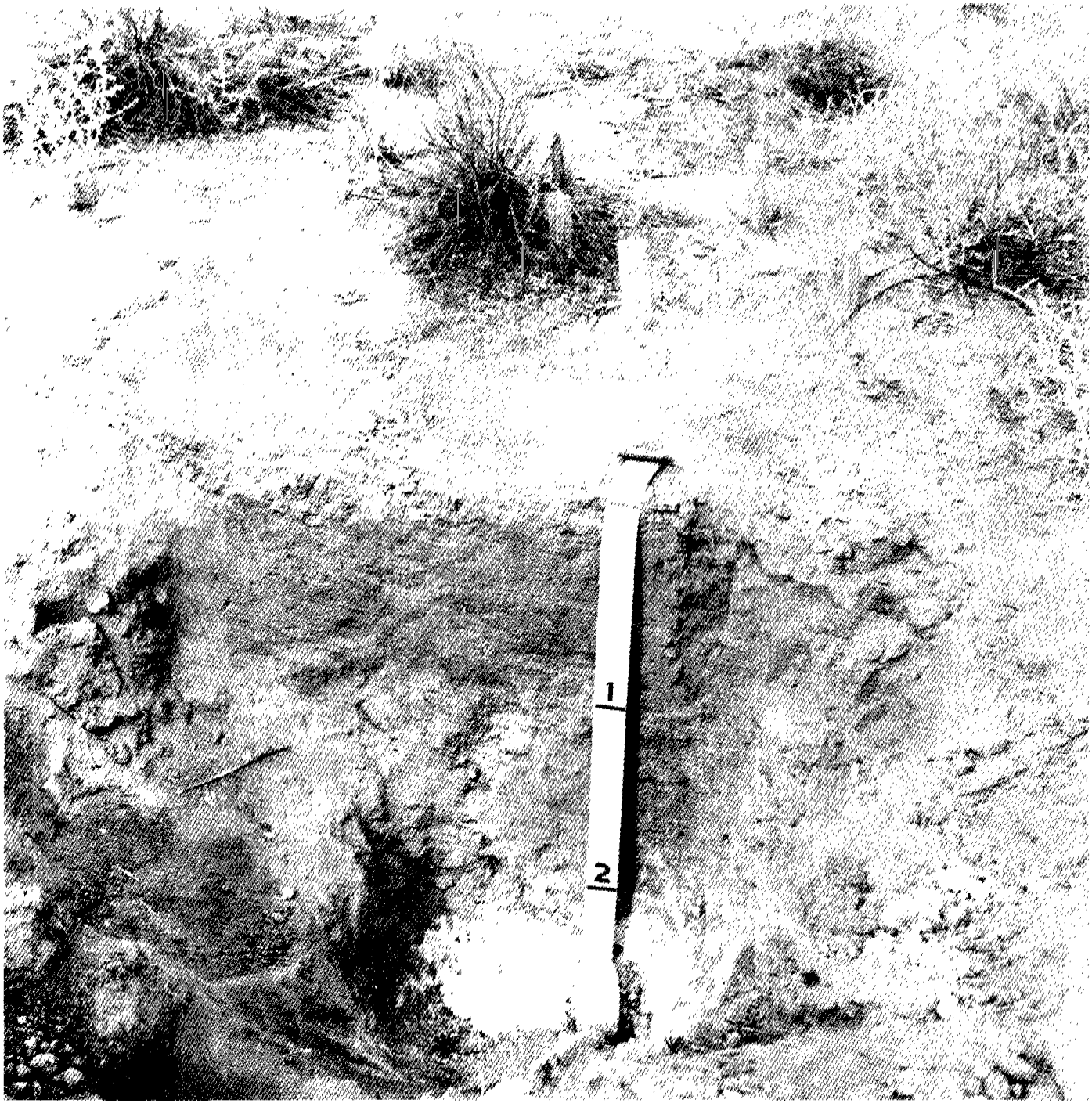


Figure 118. Profile of upper horizons of the Petrocalcic Paleargid Hueco #4. Scale is in feet.

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Hueco
Classification: Coarse-loamy, mixed, thermic Petrocalcic Paleargid
NSSL ID#: 90P0496
Soil Survey #: S90-NM-013-005
Location: The SW1/4SW1/4 section 36, T.19S., R.1E., in the Rabbit exclosure on the Jornada Experimental Range. The northeast corner of the exclosure is 4 m south of the south edge of the road to Headquarters. The sampled pedon is 2.3 m southeast of the nonrecording rain gauge, and 50 cm southeast of wires leading to the soil moisture blocks.
Elevation: 4350 ft, 1326 m
Landform: Interdune area on broad basin floor
Geomorphic Surface: La Mesa
Parent Material: Upper Camp Rice Formation (fluvial facies) sand
Vegetation: Mostly mesquite, with a few fourwing saltbush
Described By: L.H. Gile
Date: Feb. 12, 1990

Soil surface: dominantly a thin layer of loose sand; a smooth crust is at the surface in places.

A--0 to 5 cm; yellowish red (5YR 5/6) loamy sand; yellowish red (5YR 3.5/6) moist; lesser amount slightly darker; dominantly weak fine platy structure and soft, with some plates separated by soft fine granules or by loose, single-grain material; very few fine roots; 90P2748; noncalcareous; abrupt smooth boundary.

C--5 to 12 cm; yellowish red (5YR 5/6) loamy sand; yellowish red (5YR 3.5/6) moist; massive; soft, very friable; very few fine roots; 90P2749; noncalcareous; clear wavy boundary.

BAtkb--12 to 23 cm; reddish brown (5YR 5.5/4) fine sandy loam; reddish brown (5YR 4/4) moist; very weak coarse subangular blocky structure; slightly hard, friable; very few fine roots; 90P2750; sand grains coated with oriented clay; few carbonate filaments; strongly effervescent; clear wavy boundary.

Btk1b--23 to 34 cm; reddish brown (5YR 5.5/4) fine sandy loam; reddish brown (5YR 4/4) moist; weak fine medium subangular blocky structure; slightly hard, friable; very few fine roots; 90P2751; sand grains coated with oriented clay; common carbonate filaments; strongly effervescent; clear wavy boundary.

Btk2b--34 to 44 cm; light reddish brown (6YR 6/4) fine sandy loam; reddish brown (6YR 5/4) moist; lesser amount of yellowish red 5YR 5/5; weak fine and medium subangular blocky structure; slightly hard and hard, friable; very few fine roots; 90P2752; sand grains coated with oriented clay; common carbonate filaments; strongly effervescent; clear wavy boundary.

Btk3b--44 to 57 cm; yellowish red (5YR 5/6) fine sandy loam; yellowish red (5YR 4/6) moist; lesser amount of light reddish brown 5YR 6.5/4; weak fine and medium subangular blocky structure; slightly hard to hard, friable; very few fine roots; 90P2753; sand grains coated with oriented clay; common carbonate filaments; strongly effervescent; abrupt wavy boundary.

K1tb--57 to 67 cm; pinkish white to pink (7YR 8/3) fine sandy loam; pink (7.5YR 7/4) moist; lesser amount of reddish brown (5YR 5/4); moderate fine and medium subangular blocky structure; very hard, firm; very few fine roots; 90P2754; sand grains of 5YR 5/4 material coated with oriented clay; strongly effervescent; abrupt wavy boundary.

K2mb--67 to 69 cm; pinkish white to pink (7.5YR 8/3) carbonate cemented material; pink (7.5YR 7/4) moist; lesser amount of pinkish white 7.5YR 9/2; breaks out with hammer as medium and coarse subangular blocks; extremely firm; no roots; strongly effervescent.

S90NM-013-005 *** PRIMARY CHARACTERIZATION DATA *** PRINT DATE 11/29/91

Soil series: HUECO COARSE-LOAMY, MIXED, THERMIC PETROCALCIC PALEARGID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 496, SAMPLES 90P2748-2756
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	SILT COS LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS(MM) WEIGHT 2 -5	5 -20	20 -75	.1-75	>2MM WT PCT OF WHOLE SOIL
			<- - - - - - - - - - - - PCT OF <2MM (3A1) - - - - - - - - - - - ->												<- PCT OF <75MM(3B1)->				
90P2748S	0- 5	A	8.9	2.3	88.8			1.9	0.4	13.8	41.9	30.1	2.6	0.4	--	--	--	75	--
90P2749S	5- 12	C	9.2	2.0	88.8			1.5	0.5	11.6	39.9	32.2	4.3	0.8	1	TR	--	77	1
90P2750S	12- 23	BATKB	14.7	4.2	81.1		1.5	3.1	1.1	10.2	35.8	29.7	4.7	0.7	TR	--	--	71	TR
90P2751S	23- 34	BTK1B	18.9	5.4	75.7		2.4	3.6	1.8	12.0	31.3	25.9	5.7	0.8	1	TR	--	64	1
90P2752S	34- 44	BTK2B	19.9	3.7	76.4		2.4	3.3	0.4	12.1	31.6	25.9	5.5	1.3	1	TR	--	65	1
90P2753S	44- 57	BTK3B	16.1	6.6	77.3		1.5	3.5	3.1	9.9	32.0	26.8	6.6	2.0	1	TR	--	68	1
90P2754S	57- 67	K1TB	19.7	10.6	69.7		7.3	5.1	5.5	10.2	30.4	23.2	4.9	1.0	2	1	--	61	3
															--	--	--		--
															--	--	--		--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B3a <2MM	EXTR P 6S3 PPM	TOTAL S 6R3a <- PERCENT	DITH-CIT EXTRACTABLE FE 6C2b OF	AL 6G7a <2MM	MN 6D2a -->	CEC 8D1	RATIO/CLAY 15 BAR 8D1	ATTERBERG LIMITS LL 4F1 PCT	PI 4F <0.4MM	BULK DENSITY FIELD MOIST 4A3a <- - G/CC	1/3 BAR 4A1d - -	OVEN DRY 4A1h - ->	COLE WHOLE SOIL 4D1 CM/CM	WATER CONTENT FIELD MOIST 4B4 <- - -	1/10 BAR 4B1c -PCT OF	1/3 BAR 4B1c <2MM	15 BAR 4B2a - ->	WRD WHOLE SOIL 4C1 CM/CM
0- 5	0.28							0.65	0.36										3.2	
5- 12	0.11							0.61	0.36										3.3	
12- 23	0.18							0.52	0.34				1.56	1.62	0.013			6.5	5.0	0.02
23- 34	0.21							0.46	0.33										6.2	
34- 44	0.16							0.51	0.38				1.55	1.63	0.017			10.8	7.6	0.05
44- 57	0.16							0.56	0.40										6.4	
57- 67	0.21							0.38	0.35				1.69	1.77	0.015			12.7	6.8	0.10

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA 5B5a 6N2a	MG 5B5a 6O2d	NA 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES 6H5a <- - - - - - - - - -MEQ / 100 G - - - - - - - - - ->	ACID-ITY	CEC SUM CATS 5A3a	CEC NH4-OAC 5A8b	EXCH NA 5B5b PCT	SAR 5E	BASE SATURATION SUM 5C3 <- -PCT- >	BASE SATURATION NH4OAC 5C1	CARBONATE AS CACO3 <2MM 6E1g <- -PCT ->	CARBONATE AS CACO3 <20MM 6E1	CASO4 AS GYPSUM <2MM 6F1a <- -PCT ->	CASO4 AS GYPSUM <20MM 6F4	SAT PASTE 8C1b	-PH CACL2 .01M 8C1f 1:2	H2O 8C1f 1:1
0- 5	7.7	0.9	TR	0.4	9.0	1.0	10.0	5.8	TR	TR	90	100	TR		--		7.3	7.1	7.1
5- 12	13.6	0.9	TR	0.4	14.9	0.1	15.0	5.6	TR		99	100	TR					7.6	8.0
12- 23		1.5	TR	0.5				7.7	TR		100	100	2					7.8	8.1
23- 34		2.2	TR	0.5				8.7	1		100	100	4					7.8	8.1
34- 44		2.9	TR	0.6				10.2	TR		100	100	4					7.8	8.1
44- 57		2.9	TR	0.5				9.0	TR		100	100	4					7.8	8.3
57- 67		2.6	--	0.4				7.4	TR		100	100	12					7.8	8.3

DEPTH (CM)	WATER EXTRACTED FROM SATURATED PASTE CA 6N1b	MG 6O1b	NA 6P1b	K 6Q1b	CO3 6I1b	HCO3 6J1b	CL 6K1c	SO4 6L1c	NO3 6M1c	H2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A3a MMHOS /CM
	< - - - - - - - - - -MEQ / LITER - - - - - - - - - ->									<- -PCT ->		
0- 5	15.5	2.5	0.1	0.6	--	1.9	0.6	8.5	6.9	26.6	TR	1.64
5- 12												0.15
12- 23												0.15
23- 34												0.15
34- 44												0.15
44- 57												0.14
57- 67												0.16

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 2, 3, 4, 5, 6, 7,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

small, and a hand-dug pit was employed in order to sample a soil very similar to the one in which the soil water blocks were placed. Diagnostic horizons are an ochric epipedon, an argillic horizon, and a petrocalcic horizon. Hueco #4 is on La Mesa surface of middle Pleistocene age (table 1) and has formed in sandy fluvial sediments of the Camp Rice Formation. Numerous coppice dunes occur in the vicinity of the site. The soil water blocks and study trench are in a nearly level area between dunes (fig. 117).

The soil is noncalcareous to 12 cm depth, reflecting a zone of common wetting (fig. 118). Carbonate is currently accumulating in the horizons below 12 cm depth, and these horizons are wetted quite frequently (figs. 119-138).

Soil Water and Precipitation. The gypsum impregnated resistance blocks were installed within a rodent exclosure at Rabbit Rain Gauge at soil depths of 10, 25, and 40 cm on August 5, 1957, and at the 60-cm soil depth on July 29, 1959. Rabbit Rain Gauge was established in 1927. The moisture control section (25-cm depth) had soil water >-1.5 MPa August 5-October 2 (59 days) and October 9, 1957-May 21, 1958 (figs. 119, 120). There was a major storm of 56 mm rainfall on July 25, 1957. That storm plus rainfall in August resulted in a supply of soil water >-1.5 MPa at all depths until the latter part of September. Then after a dry September, precipitation in fall, winter, and early spring, 1957-58, resulted in soil water at all depths sampled until May (figs. 119, 120). There was a brief period of soil water >-1.5 MPa at the 25-cm depth August 22-September 8, 1958. A storm dumped 80 mm rainfall on this area September 13, 1958. This, and subsequent rainfall in October, resulted in soil water >-1.5 MPa at the 25-cm depth September 14, 1958-April 23, 1959 (figs. 120, 121).

Above-average rainfall occurred in July-August, 1959 but the soil water was >-1.5 MPa at 25 cm July 23, 1959-June 8, 1960 (figs. 121, 122). Precipitation during 1960 was low with the largest event, 31 mm, occurring on December 11. Soil water >-1.5 MPa at the 25-cm depth occurred August 22-September 11 and December 23, 1960-May 18, 1961 (figs. 122, 123).

Both 1961 and 1962 had above average precipitation. Soil water at the 25-cm depth was >-1.5 MPa June 18-July 25, 1961 (fig. 123); August 13, 1961-June 7, 1962 (figs. 123, 124); July 5-August 12; and September 26, 1962-May 18, 1963 (figs. 124, 125).

Annual precipitation was below average for 1963-66. Soil water >-1.5 MPa at the 25-cm depth occurred July 31-August 3, 1963 (fig. 125); August 21-September 18, 1963; July 13-August 9, 1964 (fig. 126); August 15-September 30, 1964; March 11-April 21, 1965 (fig. 127); February 12-May 3, 1966 (fig. 128); and August 23-September 1, 1966.

Even though annual precipitation was about average in 1967, soil water >-1.5 MPa at the 25-cm depth occurred only June 23-July 30 (fig. 129). Precipitation of 25 mm on December 20, 1967 and subsequent precipitation in early 1968 resulted in soil water >-1.5 MPa at the 25-cm depth December 23, 1967-May 24, 1968 (figs. 129, 130). Annual precipitation was also about average in 1968 and then above average in 1969. There was soil water >-1.5 MPa at the 25-cm

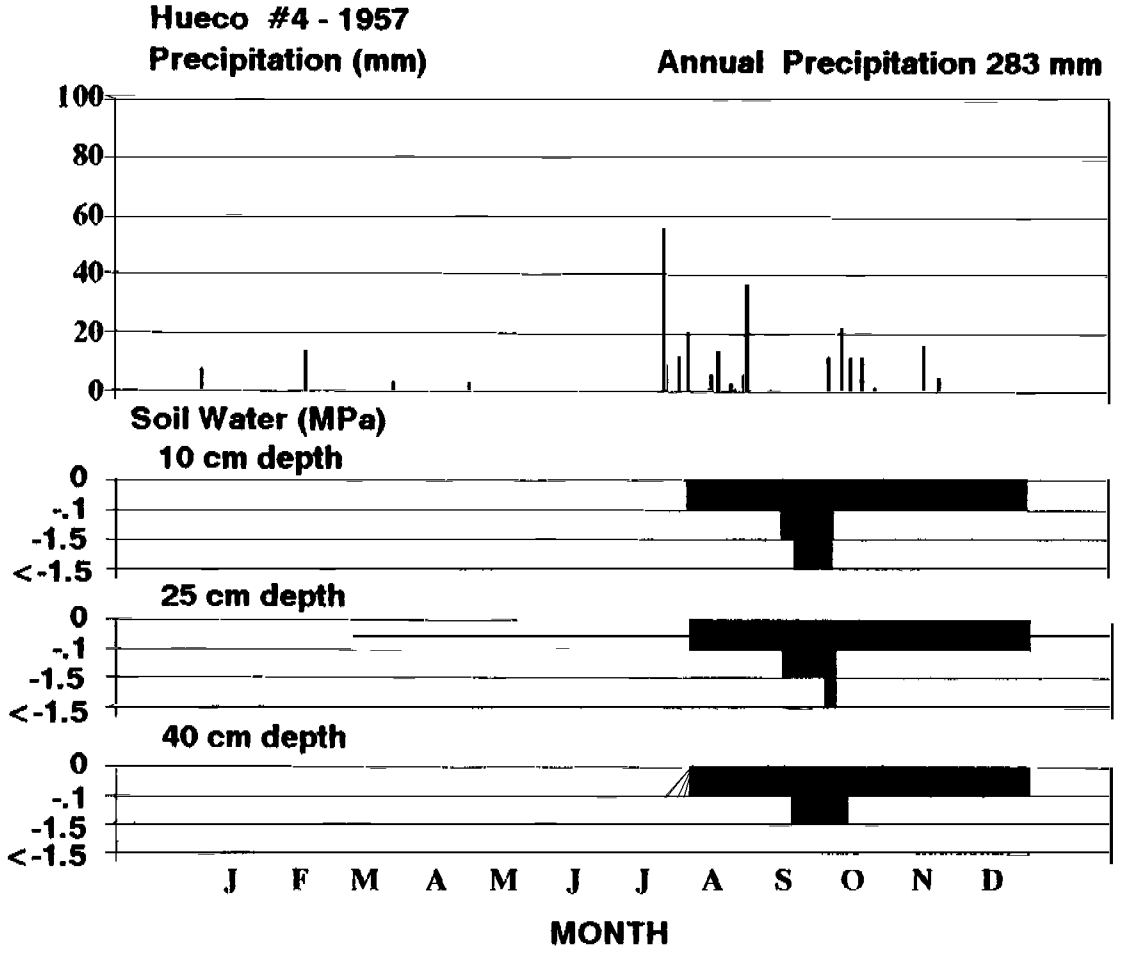


Figure 119. Annual (283 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 5-December 31, 1957 at the Hueco #4 site.

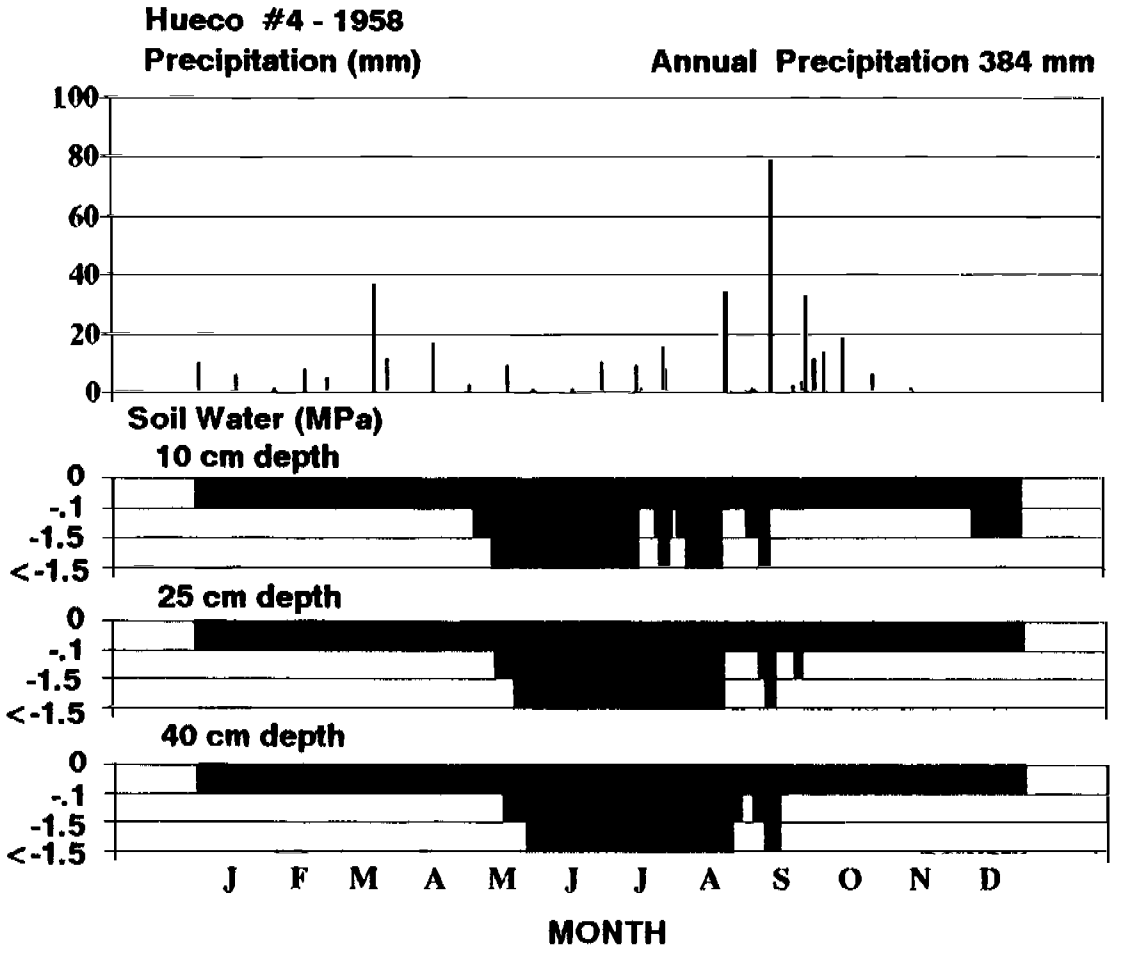


Figure 120. Annual precipitation (384 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Hueco #4 site for 1958.

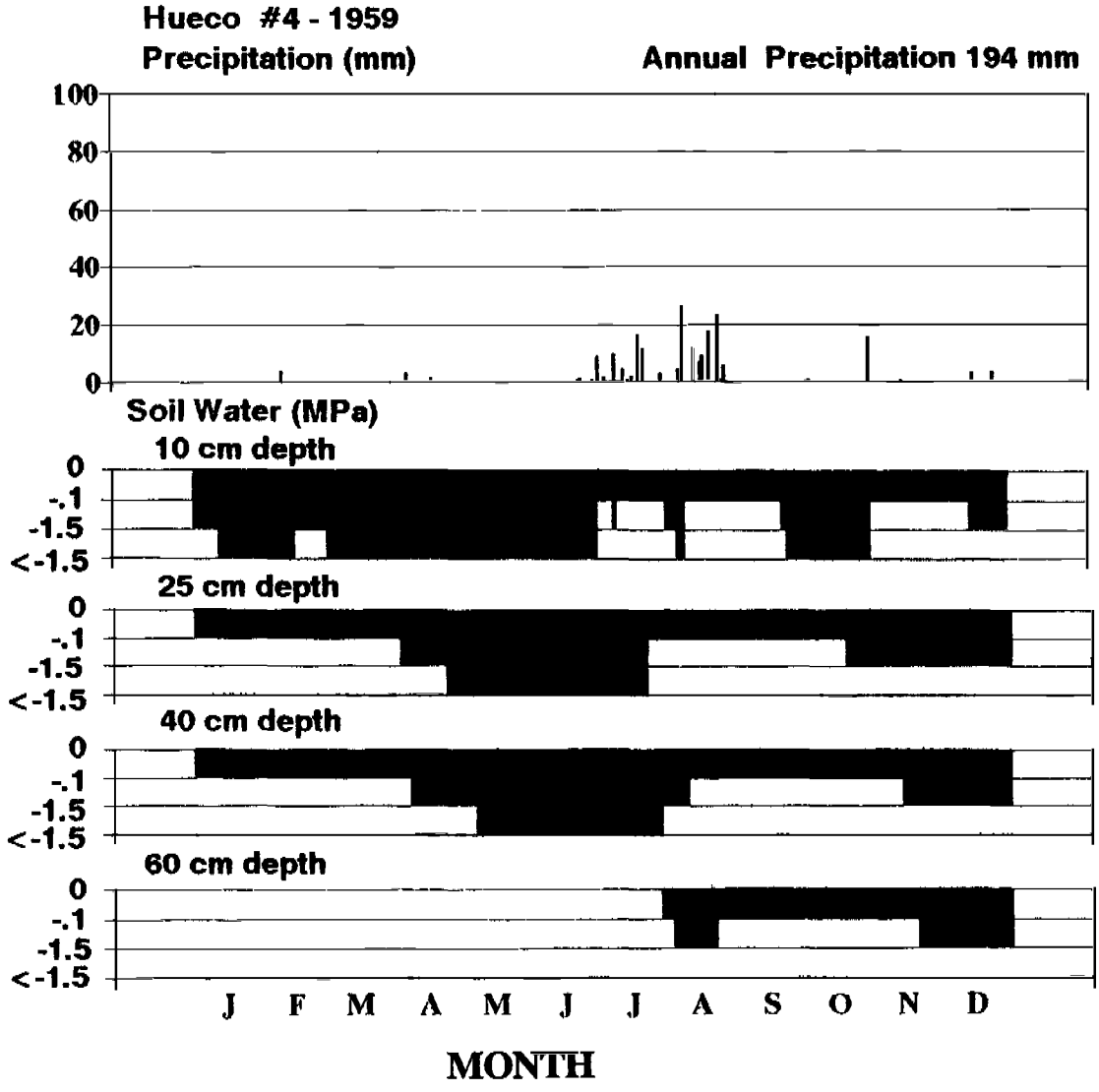


Figure 121. Annual precipitation (194 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Hueco #4 site for 1959. Also shown is the soil water at the depth of 60 cm July 29-December 31, 1959.

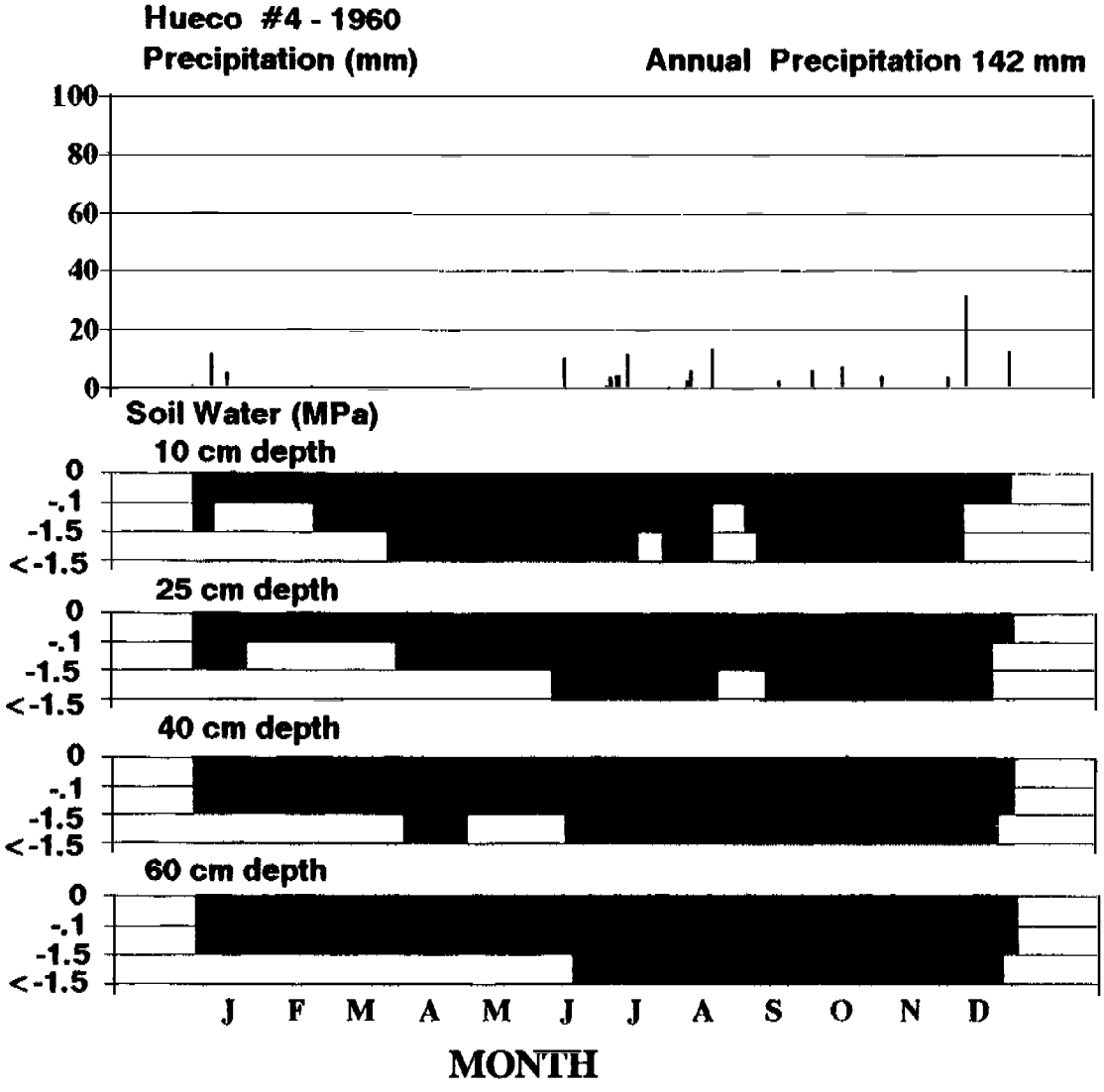


Figure 122. Annual precipitation (142 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1960.

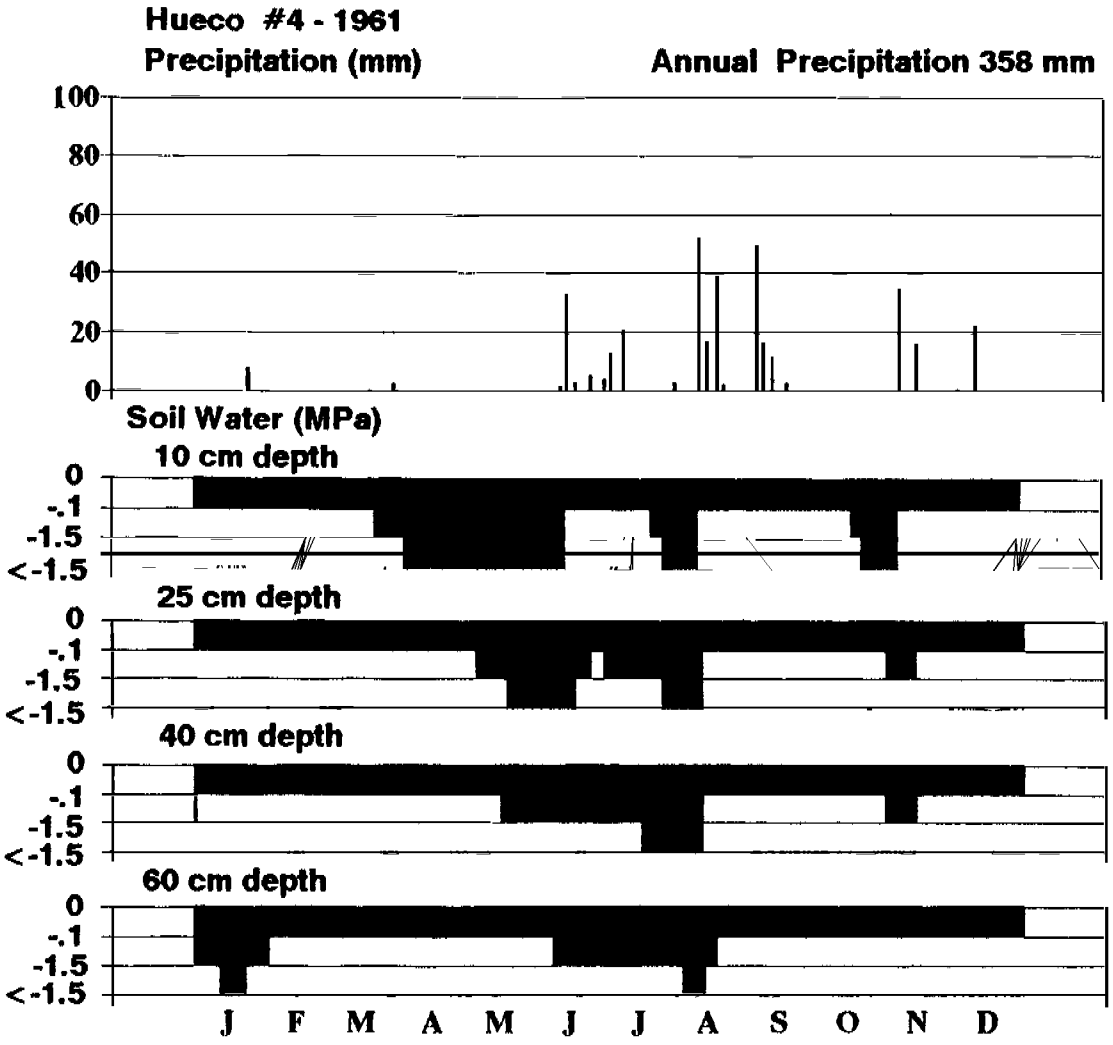


Figure 123. Annual precipitation (358 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1961.

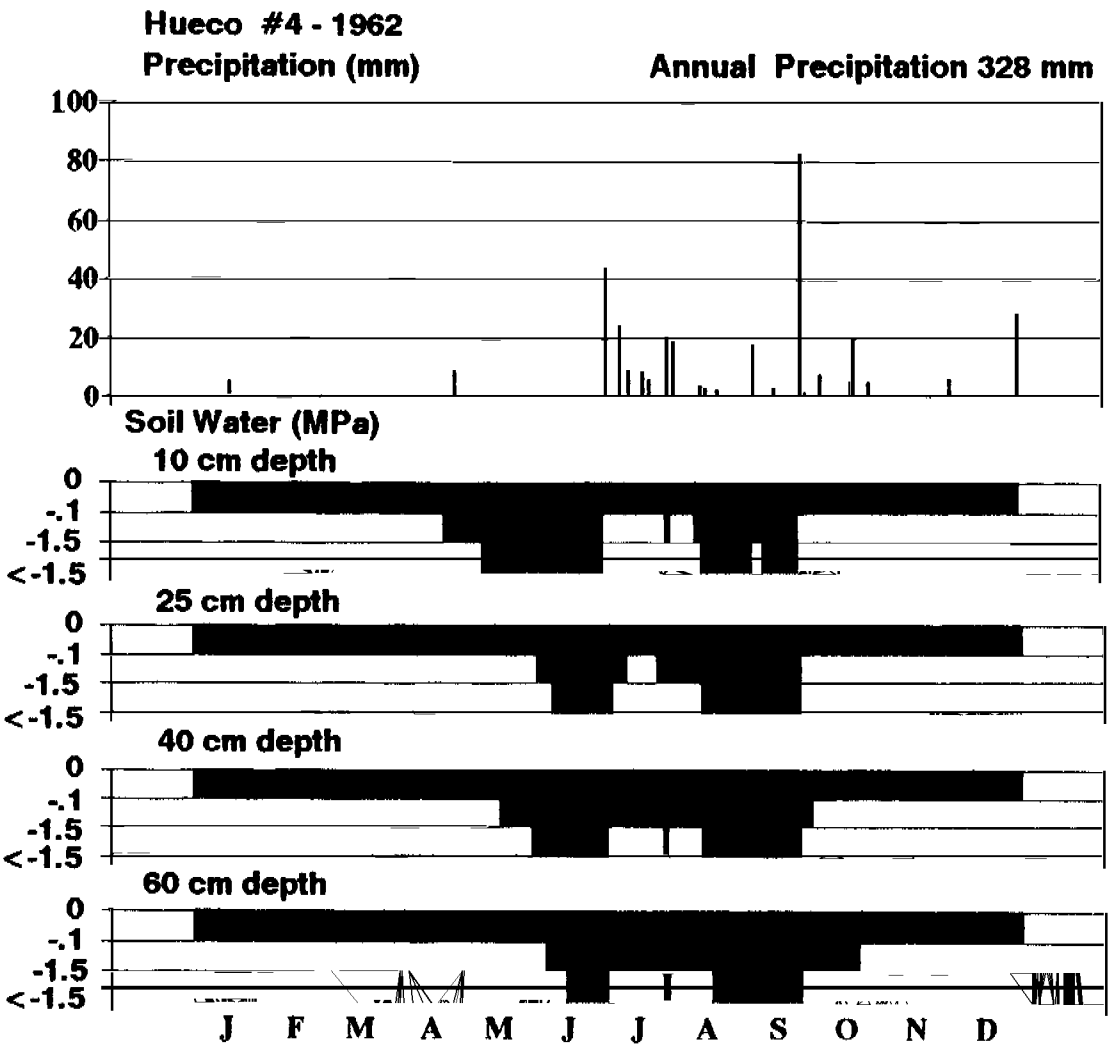


Figure 124. Annual precipitation (328 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1962.

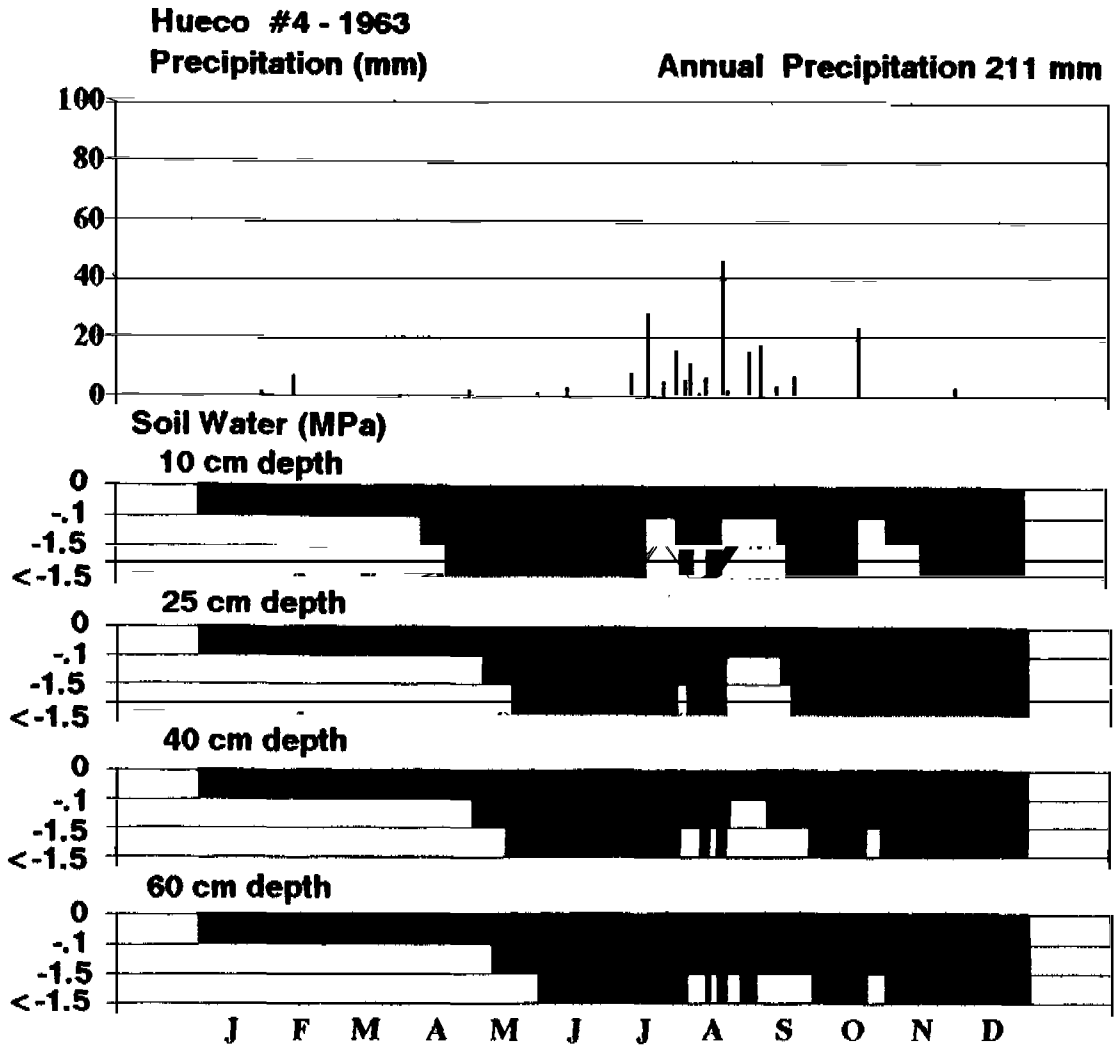


Figure 125. Annual precipitation (211 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1963.

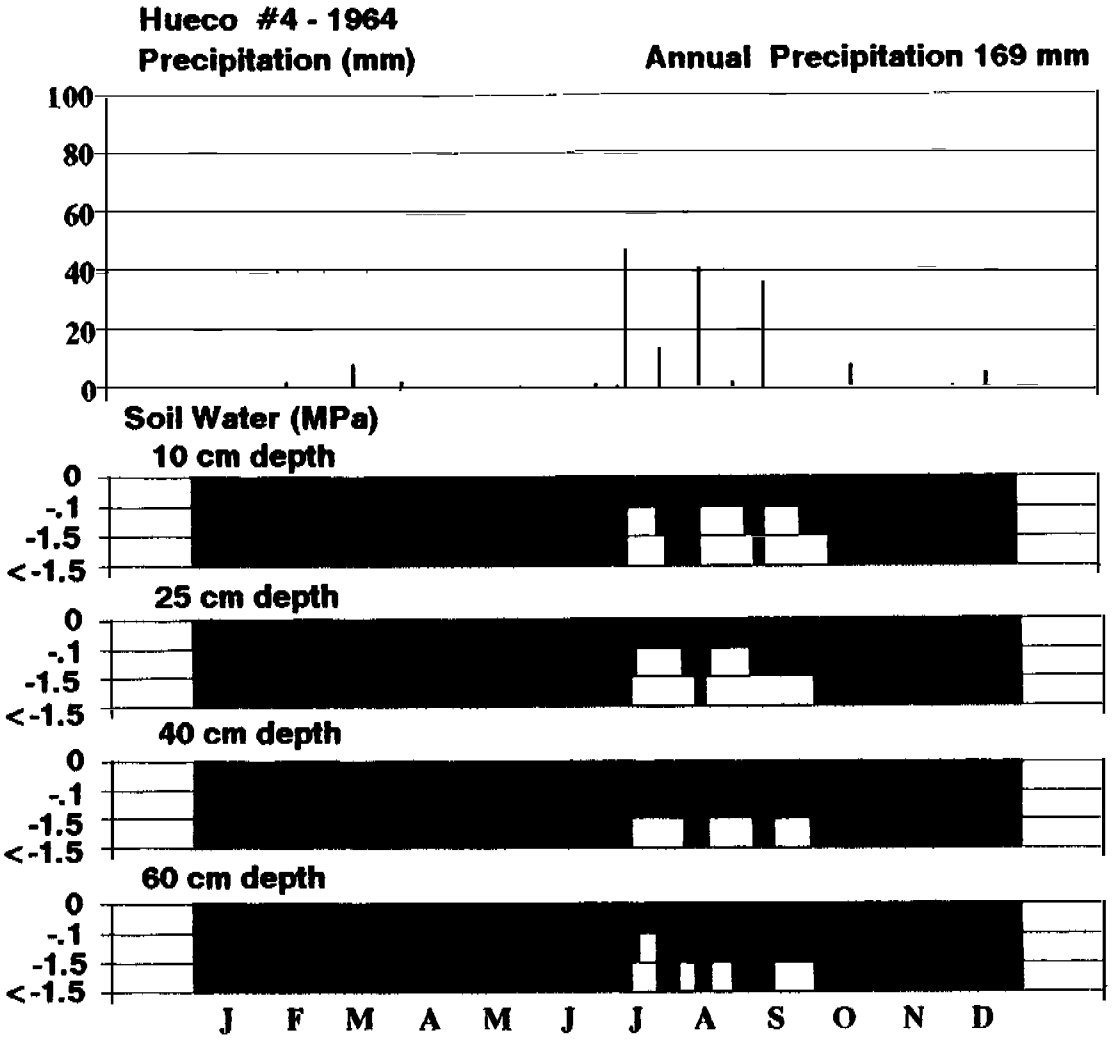


Figure 126. Annual precipitation (169 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1964.

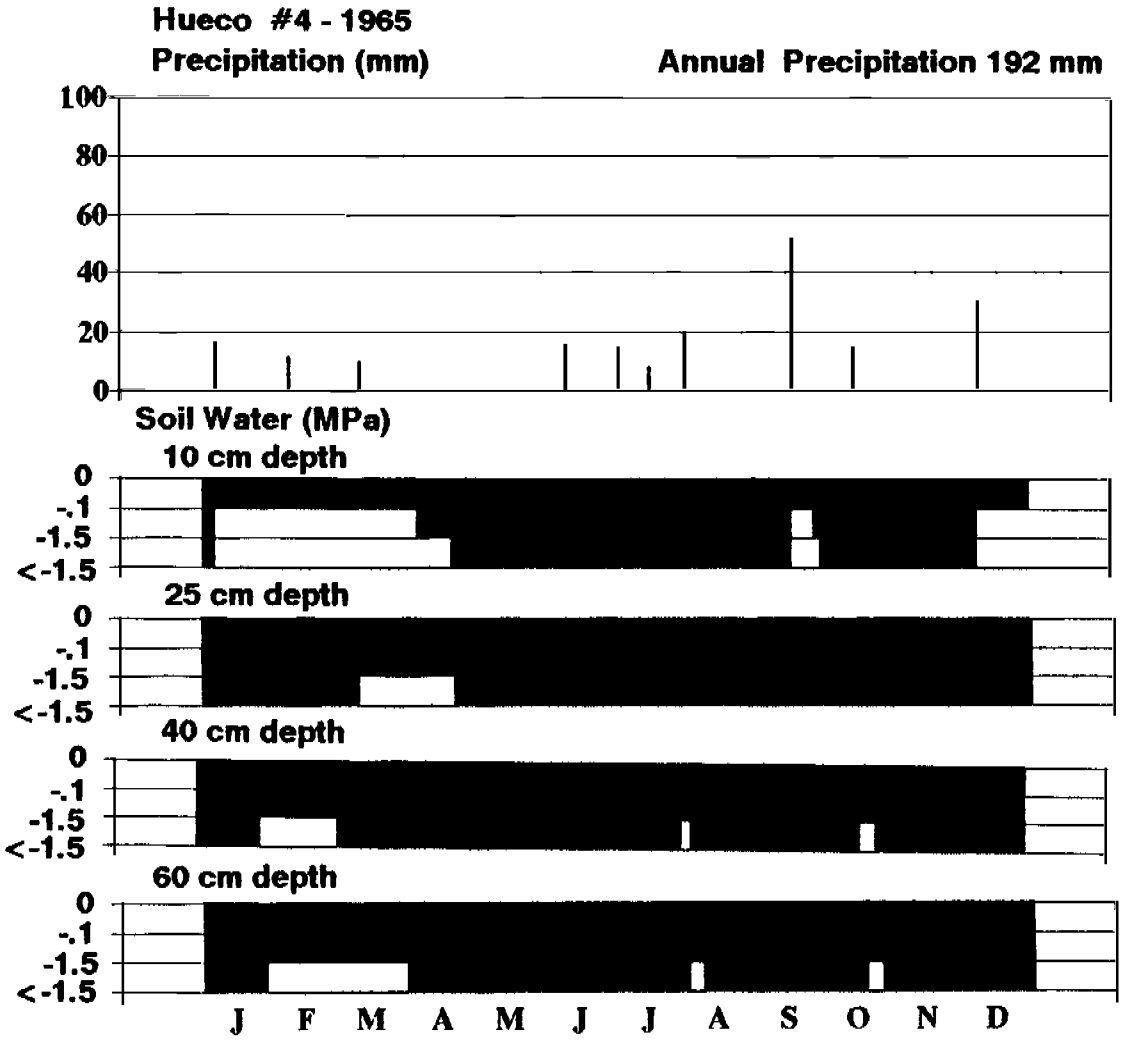


Figure 127. Annual precipitation (192 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1965.

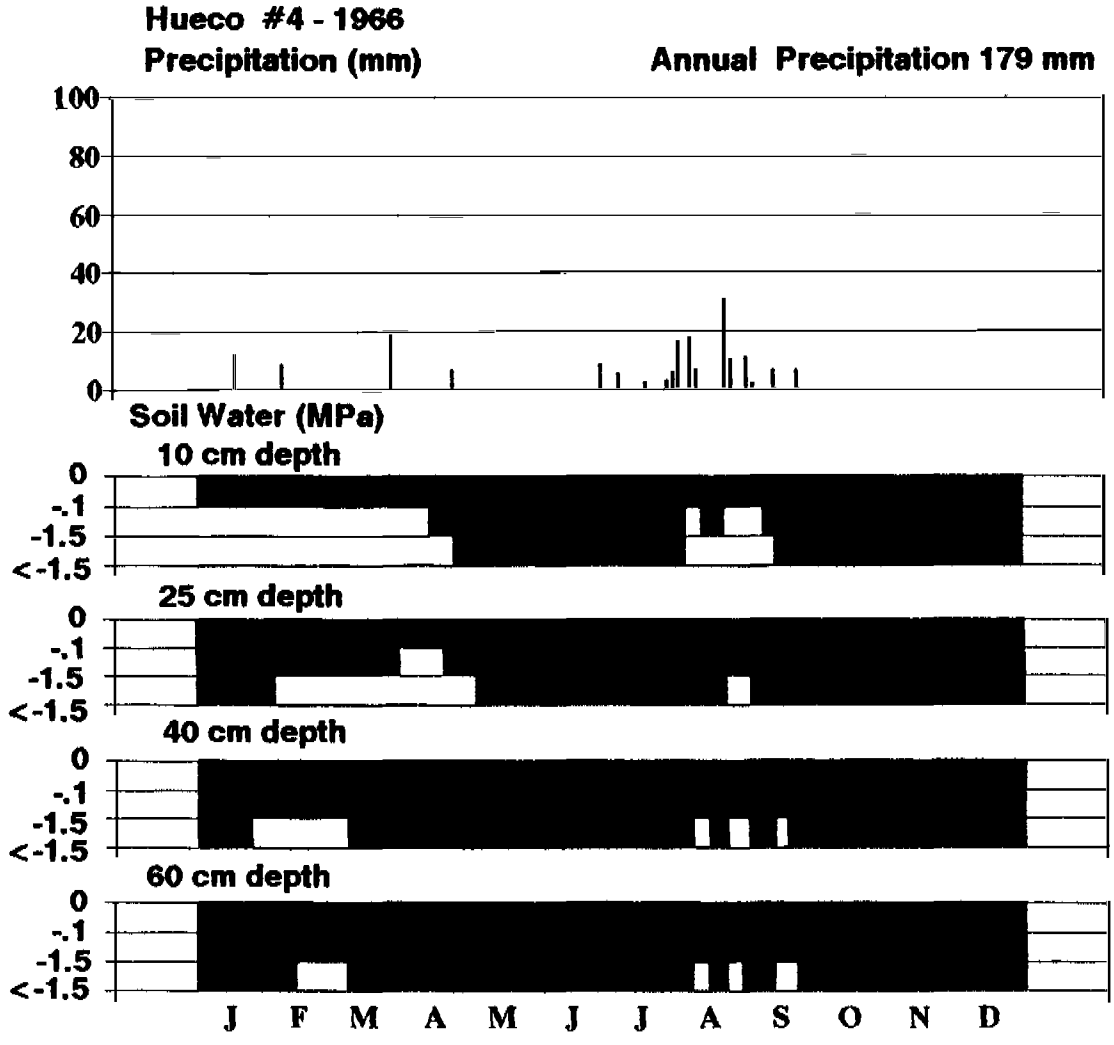


Figure 128. Annual precipitation (179 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1966.

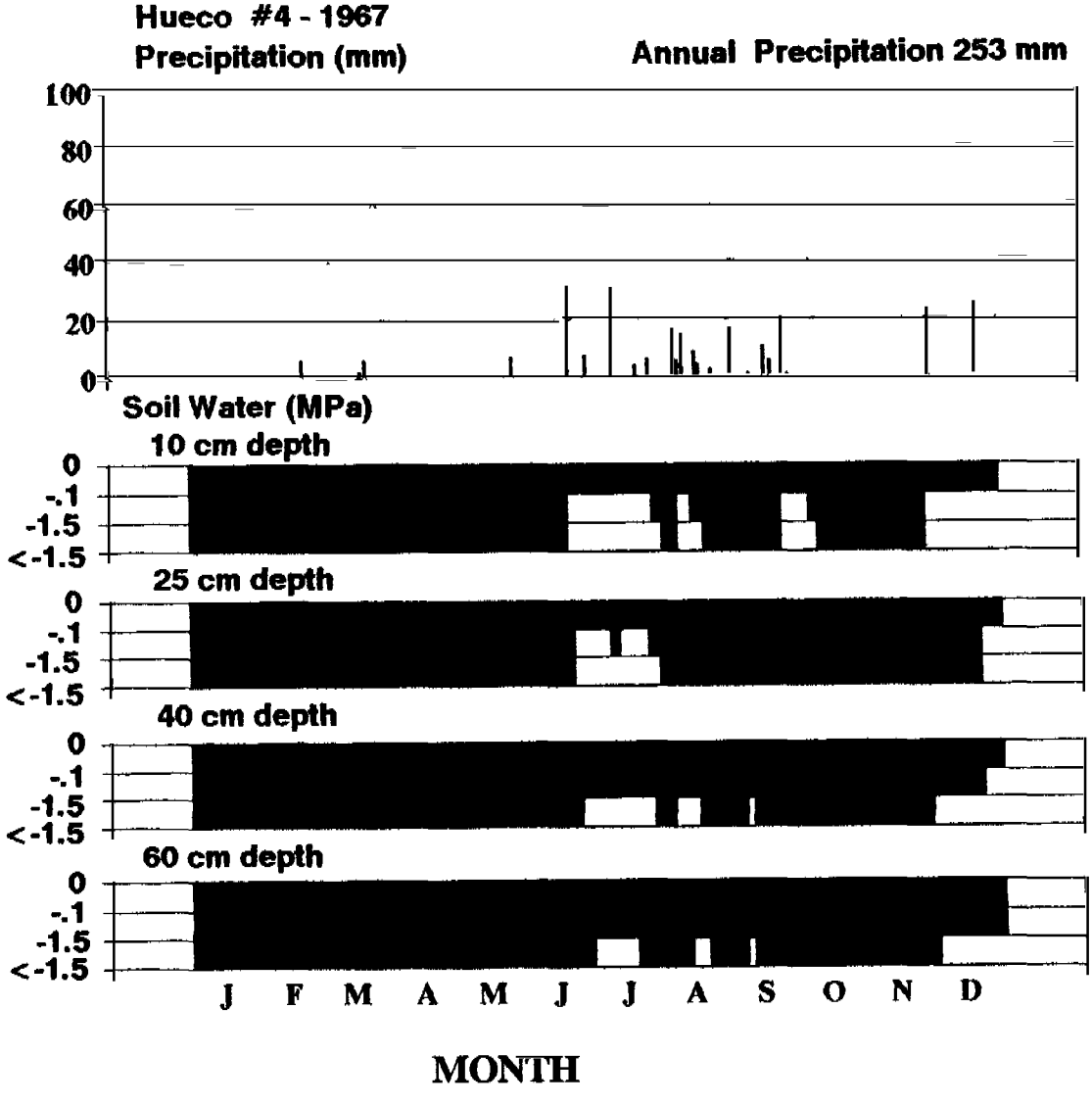


Figure 129. Annual precipitation (253 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1967.

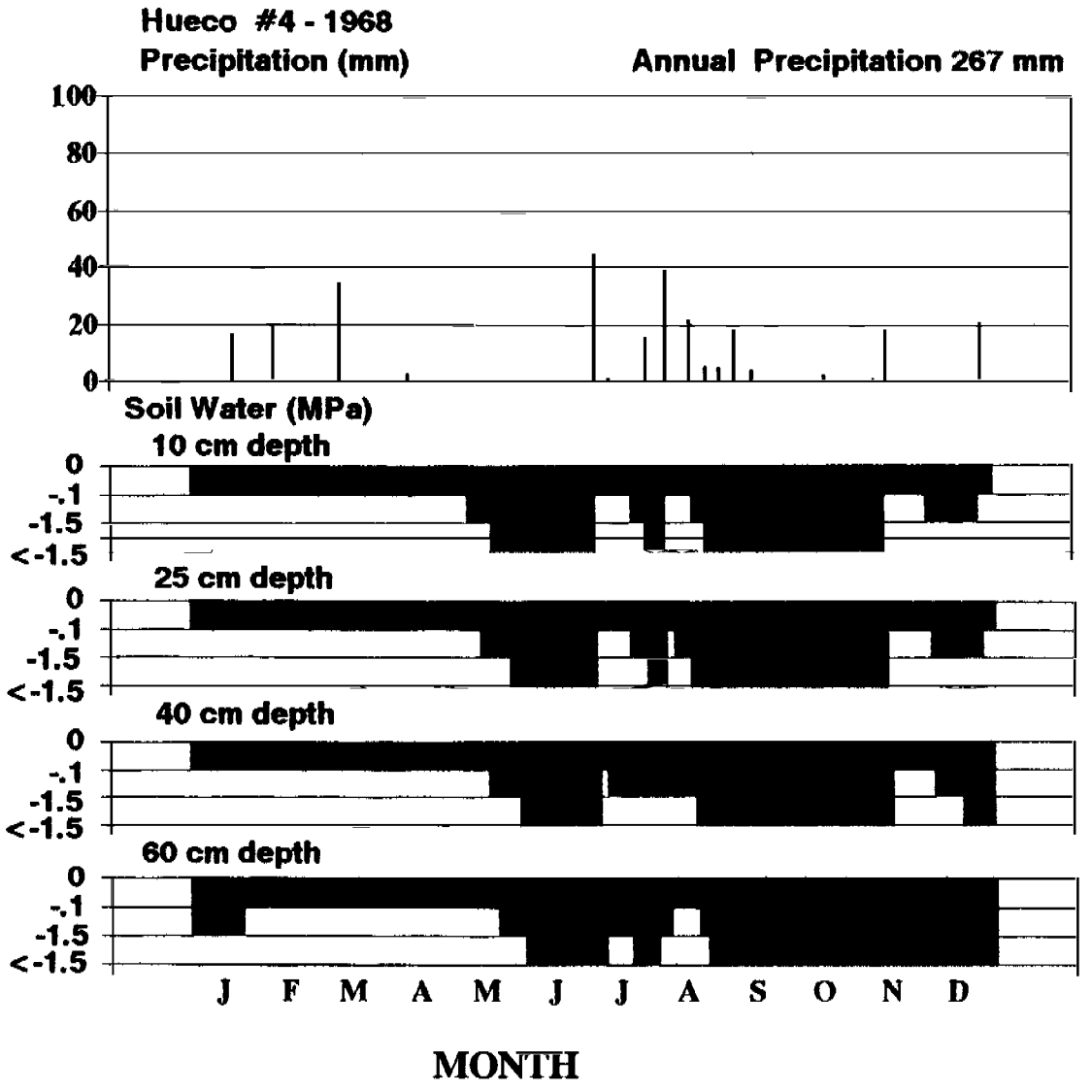


Figure 130. Annual precipitation (267 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1968.

depth July 5-26, 1968 (fig. 130); August 5-15; November 14, 1968-April 22, 1969 (figs. 130, 131); and July 11-31, 1969. Precipitation in late fall and winter 1969-70 resulted in soil water >-1.5 MPa at the 25-cm depth December 8, 1969-May 9, 1970 (figs. 131, 132) even though precipitation in 1970 was below average. There was also soil water >-1.5 MPa at the 25-cm depth July 26-August 30, 1970 (fig. 132).

Annual precipitation was below average in 1971 and it was not until 31 mm on October 25 that there was soil water >-1.5 MPa (fig. 133). The annual precipitation in 1972 was above average but the ohmmeter was inoperative August 1-December 31. The control section had soil water >-1.5 MPa October 26, 1971-April 17, 1972 (figs. 133, 134).

The precipitation in 1973 was below average. The 25-cm depth had soil water >-1.5 MPa January 1-May 3, June 16-July 1, July 20-August 1, and August 30-September 7 (fig. 135). The fall was quite dry.

Annual precipitation was above average in 1974 and about average in 1975. The 25-cm soil depth had water >-1.5 MPa January 11-31, 1974 (fig. 136); July 14-August 31; September 22, 1974-May 24, 1975 (figs. 136, 137); and September 13, 1975-February 21, 1976 (figs. 137, 138). The annual precipitation in 1976 was below average and it was in small amounts and spaced widely enough that soil water >-1.5 MPa was not measured at the 25-cm depth for the balance of the year.

Annual precipitation for 1957-76 was below average ten years, about average three years, and above average seven years. The probability of soil water >-1.5 MPa during the study period at four depths are show in figure 139. At the 25-cm depth, they averaged 67.5% for December-April, 20.1% for May and June, 36.5% for July-September, and 41.0% for October and November.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, ten of 20 years had soil water <-1.5 MPa more than half the time at 10 cm; 12 of 20 years at 25 cm; 11 of 20 years at 40 cm; and 8 of 18 years at a soil depth of 60 cm. Eight of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 7 of 20 years at 25 and 40 cm; and 6 of 18 years at a soil depth of 60 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section 16 of those 20 years and >30 consecutive days within four months after June 21 in 10 years. Both criteria were observed in the same year eight of 19 times. Data were incomplete in 1957 and 1972 but both criteria were met in 1957.

Site Cruces (C)

Site C (figs. 4, 140, 141, table 8) is in the Pasture 2 exclosure on the Jornada Experimental Range. The study trench is 1.4 m south of the south fence of the exclosure. The perennial vegetation consists of scattered clumps of black grama, soaptree yucca, mesquite, mesa dropseed, and broom snakeweed.

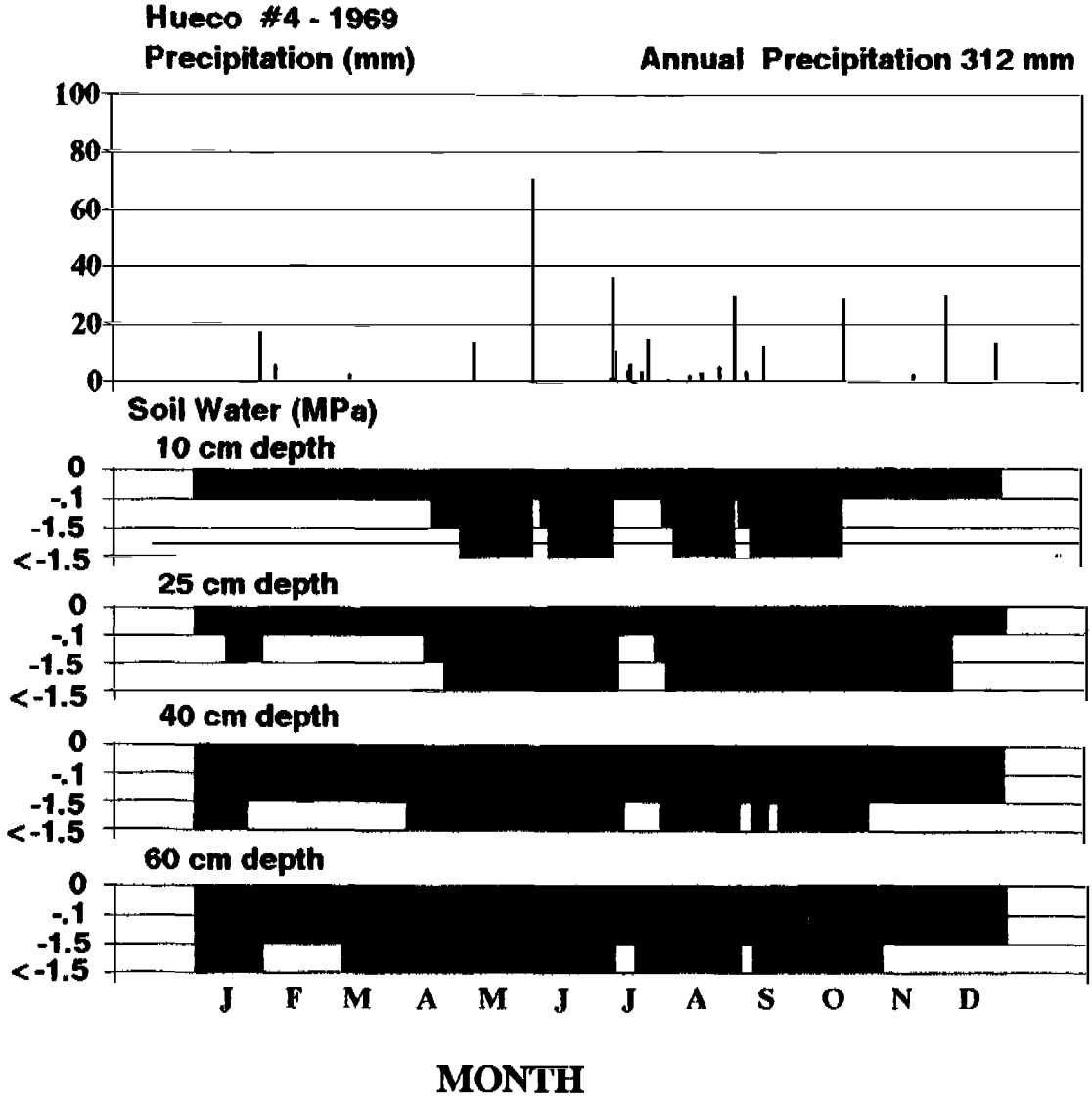


Figure 131. Annual precipitation (312 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1969.

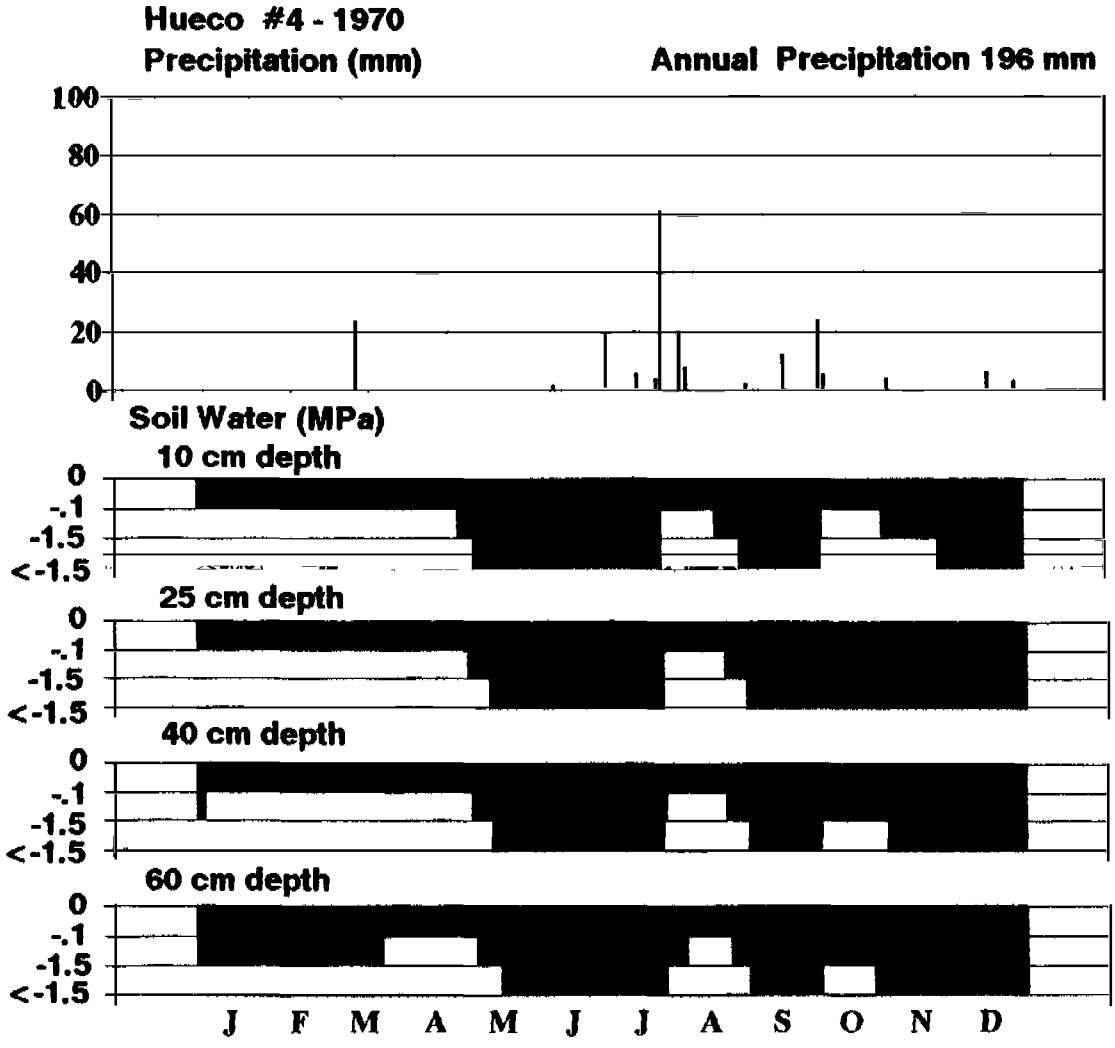


Figure 132. Annual precipitation (196 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1970.

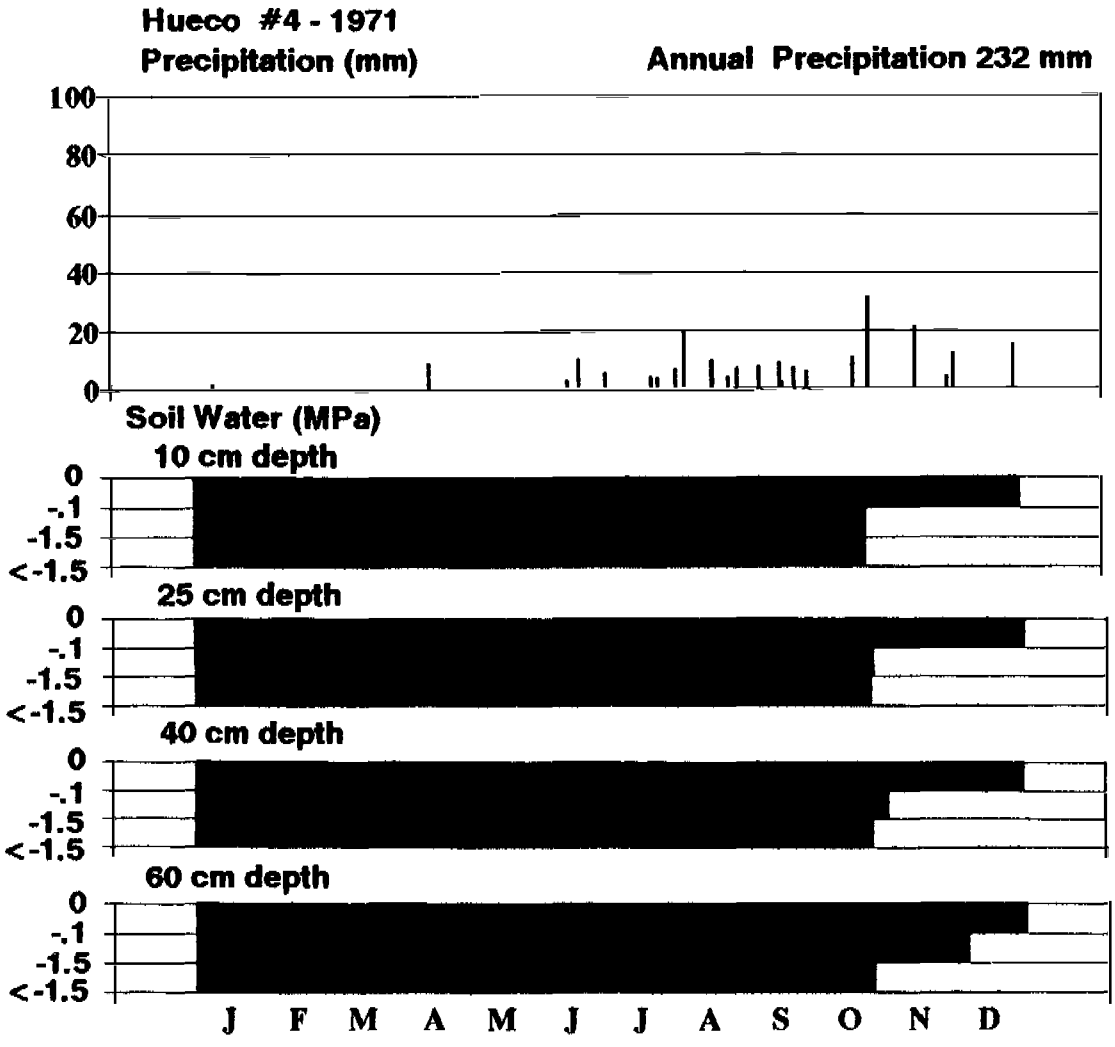


Figure 133. Annual precipitation (232 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1971.

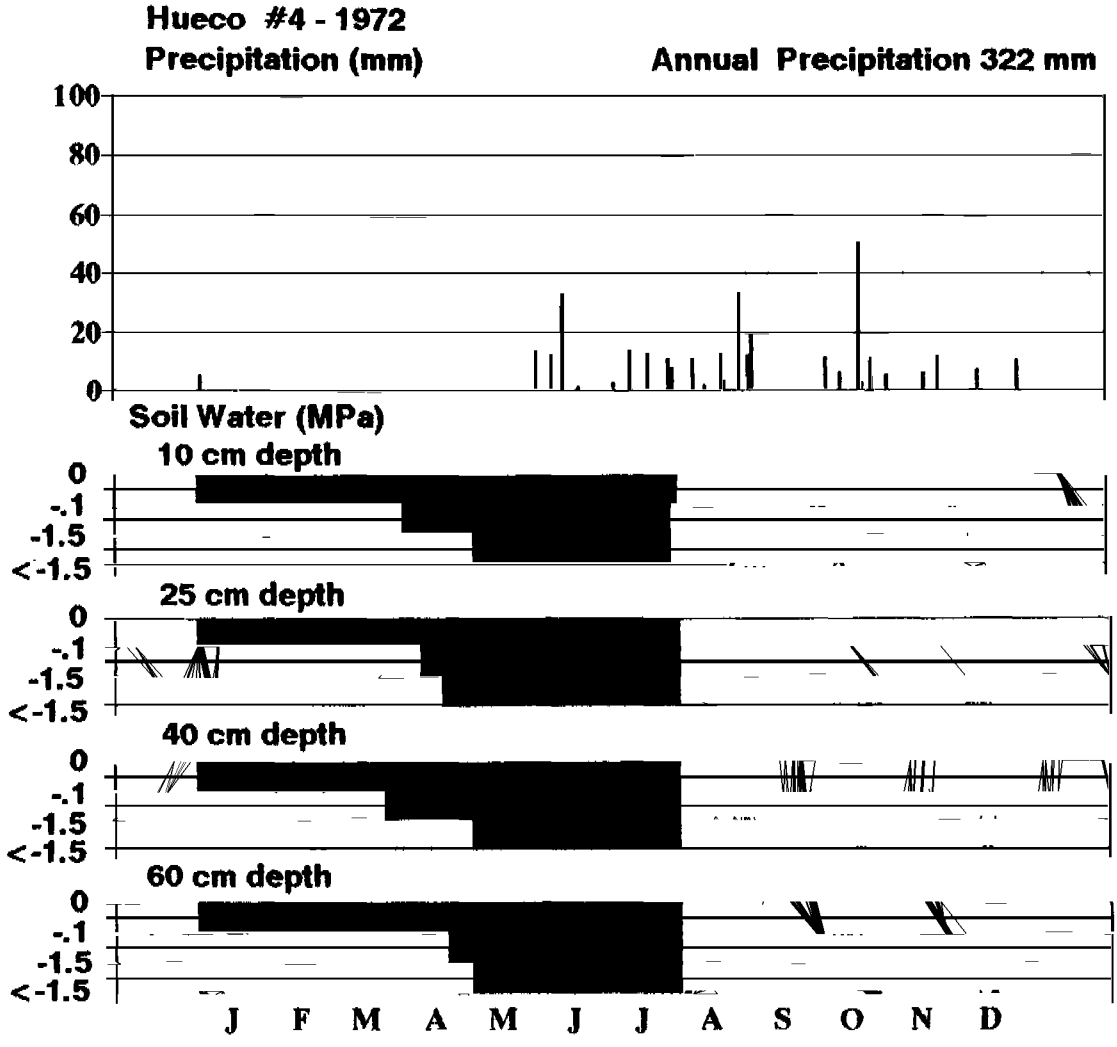


Figure 134. Annual (322 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm for January 1-August 1, 1972 at the Hueco #4 site.

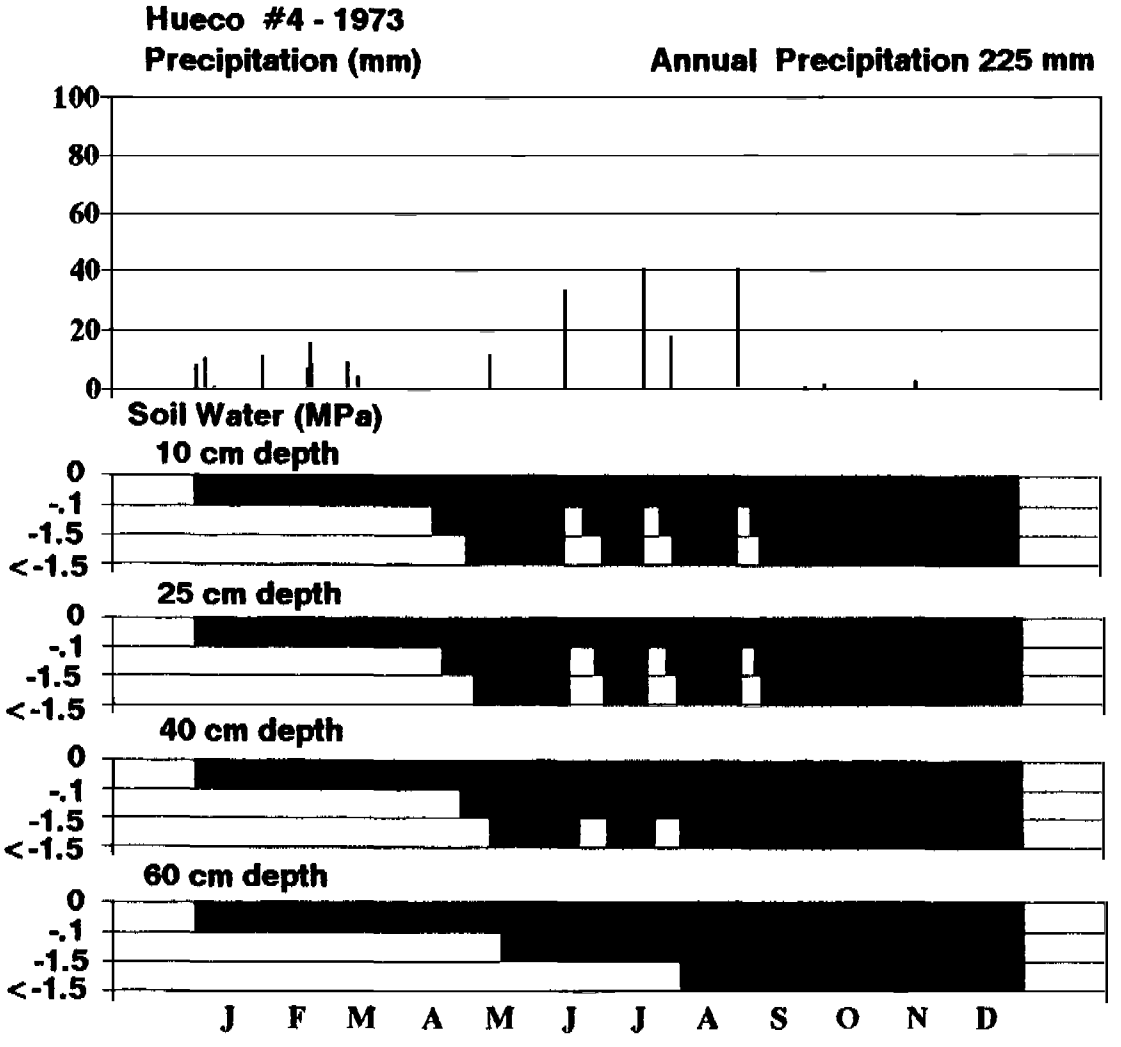


Figure 135. Annual precipitation (225 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1973.

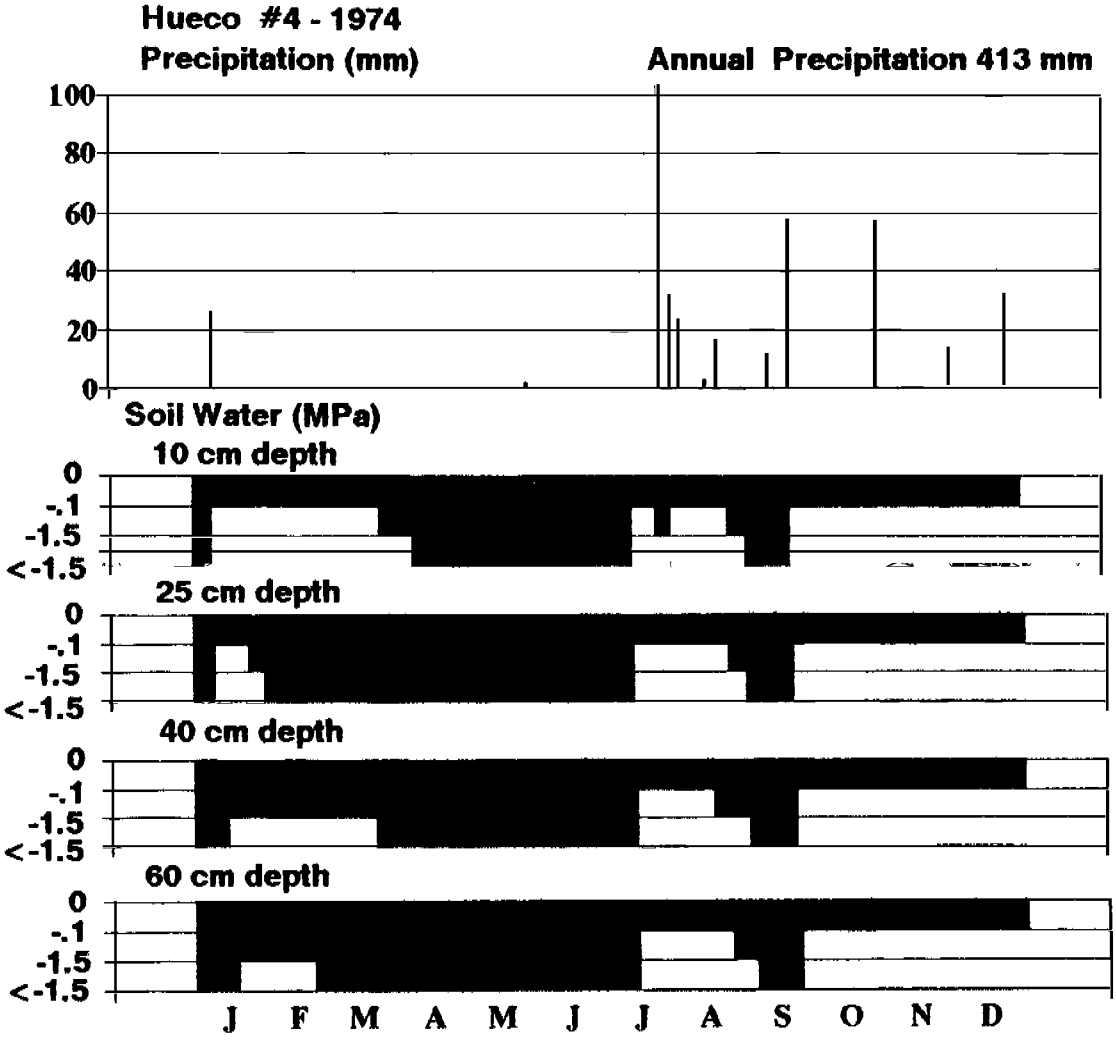


Figure 136. Annual precipitation (413 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1974.

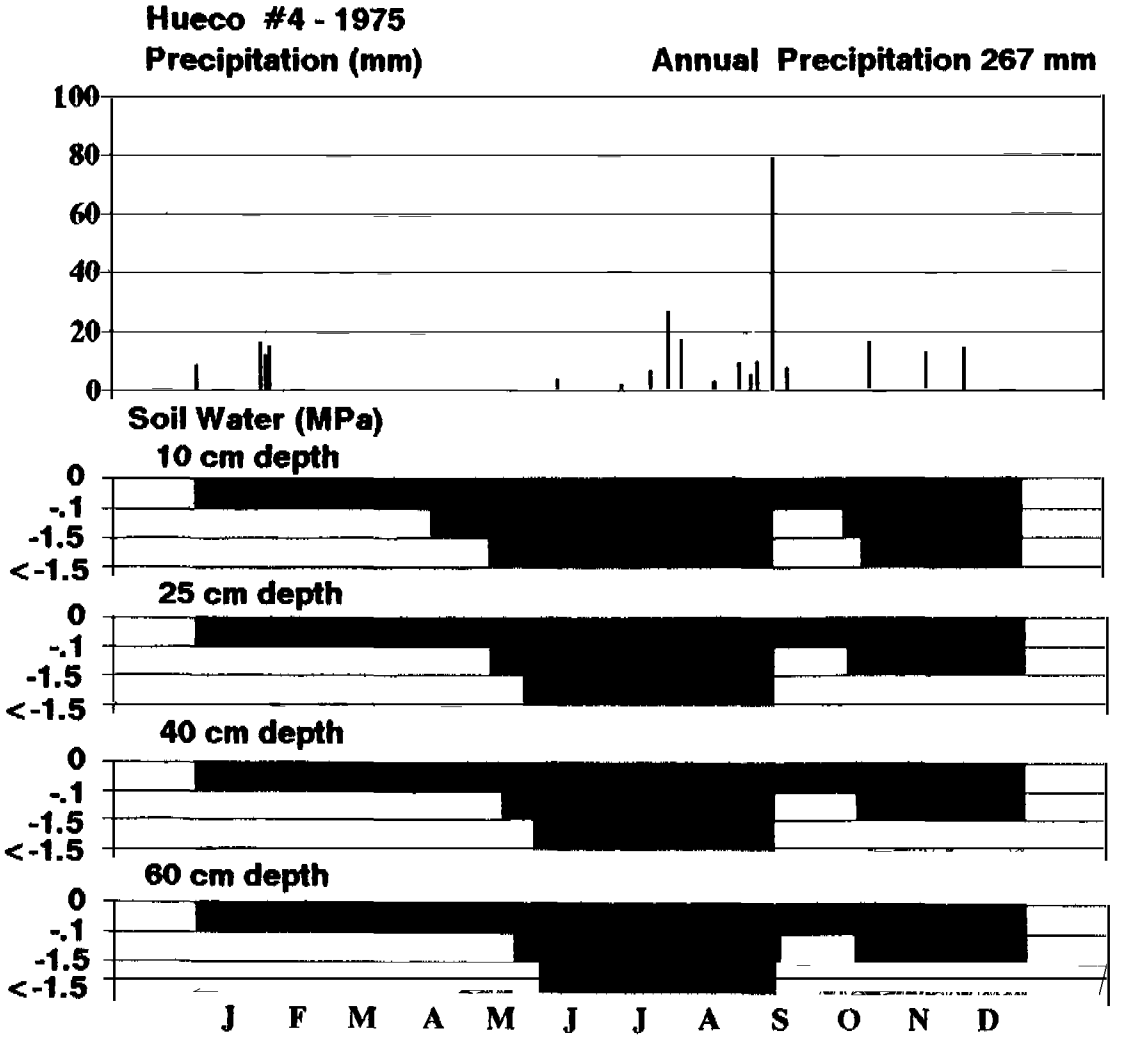


Figure 137. Annual precipitation (267 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1975.

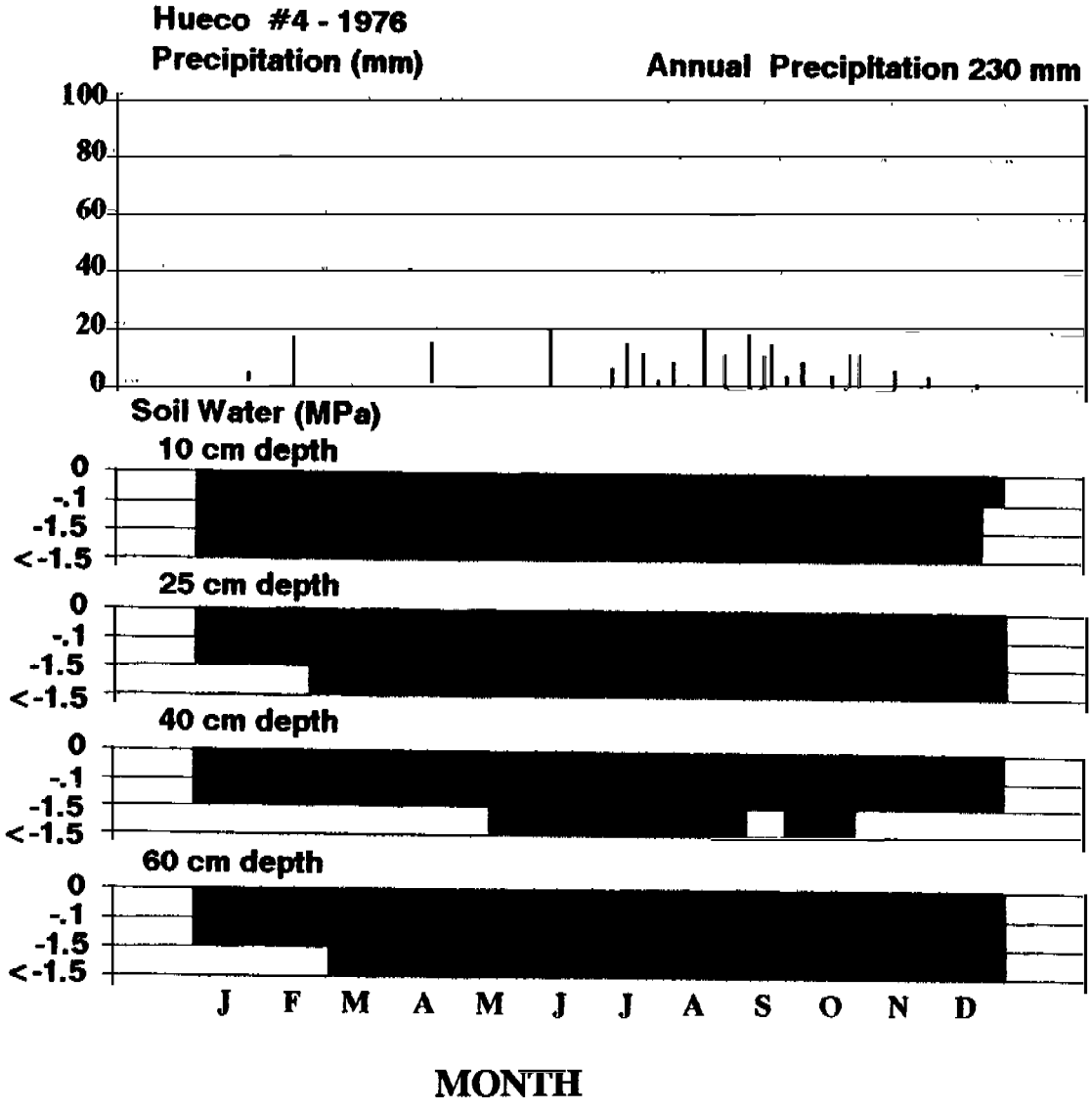


Figure 138. Annual precipitation (230 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, and 60 cm at the Hueco #4 site for 1976.

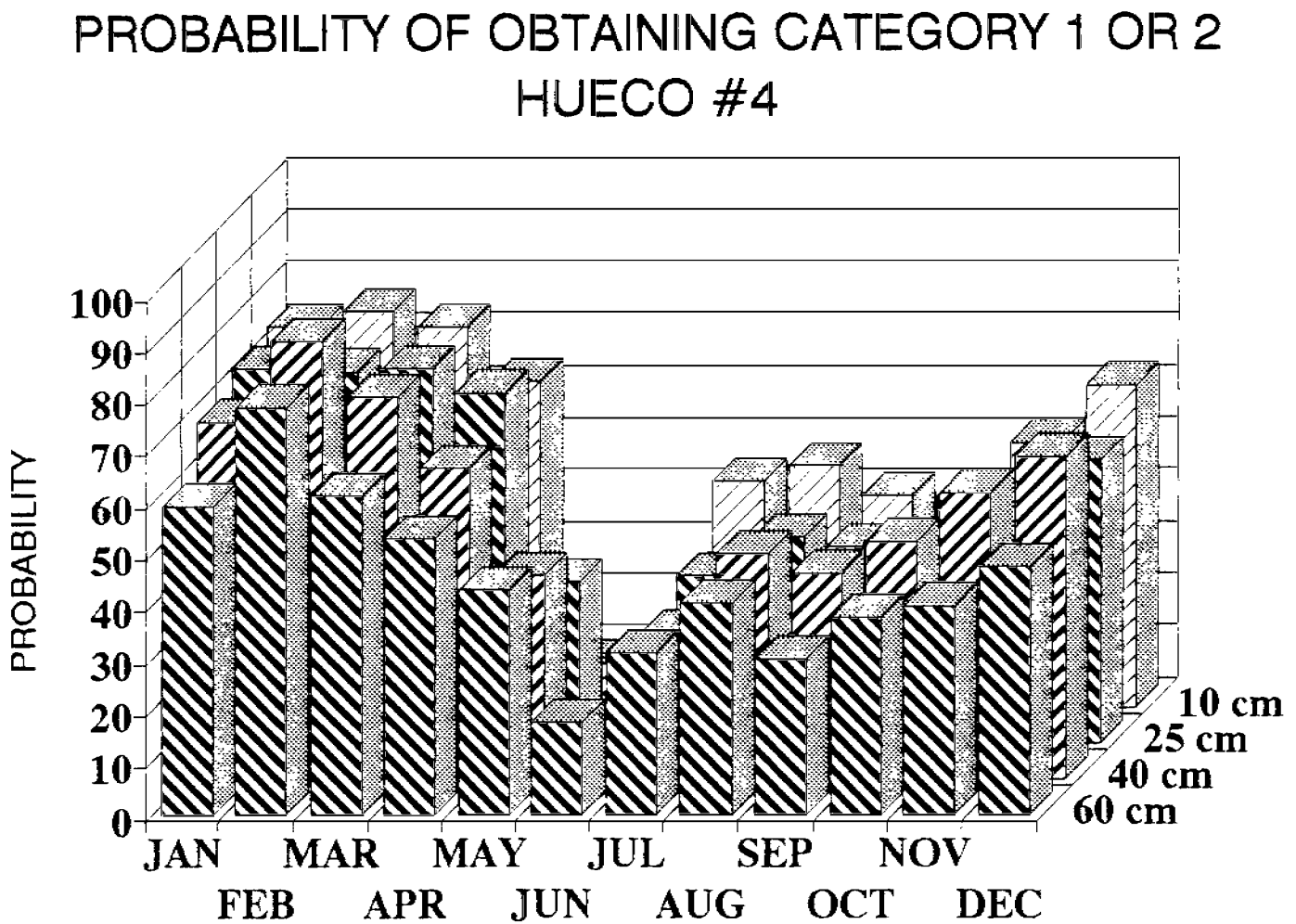


Figure 139. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, and 60 cm at the Hueco #4 site.

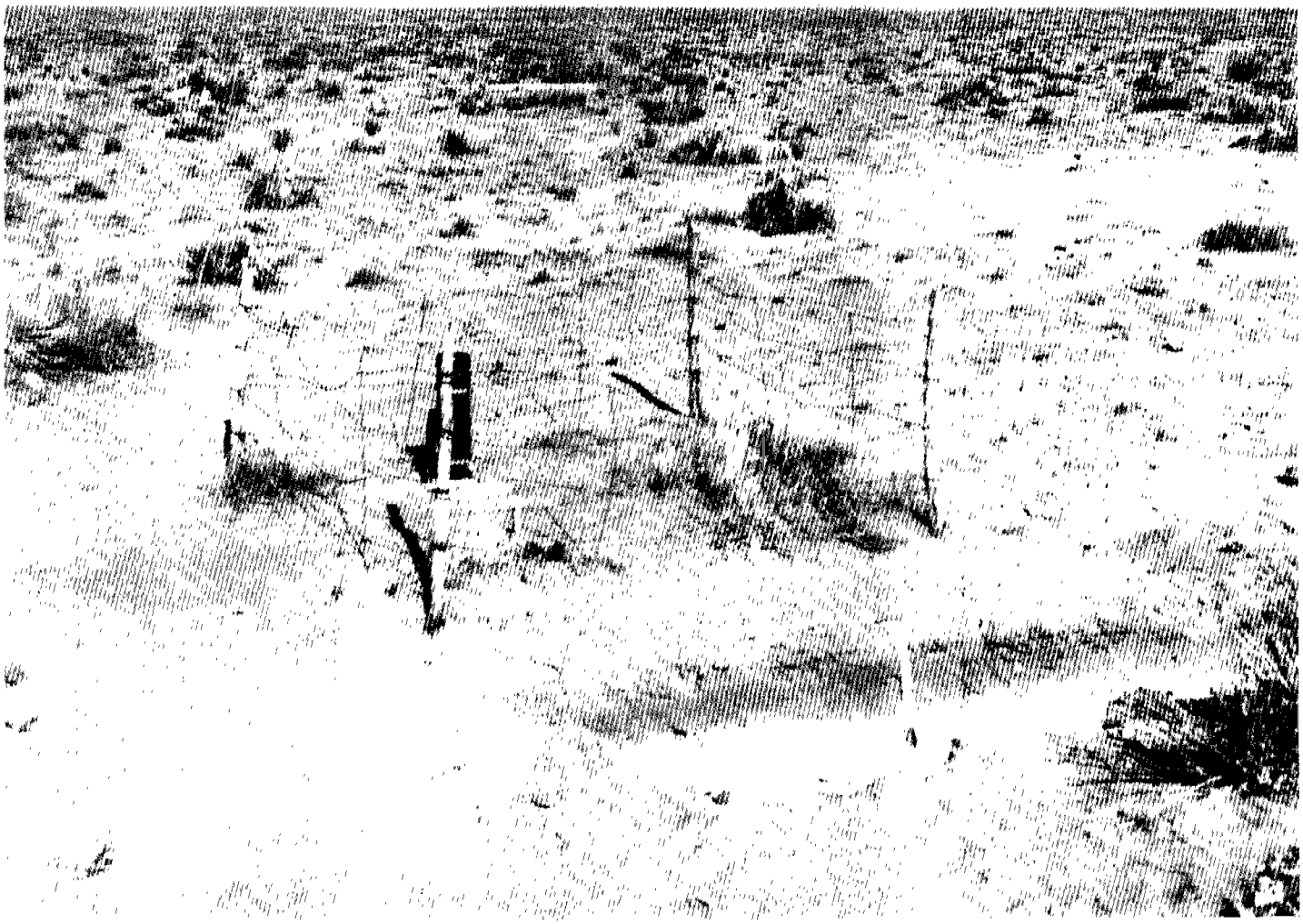


Figure 140. Landscape at Site C (fig. 4) and the Petrocalcic Paleargid Cruces, in the Pasture 2 exclosure on the Jornada Experimental Range. The nonrecording rain gauge and stakes and wires to the soil water blocks are inside the exclosure. Photographed November 1970.

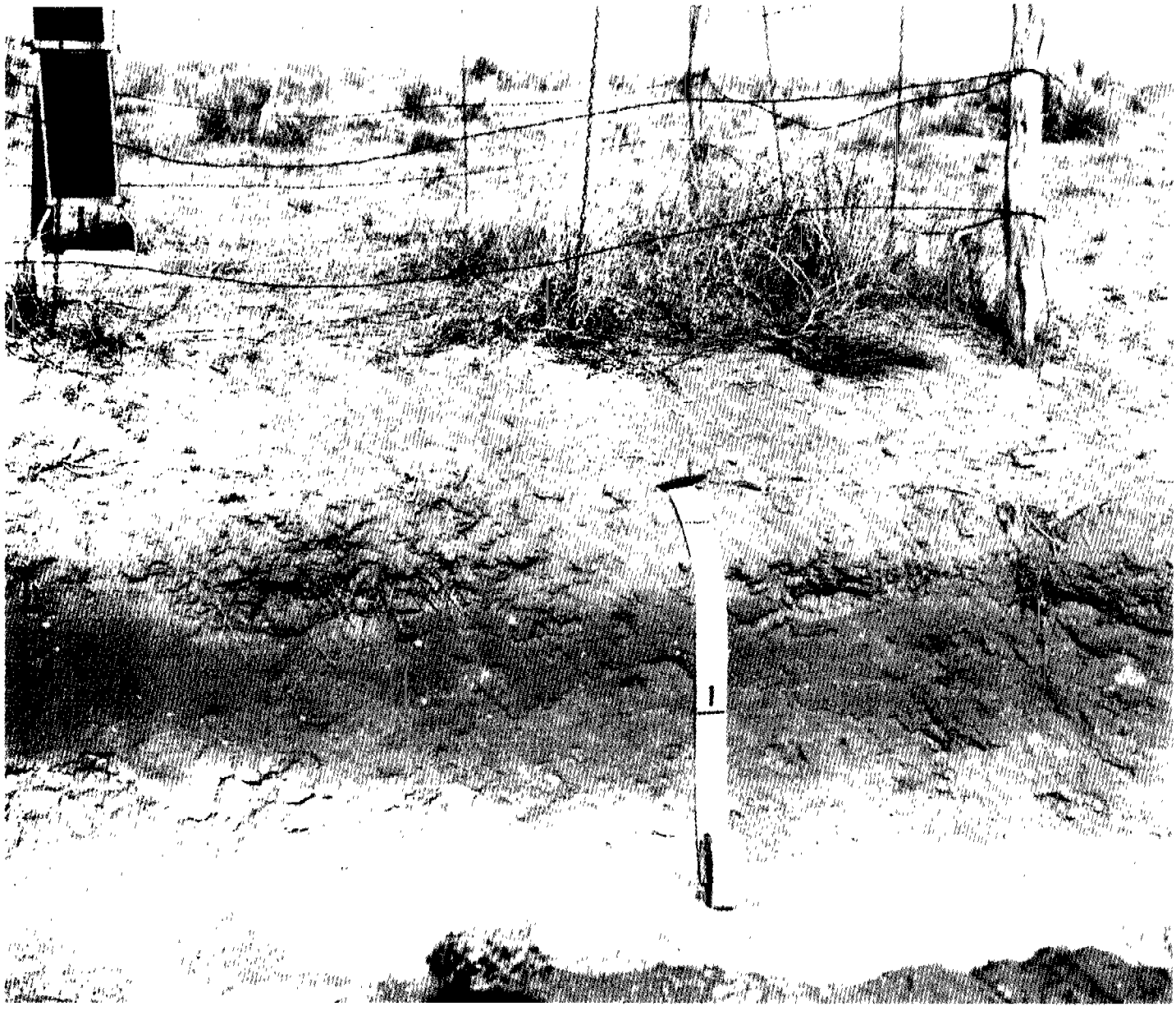


Figure 141. Profile of upper horizons of the Petrocalcic Paleargid Cruces. The very gravelly horizons just above the petrocalcic horizon consist mostly of calcrete fragments. Scale is in feet.

Soils. The soil water blocks are in the Petrocalcic Paleargid Cruces (fig. 141, table 8). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a petrocalcic horizon. The Cruces soil is on La Mesa surface of middle Pleistocene age (table 1) and has formed in sandy fluvial sediments of the Camp Rice Formation. The soil at the moisture blocks is virtually level but a few meters east is a very slight ridge that slopes about 1% towards the site.

Pebbles in the K1b horizon consist of calcrete fragments, concentrations of which occur in places on the surface (fig. 141). Some of these were apparently brought to the surface by rodents, as suggested by concentrations of calcrete fragments on mounds adjacent to rodent tunnels. This mixing activity by rodents has caused a complex pattern of Paleorthids, where the argillic horizon has been obliterated by rodents, and Paleargids, where it is still preserved, as at this site.

The soil is noncalcareous to 26 cm depth, and this depth is a zone of common wetting (figs. 142-154). Carbonate is currently accumulating in the calcareous Bt2 horizon, the K1b horizon and the K21mb horizon. Soil water data (figs. 142-154) show that soil water reaches the petrocalcic horizon at the present time.

Soil Water, Precipitation, and Yields. The gypsum resistance blocks were installed at the soil depths of 10, 25, and 40 cm on July 10, 1964 within a livestock exclosure at the Pasture 2 Rain Gauge. The rain gauge was also installed then. The soil water at 10 cm was >-1.5 MPa July 12-August 6, 1964, as a result of 30 mm rainfall on July 12 (fig. 142). Rainfall of 57 mm on August 14 resulted in soil water >-1.5 MPa at the 10-cm depth August 14-September 3 and 37 mm rainfall on September 11 gave soil water >-1.5 MPa at the 10-cm depth September 11-October 8. The moisture control section, 25-cm soil depth, had water >-1.5 MPa July 13-October 3. With the exception of August 19-25, the soil water was between -0.1 and -1.5 MPa. The soil water at the 40-cm depth was >-1.5 MPa July 13-September 3 and September 14-30. The remainder of the fall was quite dry (fig. 142).

Annual precipitation for 1965 and 1966 was below average. The soil water at 25 cm was >-1.5 MPa January 8-22, 1965; August 5-10 (fig. 143); September 23-29; December 10-22, 1965; February 1-April 26, 1966 (fig. 144); and May 2-October 3. Yields of perennial grasses were obtained each fall by clipping 20, 5-cm x 30.5-m transects. An average of 72% of the perennial grass cover was black grama. The production was 373 kg/ha (s.e.=28 kg/ha) in 1964, 121 kg/ha (s.e.=17 kg/ha) in 1965, and 463 kg/ha (s.e.=62 kg/ha) in 1966.

The annual precipitation for 1967 was above average but winter-spring was quite dry. The soil profile was moistened by 66 mm rainfall on June 29 (fig. 145). There was soil water >-1.5 MPa at the 25-cm depth July 4-22; August 12-September 1; and December 7, 1967-May 26, 1968 (figs. 145, 146). The production of perennial grasses in fall 1967 was 351 kg/ha (s.e.=44 kg/ha).

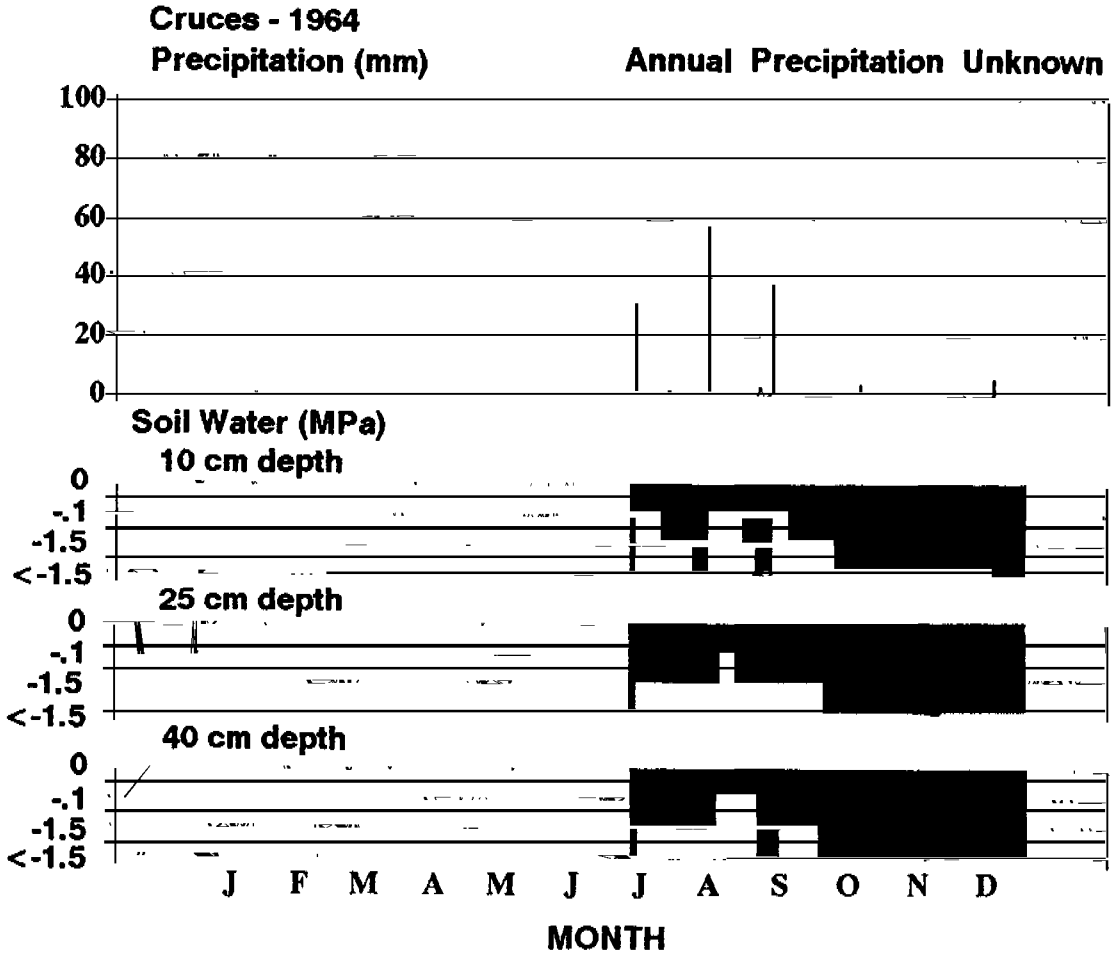


Figure 142. The daily precipitation (mm) and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for the Cruces site for July 10-December 31, 1964.

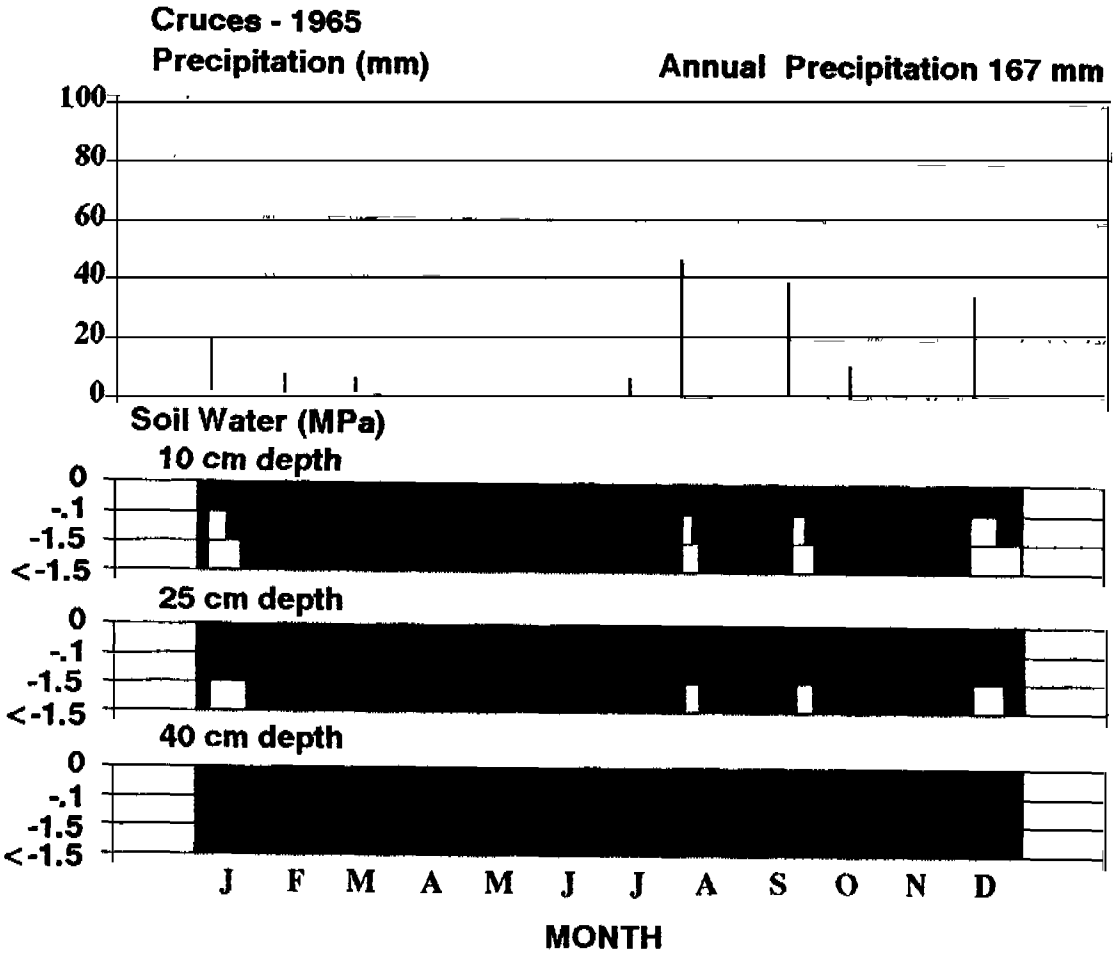


Figure 143. Annual precipitation (167 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1965.

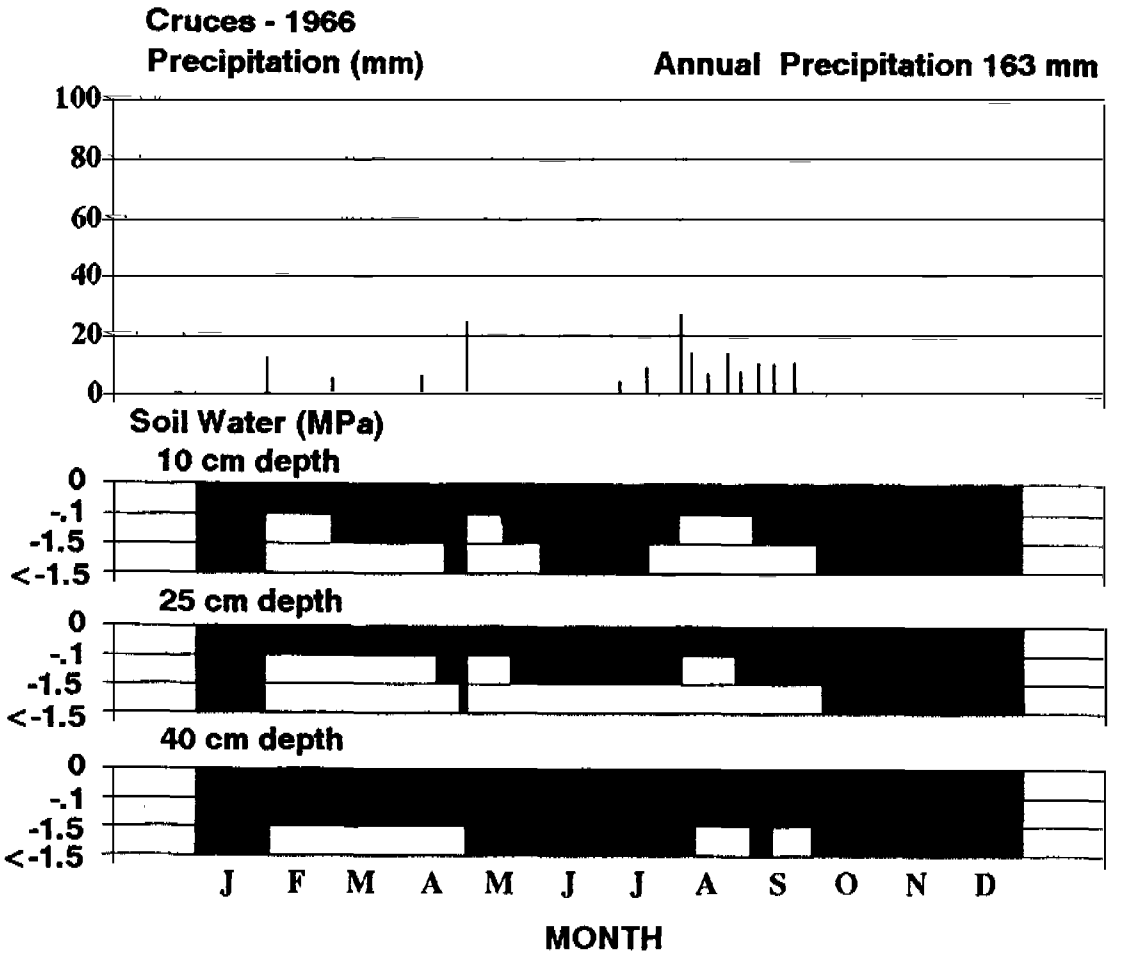


Figure 144. Annual precipitation (163 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1966.

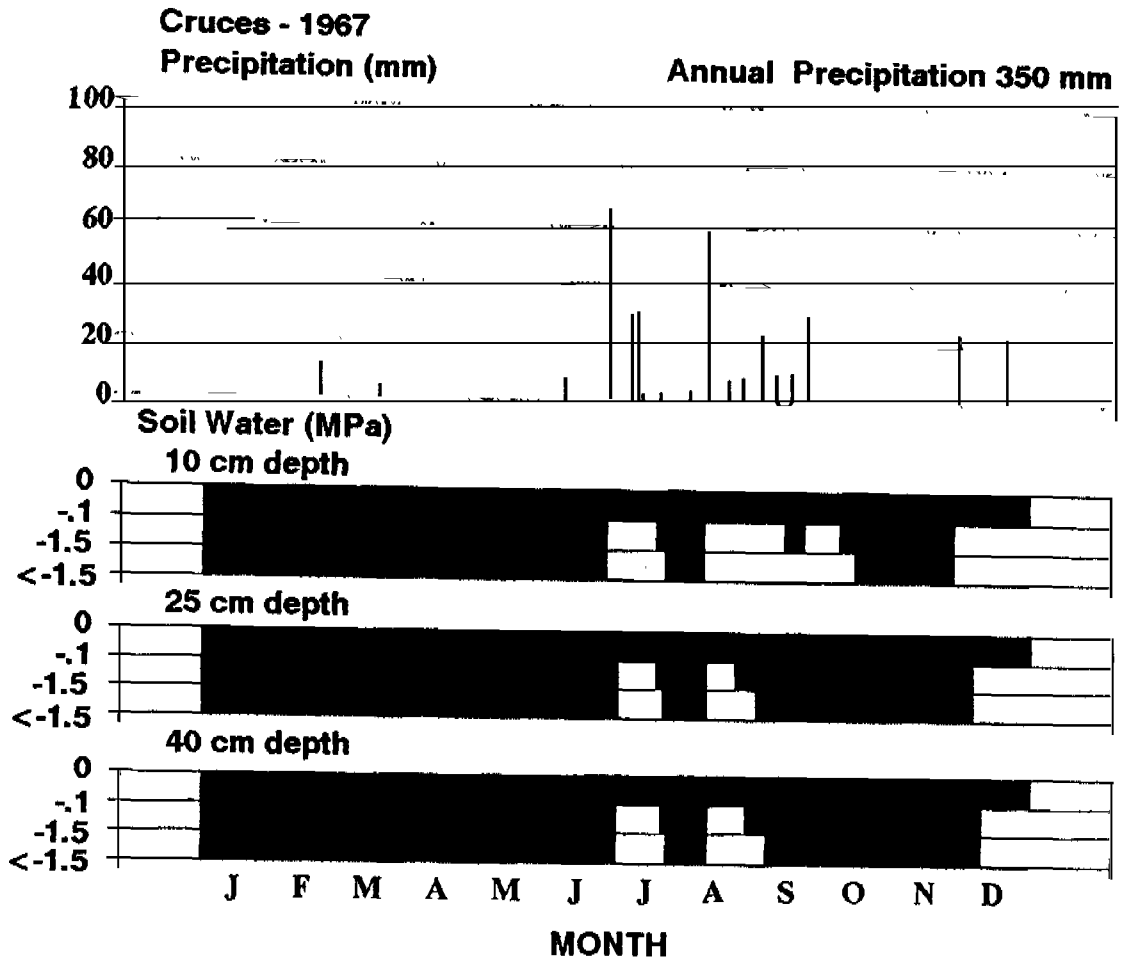


Figure 145. Annual precipitation (350 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1967.

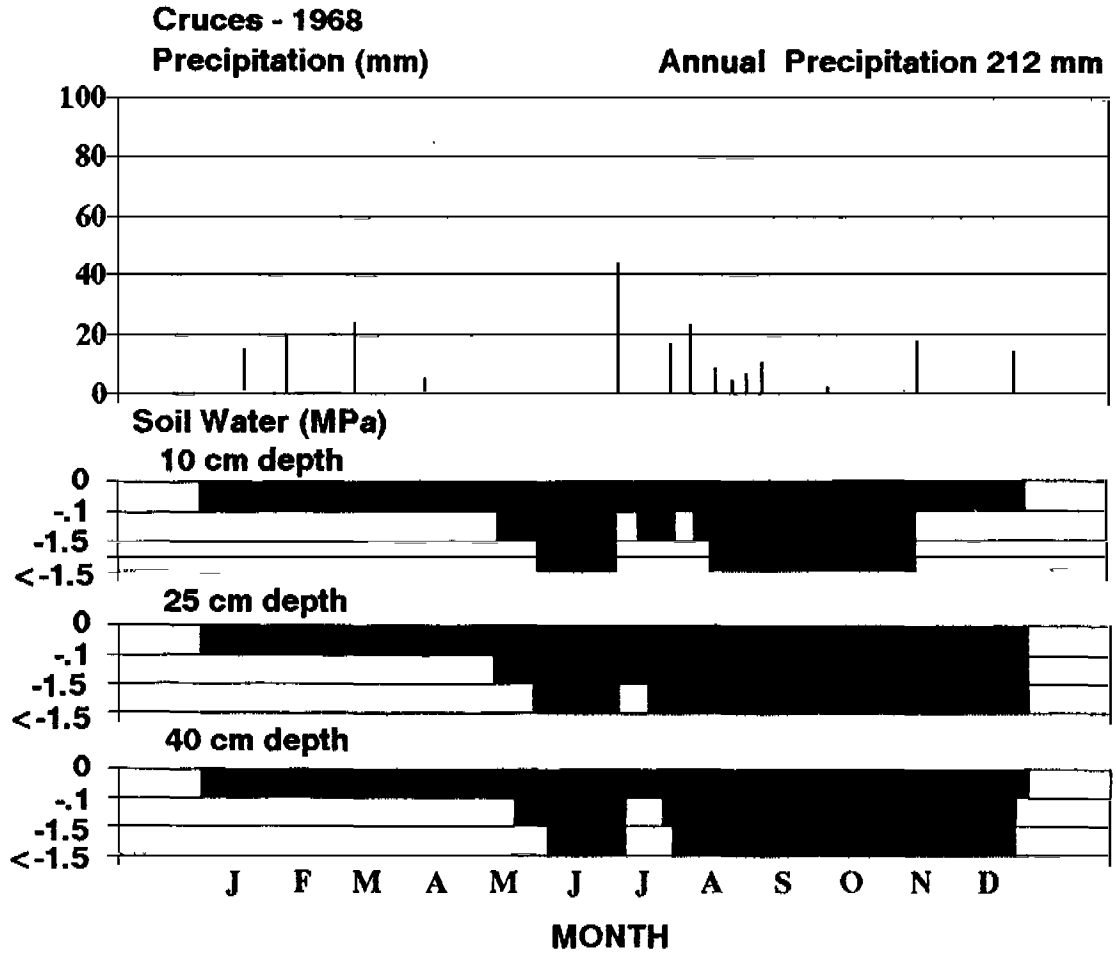


Figure 146. Annual precipitation (212 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1968.

The annual precipitation for 1968 was slightly below average but perennial grasses averaged 368 kg/ha (s.e.=40 kg/ha). Besides that mentioned above, the only soil water >-1.5 MPa at 25 cm was July 5-16 (fig. 146).

Production of perennial grasses averaged 401 kg/ha (s.e.=41 kg/ha) in 1969. Soil water at the 25-cm depth was >-1.5 MPa February 1-May 7 (fig. 147); July 11-August 5; and November 29, 1969-May 8, 1970 (figs. 147, 148).

Precipitation was considerably below average in 1970. The most significant storm was 38 mm rainfall on July 25 (fig. 148). There was soil water >-1.5 MPa at 25 cm in the winter-spring and July 26-August 30 (fig. 148). Production of perennial grasses was 93 kg/ha (s.e.=9 kg/ha).

Precipitation was slightly below average in 1971 and production of perennial grasses averaged only 148 kg/ha (s.e.=15 kg/ha). The winter-spring was dry and in the summer there was water >-1.5 MPa at the 25-cm soil depth August 1-22 (fig. 149).

Precipitation in 1972 was quite high but no soil water estimates were obtained August 1-December 31. Soil water at the 25-cm depth was >-1.5 MPa October 27, 1971-May 15, 1972 (figs. 149, 150). Average production of perennial grasses was 344 kg/ha (s.e.=27 kg/ha).

Perennial grasses yielded 290 kg/ha (s.e.=58 kg/ha) in 1973 and 270 kg/ha (s.e.=25 kg/ha) in 1974. Soil water at 25 cm was >-1.5 MPa January 1-May 31, 1973 (fig. 151); July 21-August 28; January 18-March 31, 1974 (fig. 152); July 16-25; and November 2-December 30, 1974.

Both 1975 and 1976 had above average precipitation but much different soil water patterns. Water at the 25-cm depth was >-1.5 MPa February 2-May 2, 1975 (fig. 153); September 14-November 26, 1975; July 15-August 10, 1976 (fig. 154); and December 17-31, 1976. In the fall, perennial grasses averaged 756 kg/ha (s.e.=70 kg/ha) in 1975 and 498 kg/ha (s.e.=44 kg/ha) in 1976.

Production of perennial grasses averaged 344 kg/ha during 1964-76. The probability of soil water >-1.5 MPa at the 25-cm depth averaged 47.1% for December-April, 20.6% for May-June, 36.5% for July-September, and 17.9% for October-November (fig. 155).

Annual precipitation for 1965-76 was below average six years, about average two years, and above average four years.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, seven of 13 years had soil water <-1.5 MPa more than half the time at 10 cm, and 11 of 13 years at soil depths of 25 and 40 cm. Seven of 13 years had soil water <-1.5 MPA for >90 consecutive days at 10 cm, 6 of 13 years at 25 cm, and 8 of 13 years at a soil depth of 40 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 10 of 13 years and >30 consecutive days in the four months after June 21, 5 of 11 years. Soil water data were incomplete in 1964 and 1972 but both criteria were observed in 1964 and there were >60 consecutive days of soil water >-1.5 MPa at the 25-cm depth in 1972.

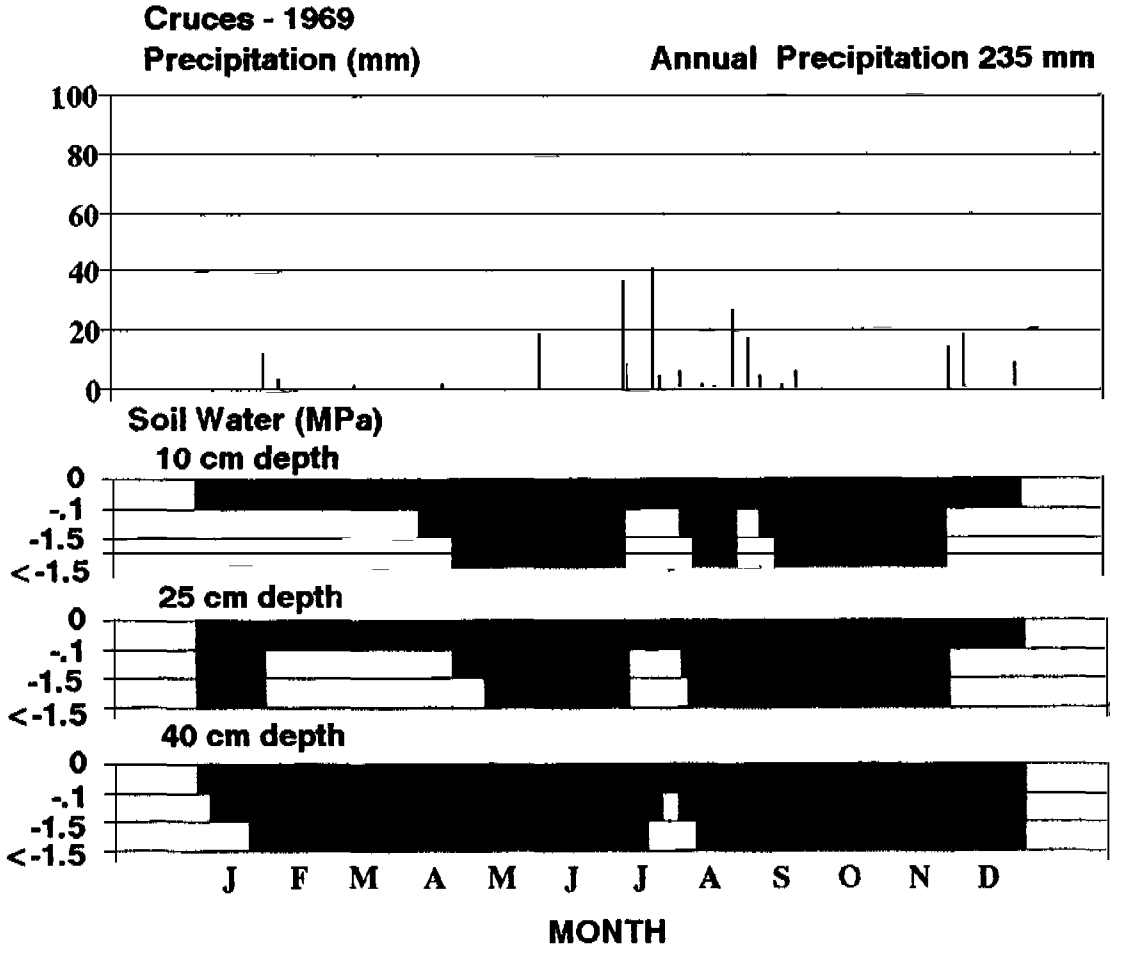


Figure 147. Annual precipitation (235 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1969.

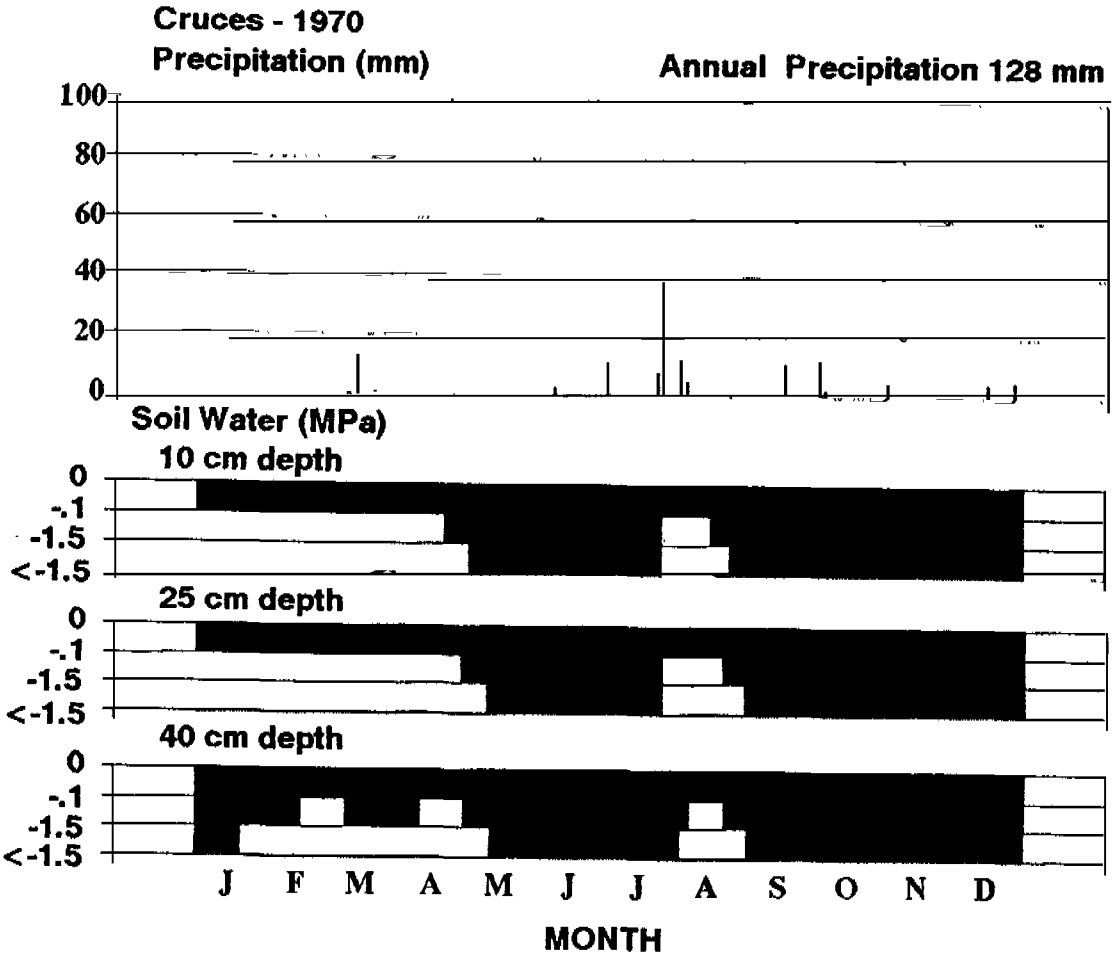


Figure 148. Annual precipitation (128 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1970.

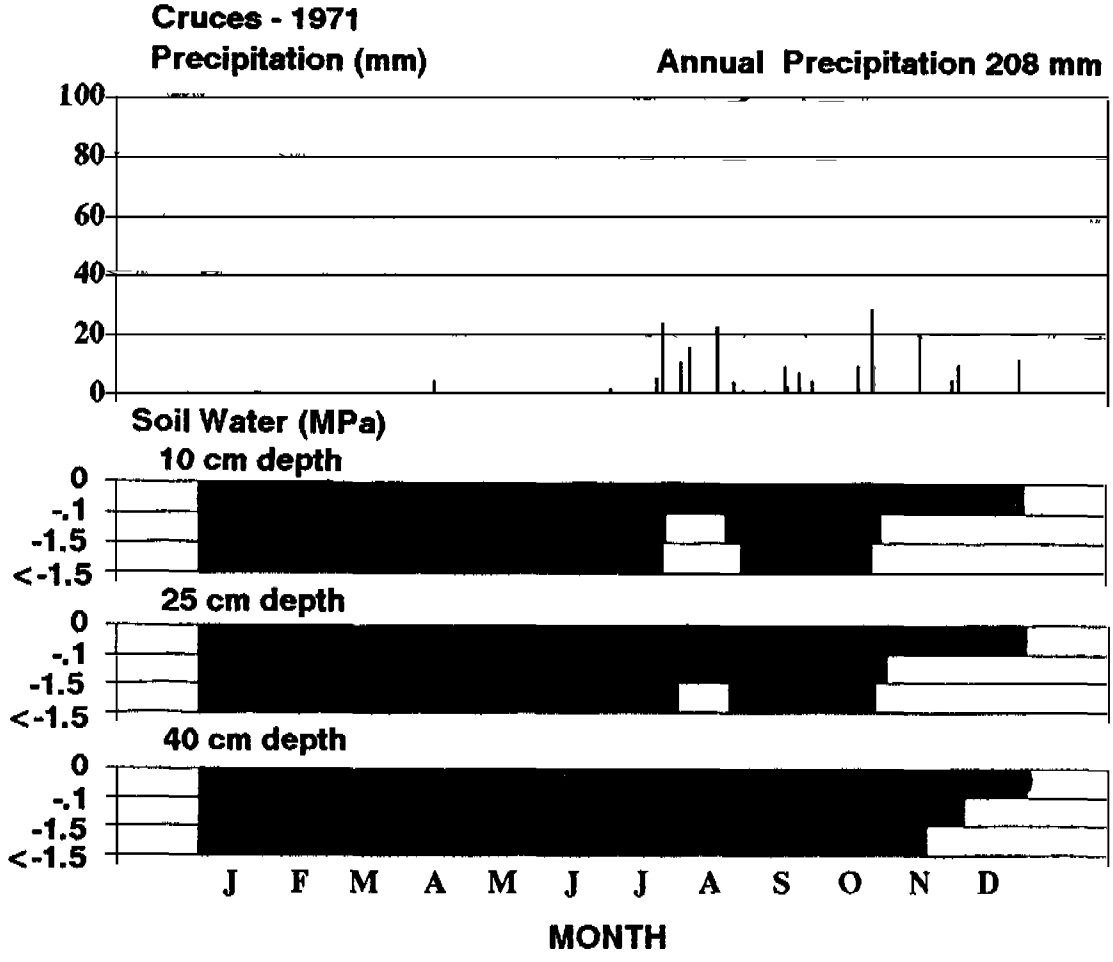


Figure 149. Annual precipitation (208 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1971.

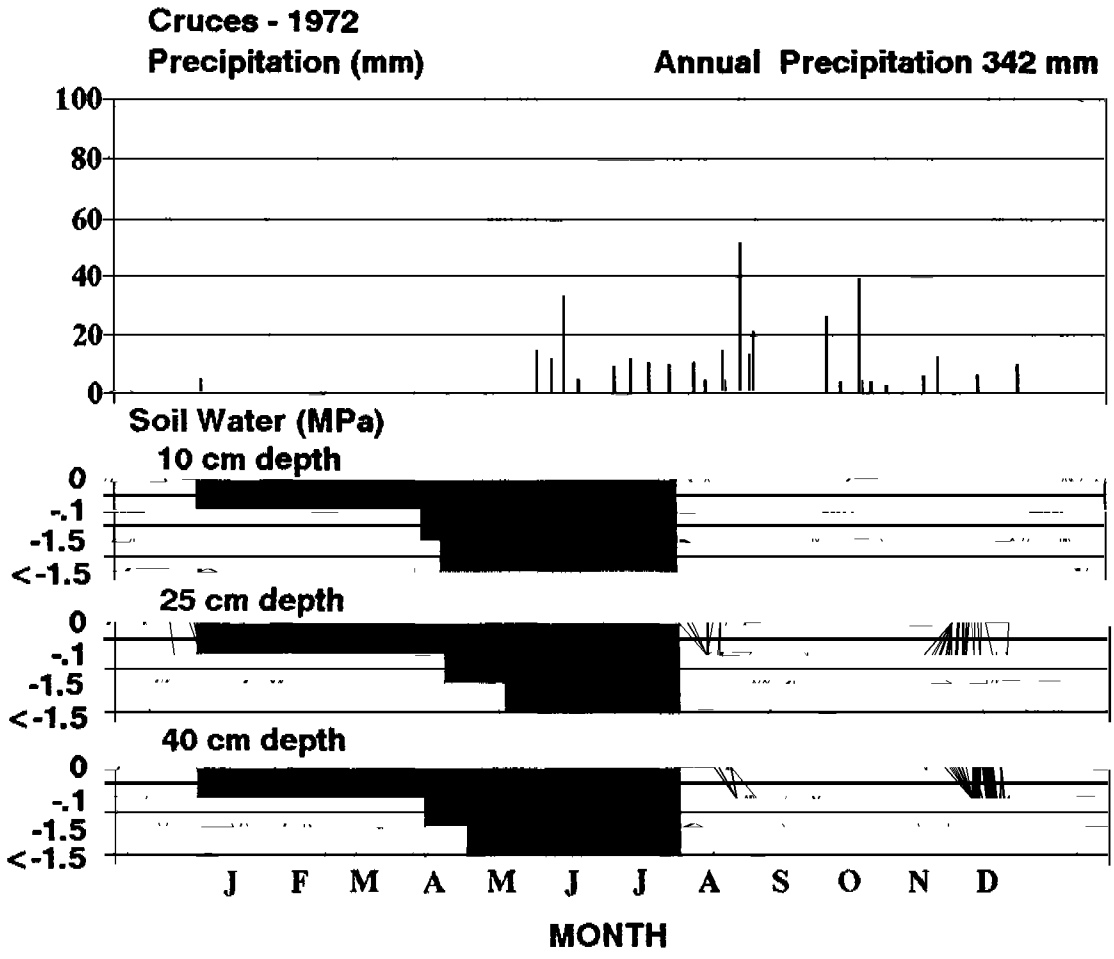


Figure 150. Annual (342 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for January 1-August 1, 1972.

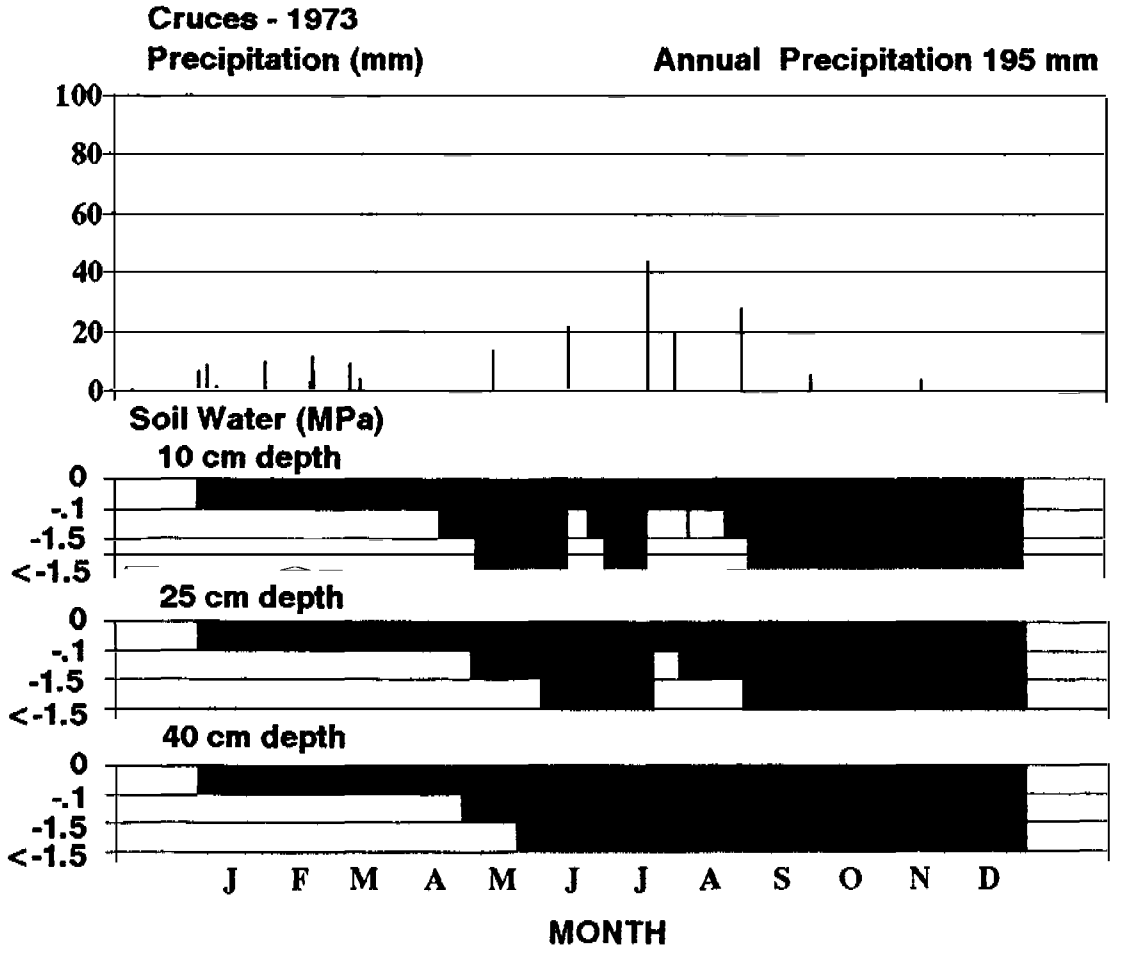


Figure 151. Annual precipitation (195 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1973.

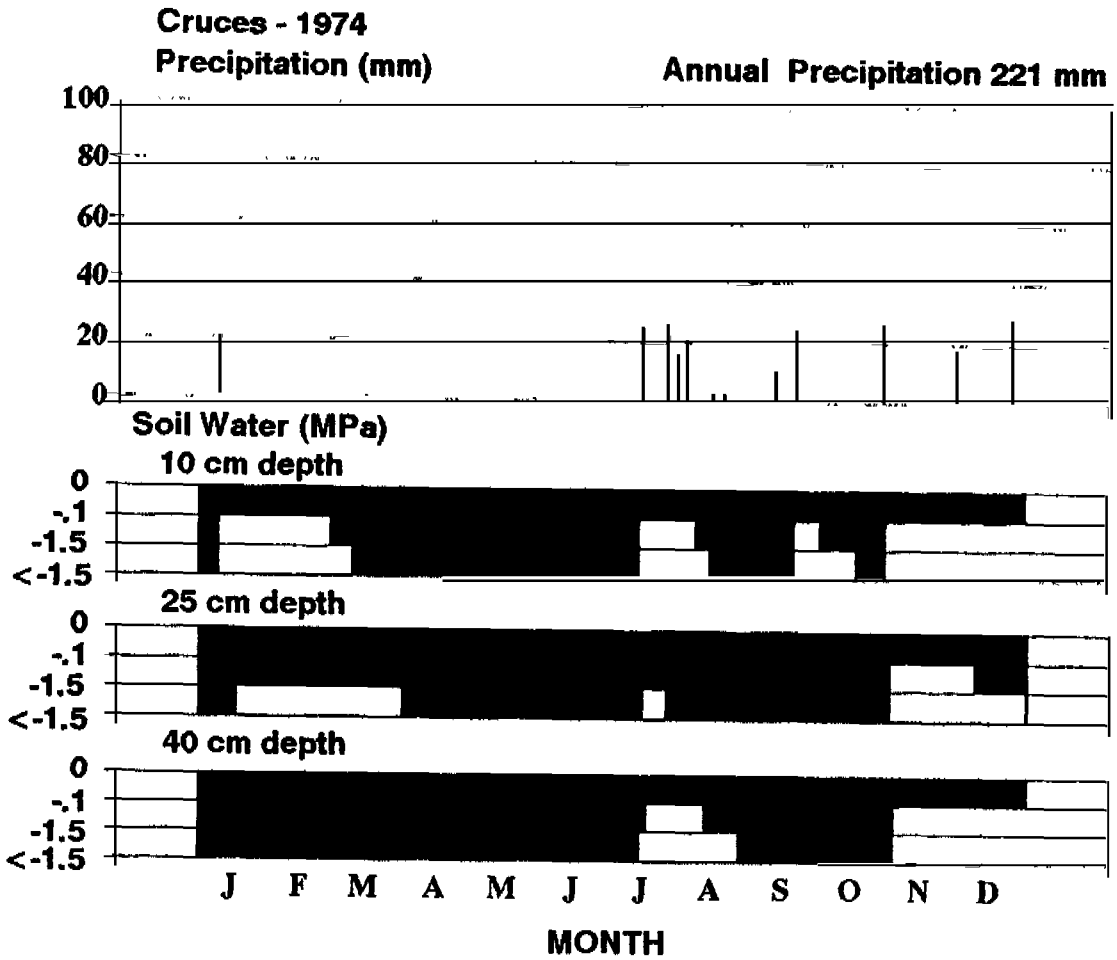


Figure 152. Annual precipitation (221 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1974.

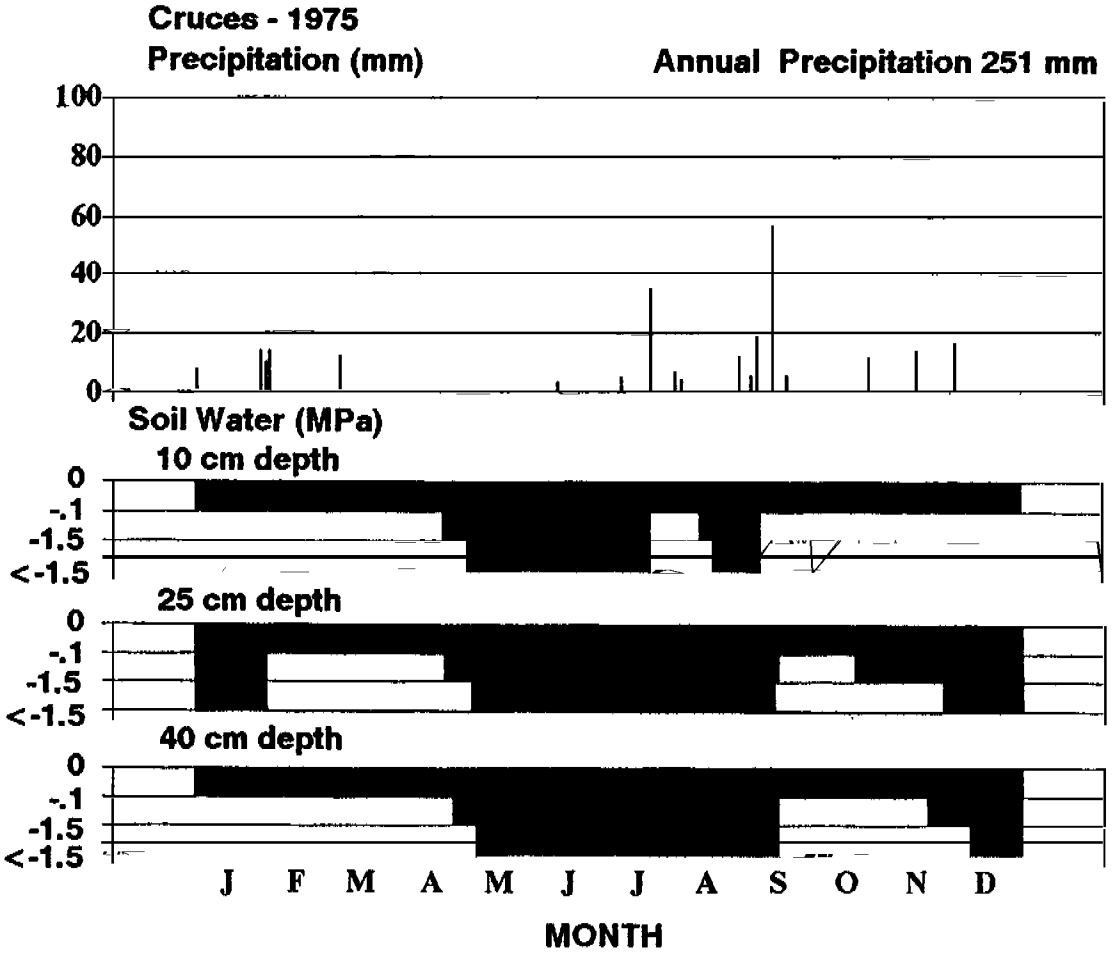


Figure 153. Annual precipitation (251 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1975.

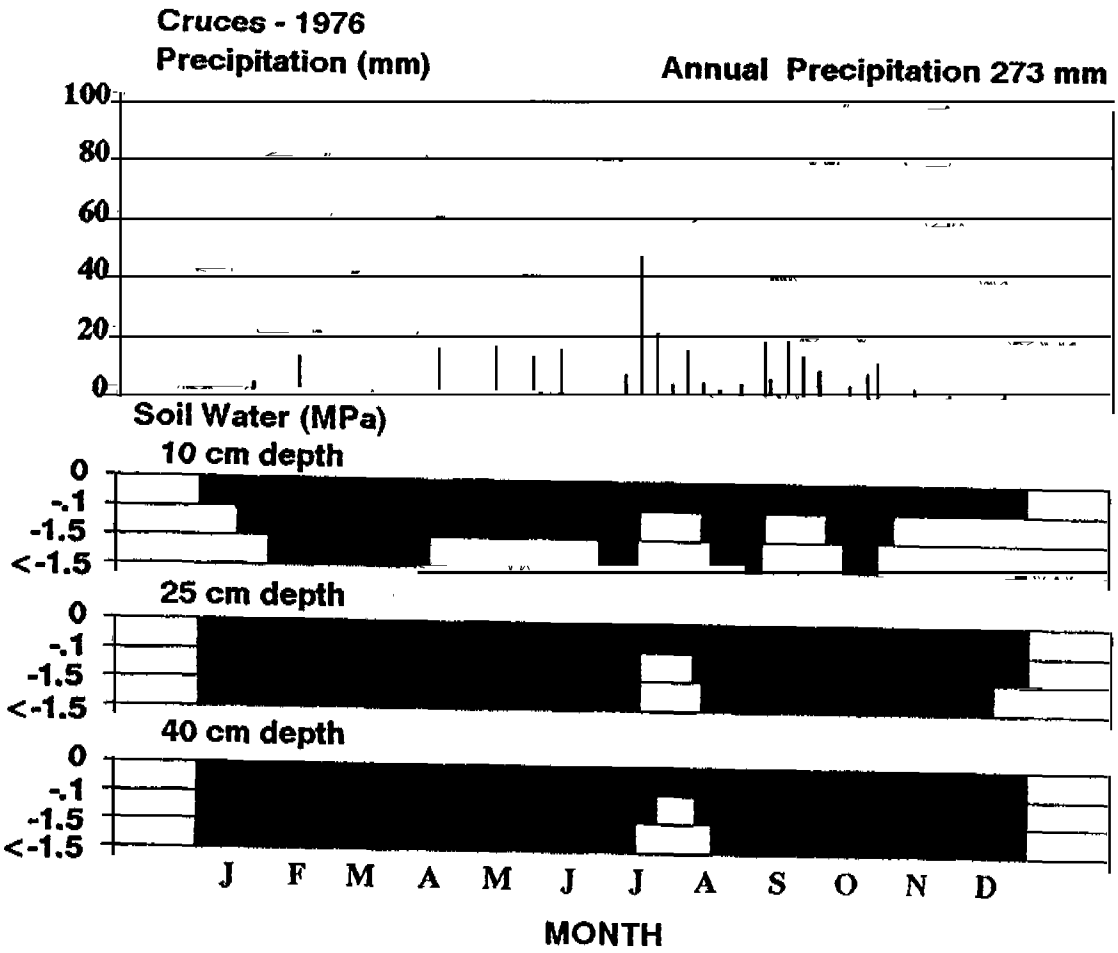


Figure 154. Annual precipitation (273 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Cruces site for 1976.

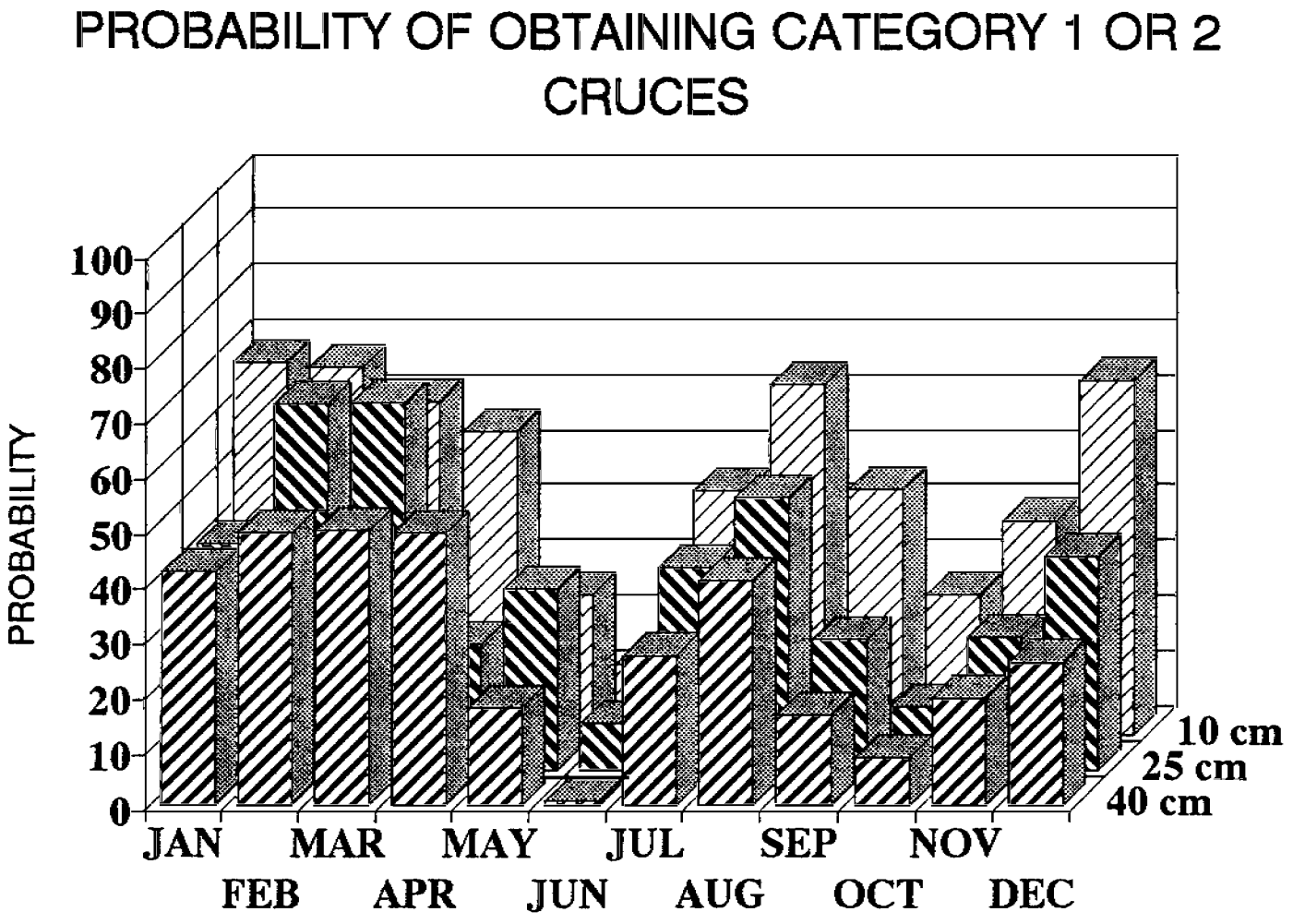


Figure 155. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, and 40 cm at the Cruces site.

Site Sonoita (S)

Site S (figs. 4, 157-159, table 9) is in the West Well exclosure on the Jornada Experimental Range. The sampled pedon is 1.8 m south of the nonrecording rain gauge and 0.9 m south of the wires to the soil water blocks. The perennial vegetation is mesquite, broom snakeweed, and a few small soaptree yucca.

Soils. The soil water blocks are in the Typic Haplargid Sonoita (figs. 158-159, tables 4, 9; Sonoita description and primary data). Diagnostic horizons are an ochric epipedon and an argillic horizon. Silicate clay and organic carbon data (table 9) confirm the presence of these horizons. Sonoita is on La Mesa surface of middle Pleistocene age (table 2) and has formed in sandy fluvial sediments of the Camp Rice Formation. The site is on a ridge side in the undulating basin floor. Slope is 1% to the west.

The soil is noncalcareous to 91 cm depth, and soil water data indicate frequent wetting to that depth (figs. 161-180). This is the thickest noncalcareous zone encountered in the sixteen pedons studied. This is also the only site in which the soil water blocks are in a large pipe. Pipes are roughly funnel-shaped, downward extensions of Bt horizons that descend into and/or through underlying carbonate horizons (see Gile and Grossman, 1979, p. 185-187, for a discussion of pipes in this general area). Figure 160 locates a cross section of the pipe and gives its depth at the measured sections.

The eastern boundary of the pipe is east of the exclosure (about 6.4 m east of the sampled pedon), where the petrocalcic horizon rises to only 45 cm depth. West of the sampled pedon, at one place, the petrocalcic horizon rises to 60 cm depth about 3.5 m west of the exclosure. Although overall dimensions of the pipe were not determined, it is clearly a very large one.

The soil water data, to be discussed, show that this soil is wetted deeper than the other soils. This is probably due to the presence of the pipe because free water would occur at times along the top of the petrocalcic horizon adjacent to the pipe, as shown by data for sites H1-H4 and C. This water would augment the water supplied by vertical infiltration from the surface, particularly along margins of the pipe. The increased water in this soil, as compared to the other soils, is also probably responsible for the greater thickness of the noncalcareous zone.

Soil Water and Precipitation. The gypsum impregnated resistance blocks were installed within a livestock exclosure near West Well at soil depths of 10 and 25 cm on July 29, 1957; at the 40-cm depth on July 11, 1958; and at depths of 60, 90, and 120 cm on July 29, 1959. The standard rain gauge at this location was established July 13, 1918. The annual precipitation in 1957 was 310 mm. The matric potential of the soil water at 10 cm was >-1.5 MPa July 29-August 24 (fig. 161); August 29-September 24; and October 8, 1957-May 13, 1958 (figs. 161-162). The moisture control section, 25-cm depth, had soil water >-1.5 MPa July 29-August 22 (fig. 161); September 1-22; and October 12, 1957-May 14, 1958 (figs. 161, 162).

Table 9. Characteristics of Haplargids and Calciorthids at sites S, W, and T.

Horizon	Depth cm	Hue	Value/chroma Dry	Value/chroma Moist	Structure	Consistence Dry	Consistence Moist	Eff. with HCl	Textural class	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay < 0.002 mm	Organic C	$CaCO_3$
										%				
Typic Haplargid Sonoita (S90NM-013-006)														
C1	0-8	5YR 6YR	5/4 4/3	3.5/4	ms	s,l	vfr,l	nc	s	91	4	5	0.28	—
C2	8-16	5YR	5/4	3.5/4	ms	s, l	vfr	nc	s	92	3	5	0.14	TR
C3	16-33	5YR	5/4	3.5/4	m,cl	s	vfr	nc	s	91	4	5	0.12	TR
Ab	33-39	6YR 5YR	4/3 5/4	2.5/3	lf,msbk	s,sh	vfr	nc	ls	86	7	7	0.18	TR
BAtb	39-44	5YR	4.5/4	3.5/4	lm,csbk	sh	vfr	nc	ls	83	6	11	0.22	TR
Bt1b	44-55	5YR	4.5/4	3.5/4	lm,csbk	sh	vfr	nc	ls	84	5	11	0.20	TR
Bt2b	55-70	5YR	4.5/4	3.5/4	lmsbk	sh	vfr	nc	fsl	81	7	12	0.20	TR
Bt3b	70-91	5YR	5/4	4/4	lm,csbk	sh,h	vfr	nc	fsl	77	10	13	0.18	TR
Btk1b	91-109	6YR 5YR	6/3.5 5/4	5/4	lmsbk	sh,h	fr	es	fsl	77	7	16	0.17	3
Btk2b	109-129	6YR 5YR	6/3.5 5/4	5/4	lmsbk	h,vh	fr	es	fsl	80	6	14	0.10	2
Btk3b	129-143	6YR 5YR	6/3.5 5/4	5/4	lm,csbk	vh	fr	e,es	fsl	82	6	12	0.08	2
Typic Calciorthid Wink phase (S90NM-013-004)														
C	0-9	7.5YR	6/3	4.5/3	f,ms,lfgr, sg	s,l	vfr,l	es	ls	87	5	8	0.26	1
Ab	9-18	7.5YR	5/2.5	3.5/3	vlmsbk	sh	vfr	es	ls	84	7	9	0.26	1
Akb	18-30	7.5YR	6/3	4/3	vlmsbk	sh	vfr	es	ls	86	4	11	0.23	2
Bk1b	30-42	7.5YR	6.5/3	5/3.5	lmsbk	sh,h	vfr	es	fsl	81	6	13	0.23	5
Bk2b	42-58	7.5YR	6.5/3	5/3.5	lmsbk	sh,h	fr	es	fsl	79	7	13	0.21	7
Bk3b	58-78	7.5YR	7/3	5.5/3.5	lmsbk	h	fi	es	fsl	77	8	14	0.18	6
K2b	78-101	7.5YR 7.5YR 10YR	7.5/3 9/2 7/6	6/3 8/2	2msbk	h,vh	fi	es	scl	64	14	22	0.22	17
K3b	101-117	7.5YR 7.5YR 10YR	7.5/3 9/2 7/6	6/3 8/2	2msbk	vh	fi	es	scl	60	17	23	0.18	12
Bkb	117-127	7.5YR 5YR 10YR	6.5/3 6/3 7/6	5/3	lmsbk	h	fr	es	scl	65	14	21	0.19	10
Cb	127-136	10YR	9/2	8/3	lm,csbk	vh	fi	es,n	sl	61	31	8	0.08	2
Typic Calciorthid Turney taxadiunct (S90NM-013-007)														
A	0-5	7.5YR 6 YR	7/3 6/3.5	5/3	lfpl,lfgr, sg	s,l	vfr,l	es	ls	83	9	8	0.18	3
C	5-19	6YR	6/3.5	4.5/3.5	m	s	vfr	es	ls	85	7	8	0.19	3
Bk1b	19-34	7.5YR	6/2.5	4.5/3	lm,csbk	h	fr	es	fsl	69	15	16	0.30	6
Bk2b	34-46	7YR	6/3	4.5/3	lmsbk	sh,h	fr	es	sl	65	16	19	0.32	11
Bk3b	46-57	6YR	6/3	4.5/3	lmsbk	sh,h	fr	es	scl	62	18	21	0.26	12
Bk4b	57-67	6YR	6/3	4.5/3	lmsbk	sh,h	fr	es	scl	53	19	28	0.33	18
K21b	67-77	7.5YR 7.5YR	8/2 7/4	7/4	2f,msbk	h,vf	fi	es	cl	40	27	33	0.30	34
K22b	77-92	7.5YR 7.5YR	7/4 8/2	6/4	2f,msbk	vh	fi	es	cl	37	30	33	0.20	38
Btkb	92-111	5YR 5YR 7.5YR	6/4 5/4 7/3	5/4	2msbk	vh		e,es	cl	43	27	30	0.14	31

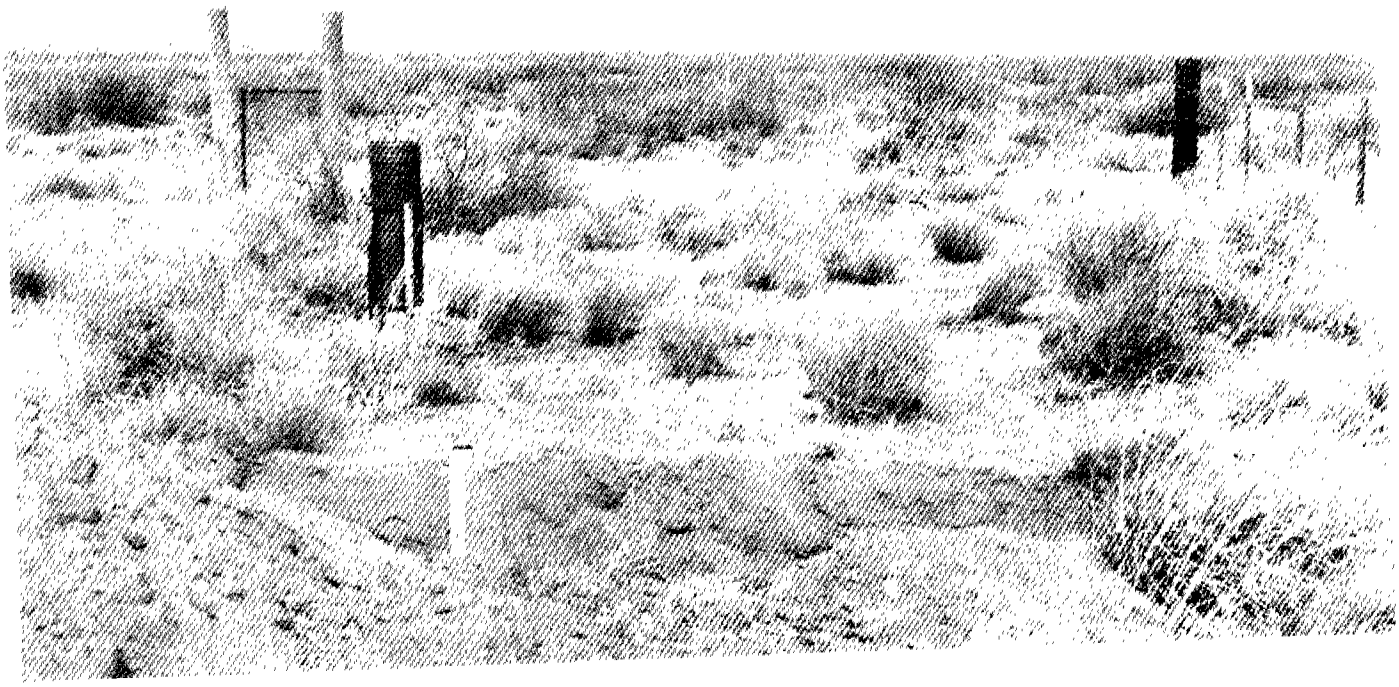


Figure 157. Landscape at site S (fig. 4) and the Typic Haplargid Sonoita, in the West Well exclosure on the Jornada Experimental Range. Wires to the soil water blocks are between the study trench and the nonrecording rain gauge. The road just beyond the exclosure leads to the Jornada Experimental Range Headquarters. Photographed February 1990.

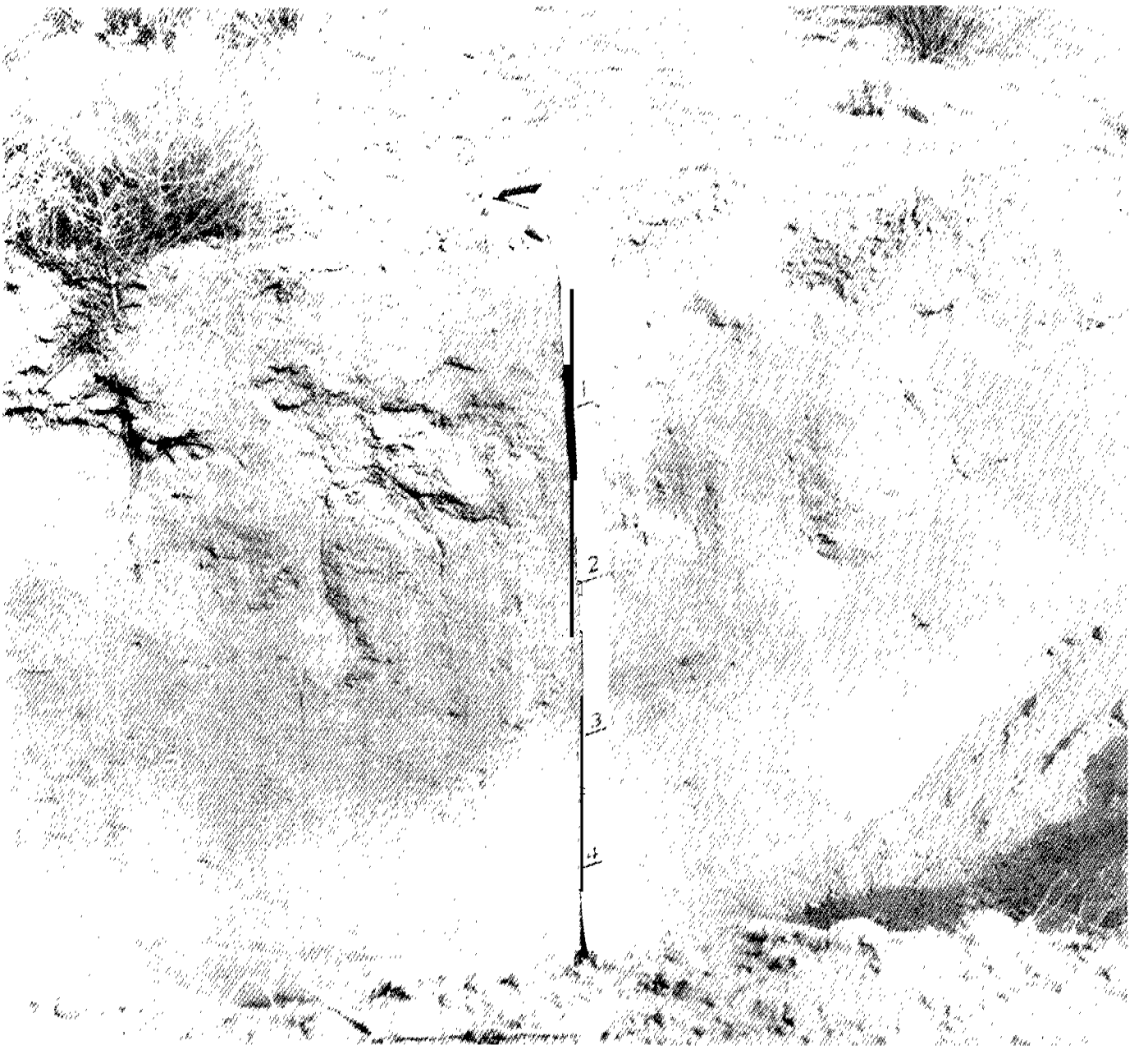


Figure 158. Profile of the Typic Haplargid Sonoita, which is in a large pipe that descends into the petrocalcic horizon (see figs. 159, 160). Scale is in feet.

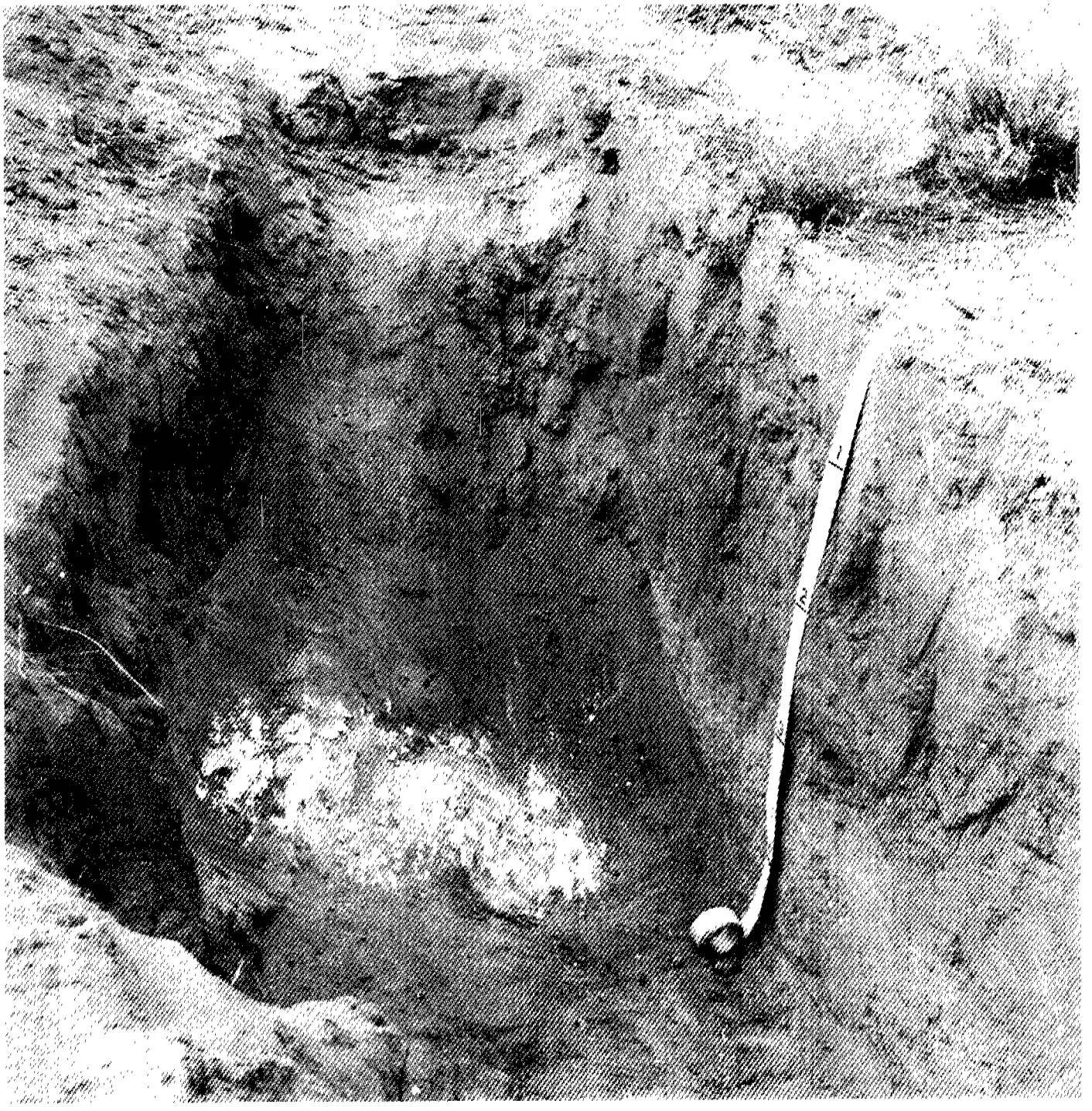


Figure 159. View of the study trench looking west. The top of the petrocalcic horizon is the south wall of the pipe, which slopes downward from left to right and dips steeply downward below the tape (see text discussion).

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Sonoita
Classification: Coarse-loamy, mixed, thermic Typic Haplargid
NSSL ID#: 90P0497
Soil Survey #: S90NM-013-006
Location: The SW1/4SE1/4SW1/4 section 33, T.19S., R.1E., in the West Well exclosure of the Jornada Experimental Range. The north side of the exclosure is about 7.6 m south of the south edge of the road to Headquarters. The sampled pedon is 1.8 m south of the nonrecording rain gauge and 0.9 m south of wires to the soil moisture blocks.
Elevation: 4315 ft, 1315 m
Landform: West-facing side of gentle ridge in the undulating basin floor. Slope is 1% to the west.
Geomorphic Surface: La Mesa
Parent Material: Upper Camp Rice Formation (fluvial facies) sand
Vegetation: Mesquite, snakeweed, and a few small soaptree yucca
Described By: L.H. Gile
Date: Feb. 8, 1990

C1--0 to 8 cm; stratified reddish brown (5YR 5/4) sand; dark reddish brown (5YR 3.5/4) moist; lesser amount 7.5YR 5/3 and 4/2; massive, in places with horizontal cleavage to thin and medium lenses; generally soft, with some lenses separated by soft fine granules or by loose, single-grain material; loose and very friable; few fine roots; 90P2757; noncalcareous; abrupt and clear, wavy boundary.

C2--8 to 16 cm; stratified reddish brown (5YR 5/4) sand; dark reddish brown (5YR 3.5/4) moist; massive, in places with horizontal cleavage to medium and thick lenses; soft and loose, very friable; few fine roots; 90P2758; noncalcareous; abrupt and clear, broken boundary.

C3--16 to 33 cm; stratified reddish brown (5YR 5/4) sand; dark reddish brown (5YR 3.5/4) moist; massive, in places with horizontal cleavage to medium and thick lenses; soft, very friable; very few fine roots; 90P2759; noncalcareous; abrupt wavy boundary.

Ab--33 to 39 cm; reddish brown (6YR 4/3) loamy sand; dark reddish brown (6YR 2.5/3) moist; lesser amount of reddish brown (5YR 5/4); weak fine and medium subangular blocky structure; soft and slightly hard, very friable; very few fine roots; 90P2760; noncalcareous; abrupt wavy boundary.

BAtb--39 to 44 cm; reddish brown (5YR 4.5/4) loamy sand; dark reddish brown (5YR 3.5/4) moist; weak medium and coarse subangular blocky structure; slightly hard, very friable; very few fine roots; 90P2761; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt1b--44 to 55 cm; reddish brown (5YR 4.5/4) loamy sand; dark reddish brown (5YR 3.5/4) moist; weak medium and coarse subangular blocky structure; slightly hard, very friable, very few fine roots; 90P2762; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt2b--55 to 70 cm; reddish brown (5YR 5/4) fine sandy loam; dark reddish brown (5YR 3.5/4) moist; weak medium subangular blocky structure; slightly hard, very friable; very few fine roots; 90P2763; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt3b--70 to 91 cm; reddish brown (5YR 5/4) fine sandy loam; reddish brown (5YR 4/4) moist; weak medium and coarse subangular blocky structure; slightly hard and hard, very friable; very few fine roots; 90P2764; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Btk1b--91-109 cm; light reddish brown (6YR 6/3.5) fine sandy loam; reddish brown (6YR 5/4) moist; lesser amount of reddish brown (5YR 5/4), weak medium subangular blocky structure; slightly hard and hard, friable; very few fine roots; 90P2765; sand grains of 5YR 5/4 material coated with oriented clay; few carbonate filaments; strongly effervescent; clear wavy boundary.

Btk2b--109 to 129 cm; light reddish brown (6YR 6/3.5) fine sandy loam; reddish brown (6YR 5/4) moist; lesser amount of reddish brown, 5YR 5/4), weak medium subangular blocky structure; hard and very hard, friable; very few fine roots; 90P2766; sand grains of 5YR material coated with oriented clay; few carbonate filaments; strongly effervescent; clear wavy boundary.

Btk3b--129 to 143 cm; light reddish brown (6YR 6/3.5) fine sandy loam; reddish brown (6YR 5/4) moist; lesser amount of reddish brown (5YR 5/4); weak medium coarse subangular blocky structure; very hard, friable; no roots; 90P2767; sand grains of 5YR 5/4 material coated with oriented clay; few carbonate filaments; weakly and strongly effervescent.

S90NM-013-006 *** PRIMARY CHARACTERIZATION DATA ***

PRINT DATE 11/29/91

Soil series: Sonoita COARSE-LOAMY, MIXED, THERMIC TYPIC HAPLARGID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 497, SAMPLES 90P2757-2769
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY LT .002	SILT CO3 FINE .002 -.02	SILT COARSE .02 -.05	SILT VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS(MM) WEIGHT 2 -5	COARSE FRACTIONS(MM) WEIGHT 5 -20	COARSE FRACTIONS(MM) WEIGHT 20 -75	>2MM WEIGHT .1- 75	WT PCT OF WHOLE SOIL
			<- - - - - - - - - -				PCT OF <2MM				(3A1) - - - - - - - - - -			->	<- PCT OF <75MM(3B1)->				
90P2757S	0- 8	C1	4.9	3.9	91.2		1.7	2.2	9.7	37.6	40.3	3.5	0.1	--	--	--	81	--	
90P2758S	8- 16	C2	5.2	2.8	92.0		1.5	1.3	11.1	37.9	38.4	4.5	0.1	--	--	--	81	--	
90P2759S	16- 33	C3	5.1	4.1	90.8		1.5	2.6	12.9	40.4	33.8	3.5	0.2	--	--	--	78	--	
90P2760S	33- 39	AB	7.2	7.3	85.5		2.5	4.8	11.1	36.7	32.9	4.7	0.1	TR	--	--	74	TR	
90P2761S	39- 44	BAT8	10.5	6.4	83.1		2.1	4.4	11.8	34.6	31.6	4.6	0.5	TR	--	--	71	TR	
90P2762S	44- 55	BT1B	11.1	5.2	83.7		2.1	3.1	11.1	32.2	33.7	6.4	0.3	TR	--	--	73	TR	
90P2763S	55- 70	BT2B	12.4	6.9	80.7		2.5	4.4	12.6	33.2	29.2	5.3	0.4	1	1	--	69	2	
90P2764S	70- 91	BT3B	13.1	9.5	77.4		3.2	6.3	10.7	33.7	27.2	5.0	0.8	TR	TR	--	67	TR	
90P2765S	91-109	BTK1B	15.6	7.6	76.8	2.1	2.8	4.8	11.1	32.0	27.9	5.3	0.5	TR	TR	--	66	TR	
90P2766S	109-129	BTK2B	13.7	6.1	80.2	1.5	2.2	3.9	11.7	34.4	29.1	4.7	0.3	TR	TR	--	68	TR	
90P2767S	129-143	BTK3B	12.4	6.1	81.5	2.7	2.4	3.7	12.1	37.5	26.7	4.5	0.7	1	TR	--	70	1	
														--	--	--		--	

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B3a <2MM	EXTR P 6S3 PPM	TOTAL $ 6R3a	DITH-CIT EXTRACTABLE FE 6C2b	DITH-CIT EXTRACTABLE AL 6G7a	DITH-CIT EXTRACTABLE MN 6D2a	(RATIO/CLAY) CEC 8D1	(RATIO/CLAY) 15 BAR 8D1	ATTERBERG LL 4F1	ATTERBERG PI 4F	FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- PERCENT	OF	<2MM -->				PCT	<0.4MM	<- - G/CC - - ->			CM/CM	<- - -PCT OF <2MM - - ->				CM/CM
0- 8	0.28							0.94	0.45									2.2		
8- 16	0.14							0.87	0.42									2.2		
16- 33	0.12							0.84	0.41									2.1		
33- 39	0.18							0.82	0.39				1.66	1.73	0.014		5.2	2.8	0.04	
39- 44	0.22							0.80	0.34									3.6		
44- 55	0.20							0.76	0.41				1.62	1.68	0.012		6.2	4.5	0.03	
55- 70	0.20							0.73	0.40				1.64	1.70	0.012		6.9	4.9	0.03	
70- 91	0.18							0.75	0.40									5.2		
91-109	0.17							0.56	0.40				1.60	1.66	0.012		8.4	6.9	0.03	
109-129	0.18							0.68	0.42				1.62	1.78	0.016		9.2	5.7	0.06	
129-143	0.08							0.64	0.44				1.68	1.76	0.016		9.1	5.4	0.06	

AVERAGES, DEPTH 39- 89: PCT CLAY 12 PCT .1-75MM 69

DEPTH (CM)	(- NH4OAC EXTRACTABLE BASES -) CA 5B5a 6N2a	MG 5B5a 6O2d	NA 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES 6H5a	ACIDITY G	(- CEC -) SUM CATS 5A3a	NH4- OAC 5A8b	EXCH NA 5B5b PCT	SAR 5E	BASE SATURATION SUM 5C3	BASE SATURATION NH4OAC 5C1	CARBONATE AS CACO3 <2MM 6E1g	CARBONATE AS CACO3 <20MM 8E1	CASO4 AS GYPSUM <2MM 6F1a	CASO4 AS GYPSUM <20MM 6F4	(- - -PH - - -) SAT PASTE 8C1b	CACL2 .01M 8C1f 1:2	H2O 8C1f 1:1
	<- - - - - - - - - -			-MEQ / 100 G		- - - - - - - - - ->			PCT		<- -PCT- >		<- -PCT ->		<- -PCT ->				
0- 8	5.2	0.7	--	0.5	6.4	0.3	6.7	4.6	TR	TR	96	100	--				7.4	7.3	7.6
8- 16	6.6	0.8	--	0.6	8.0	0.8	8.8	4.5	TR		91	100	TR					7.5	7.7
16- 33	5.3	0.6	0.1	0.6	6.6	0.5	7.1	4.3	2		93	100	TR					7.7	8.2
33- 39	6.1	0.6	TR	0.8	7.5	0.4	7.9	5.9	1		95	100	TR					7.7	8.0
39- 44	8.6	0.9	0.1	0.9	10.5	0.8	11.3	8.4	1		93	100	TR					7.7	8.2
44- 55	9.9	1.0	TR	0.6	11.5	0.6	12.1	8.4	TR		95	100	TR					7.6	8.2
55- 70	8.7	1.3	TR	0.4	10.4	0.8	11.2	9.1	1		93	100	TR					7.6	8.0
70- 91	14.4	1.7	0.1	0.4	16.6	0.2	16.8	9.8	1		99	100	TR					7.7	8.1
91-109		2.3	0.1	0.4				8.8	1		100	100	3					7.8	8.2
109-129		3.0	0.2	0.5				9.3	2		100	100	2					7.8	8.4
129-143		2.9	0.2	0.4				7.9	2		100	100	2					7.8	8.4

DEPTH (CM)	(- - - - - - - WATER EXTRACTED FROM SATURATED PASTE - - - - - - - - -) CA 6N1b	MG 6O1b	NA 6P1b	K 6Q1b	CO3 6I1b	HCO3 6J1b	CL 6K1c	SO4 6L1c	NO3 6N1c	H2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A3a MMHOS /CM
	< - - - - - - - - - -			-MEQ / LITER	- - - - - - - - - -					>	<- -PCT ->	
0- 8	7.2	1.3	0.1	1.1	--	2.5	0.7	1.9	3.1	27.3	TR	1.01
8- 16												0.21
16- 33												0.14
33- 39												0.12
39- 44												0.11
44- 55												0.10
55- 70												0.10
70- 91												0.10
91-109												0.13
109-129												0.14
129-143												0.15

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

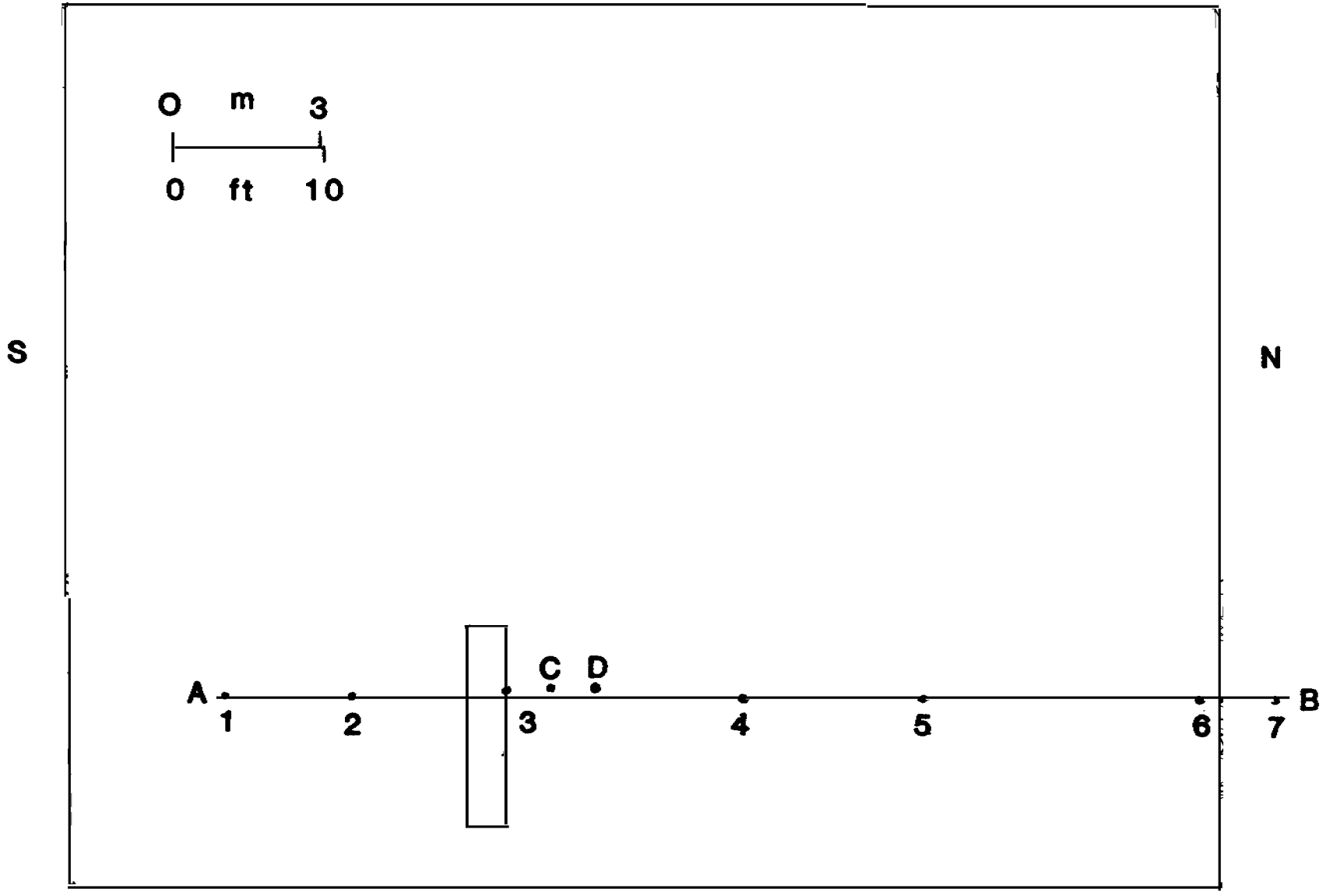


Figure 160. Diagram of the exclosure and features at West Well. Line AB locates a cross section of a large pipe; nos. 1-7 along line AB locat auger holes with the following depths to a petrocalcic horizon or to indurated materials: 1=65 cm; 2=97 cm; 3=175 cm (at the sampled pedon); 4=160 cm; 5=none within 185 cm; 6=140 cm; 7=60 cm. Other features are C=gypsum blocks, D=nonrecording rain gauge. Rectangle locates sampling trench.

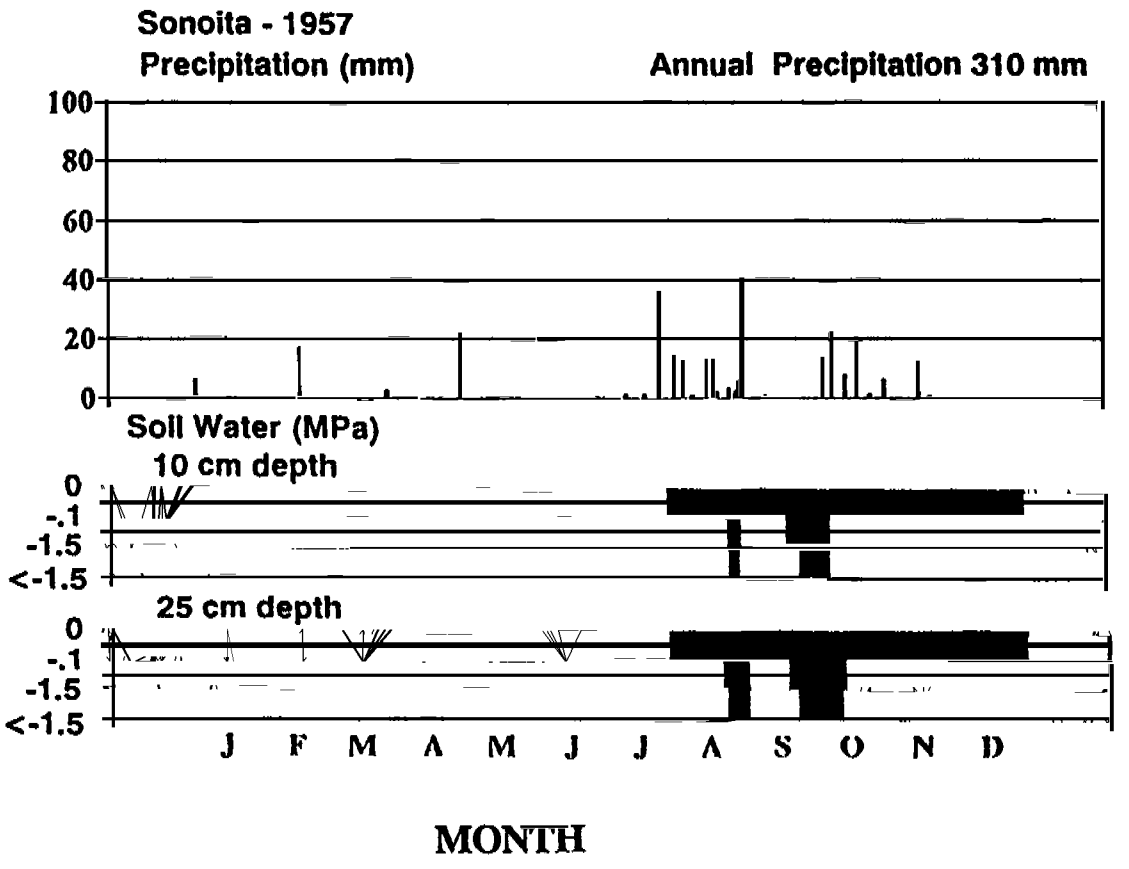


Figure 161. Annual (310 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10 and 25 cm for July 29-December 31, 1957 at the Sonoita site.

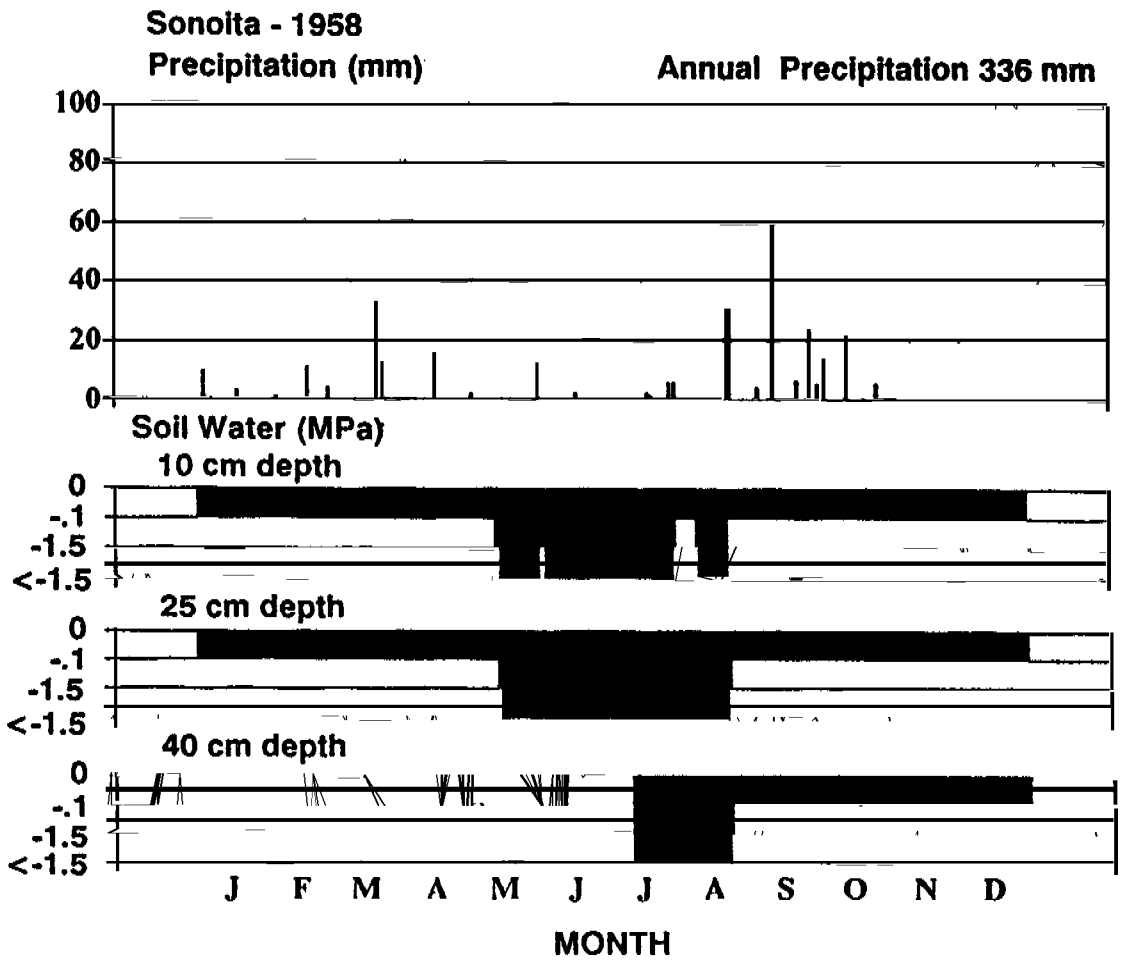


Figure 162. Annual precipitation (336 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10 and 25 cm at the Sonoita site for 1958. Also shown is the soil water at the depth of 40 cm July 11-December 31, 1958.

The 1958 precipitation was 336 mm. In addition to moist conditions in the winter-spring, the 25-cm depth had soil water >-1.5 MPa August 23, 1958-April 24, 1959 (figs. 162, 163).

The annual precipitation for 1959 was 248 mm but 87% occurred in July and August. The 25-cm depth had soil water >-1.5 MPa July 4-10 (fig. 163); July 22-October 24; and December 16, 1959-July 8, 1960 (figs. 163, 164).

The 1960 precipitation was only 142 mm but there was considerable soil water >-1.5 MPa (fig. 164). At the 25-cm depth, it was >-1.5 MPa July 15-August 5, and August 22, 1960-June 28, 1961 (figs. 164, 165).

Precipitation for 1961 and 1962 was above average. Besides th wet conditions the first 6 months of 1961, the soil water at 25 cm was >-1.5 MPa July 10, 1961-June 25, 1962 (figs. 165, 166); July 8-August 22; and September 27, 1962-May 14, 1963 (figs. 166, 167).

Precipitation was below average in 1963-1966. Besides the soil water mentioned previously, the 25-cm depth had water >-1.5 MPa August 6-October 11, 1963 (fig. 167); October 20, 1963-June 30, 1964 (figs. 167, 168); July 13-August 28; September 13-27, 1964; February 9-May 9, 1965 (fig. 169); September 10-October 16; December 9, 1965-May 30, 1966 (figs. 169, 170); July 21-August 25; and September 14-October 1, 1966. Rodent damage to the gypsum block prevented determination of soil water at the 10-cm depth November 1, 1963-February 29, 1964.

Precipitation for 1967 was 279 mm (fig. 171). Soil water >-1.5 MPa was recorded at 25 cm June 19-July 14; August 10-September 13; September 29-October 8; and November 28, 1967-August 12, 1968 (figs. 171, 172). Soil water was not determined at 120 cm after December 31, 1967.

The 1968 precipitation was 212 mm (fig. 172). Besides the soil water >-1.5 MPa until August 12, 1968, the 25-cm depth also had soil water >-1.5 MPa December 27, 1968-June 6, 1969 (figs. 172, 173).

Precipitation for 1969 was 226 mm (fig. 173). Besides the soil water >-1.5 MPa in the winter and spring, the matric potential of the water was >-1.5 MPa at the 25-cm depth July 8-August 3; September 2-October 11; and October 22, 1969-July 6, 1970 (figs. 173, 174).

Precipitation for 1970 and 1971 was below average but there was considerable soil water >-1.5 MPa at 25 cm in both years, particularly during the winter and spring (figs. 174, 175). The annual precipitation for 1972 was 299 mm (fig. 176). However, no soil water was determined August 1-December 31, 1972 because the ohmmeter was inoperative. Soil water >-1.5 MPa was recorded at 25 cm on October 20, 1971-May 22, 1972 (figs. 175, 176); June 12-18; and July 3-11, 1972.

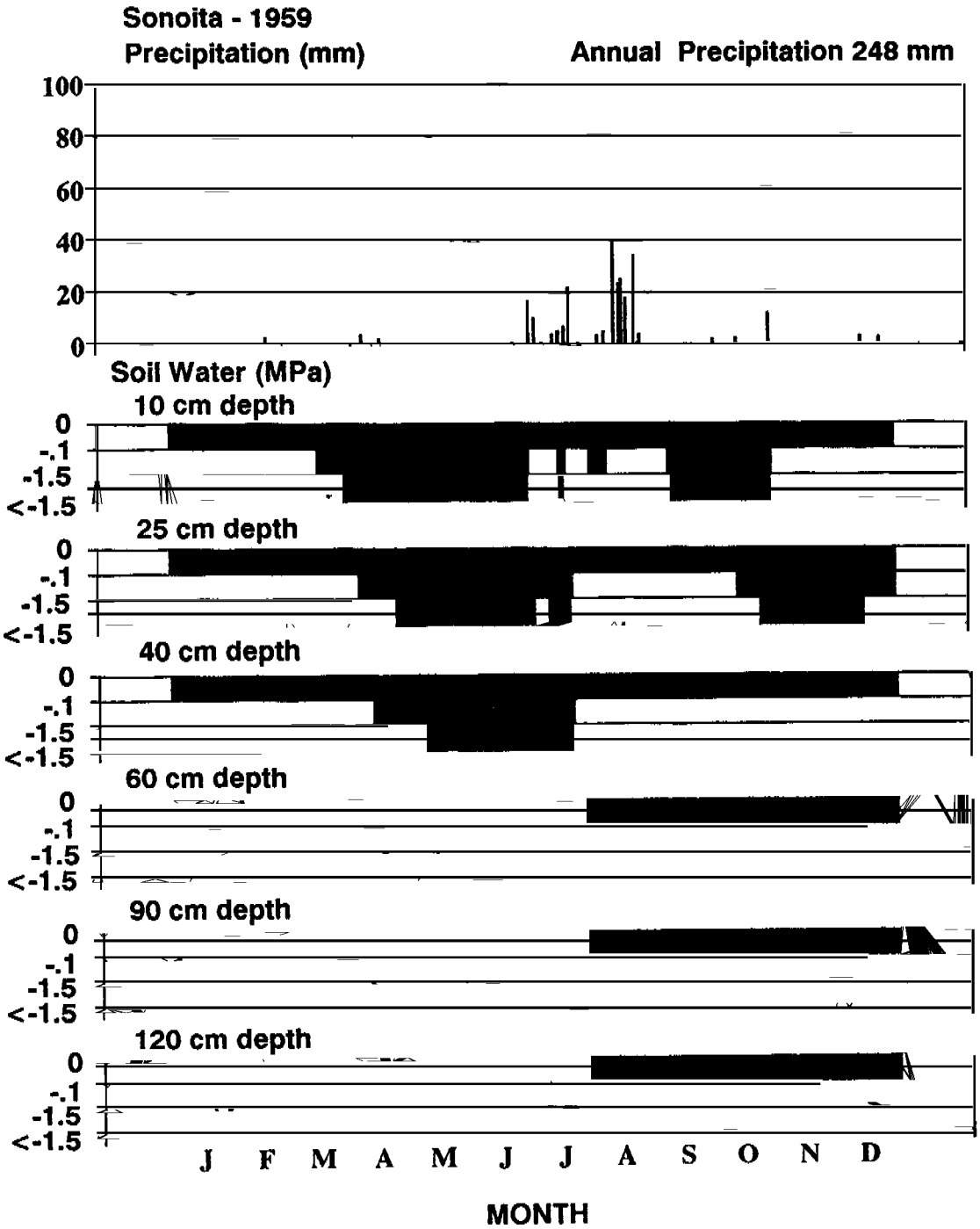


Figure 163. Annual precipitation (248 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Sonoita site for 1959. Also shown is the soil water at depths of 60, 90, and 120 cm July 29-December 31, 1959.

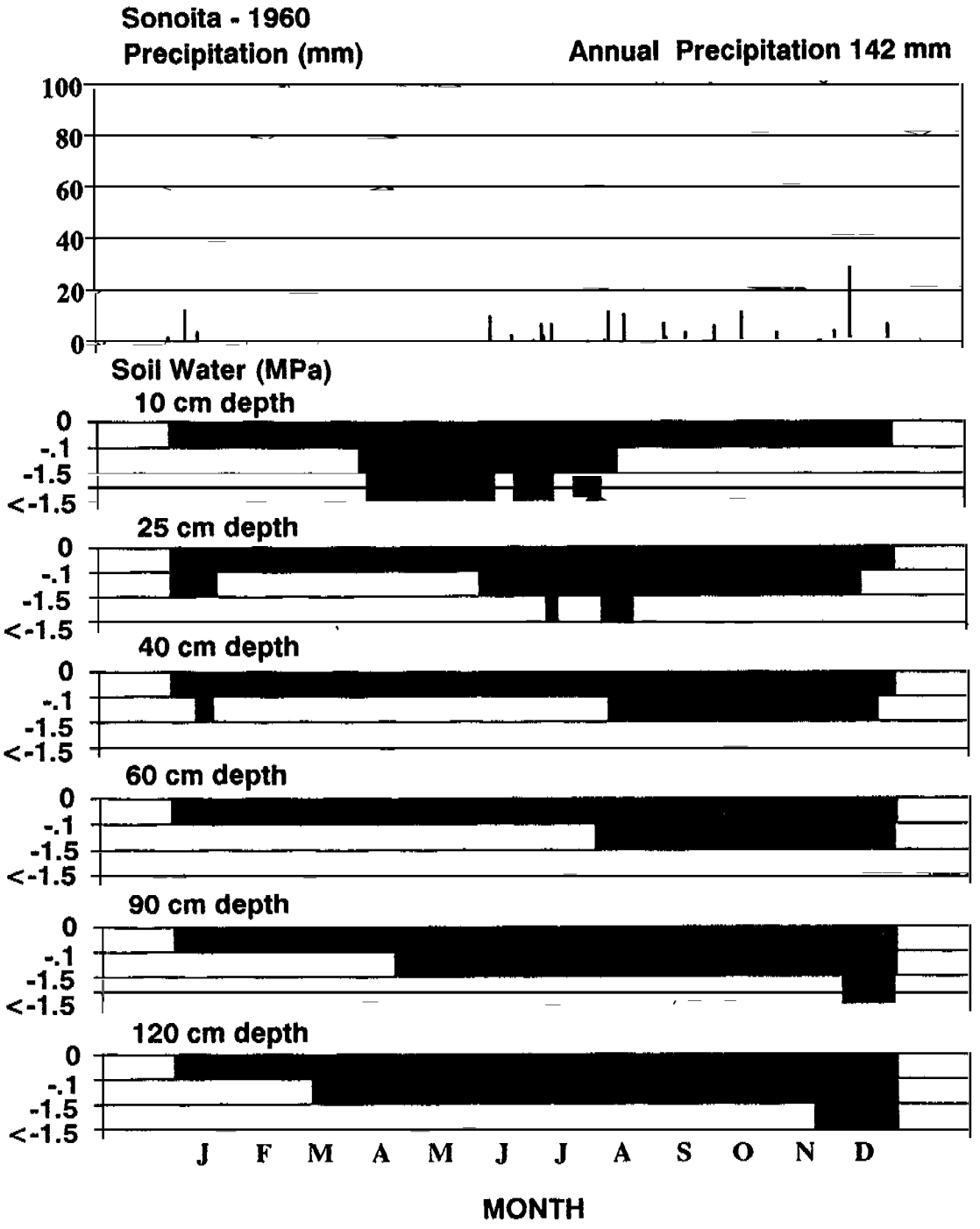


Figure 164. Annual precipitation (142 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site for 1960.

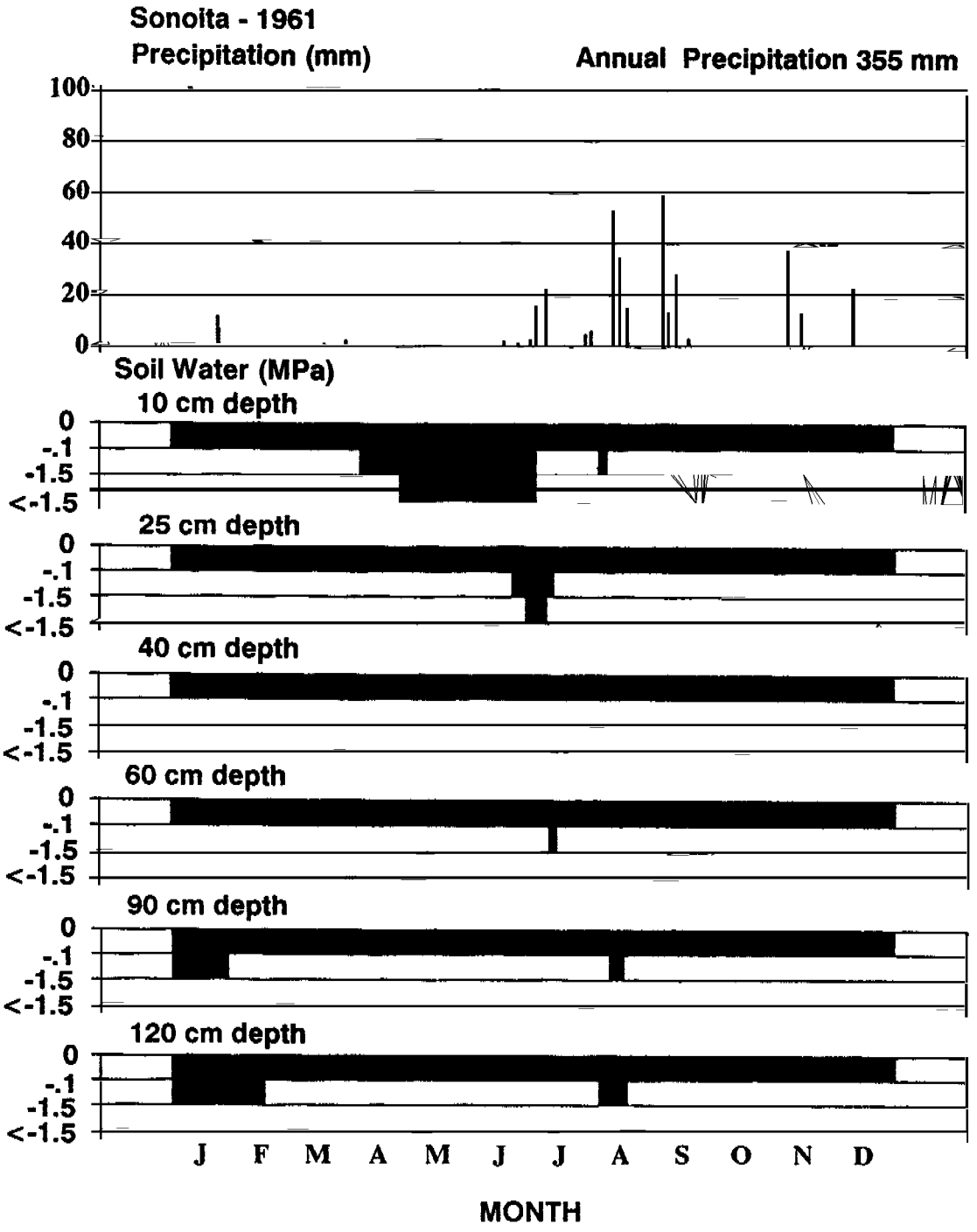


Figure 165. Annual precipitation (355 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site for 1961.

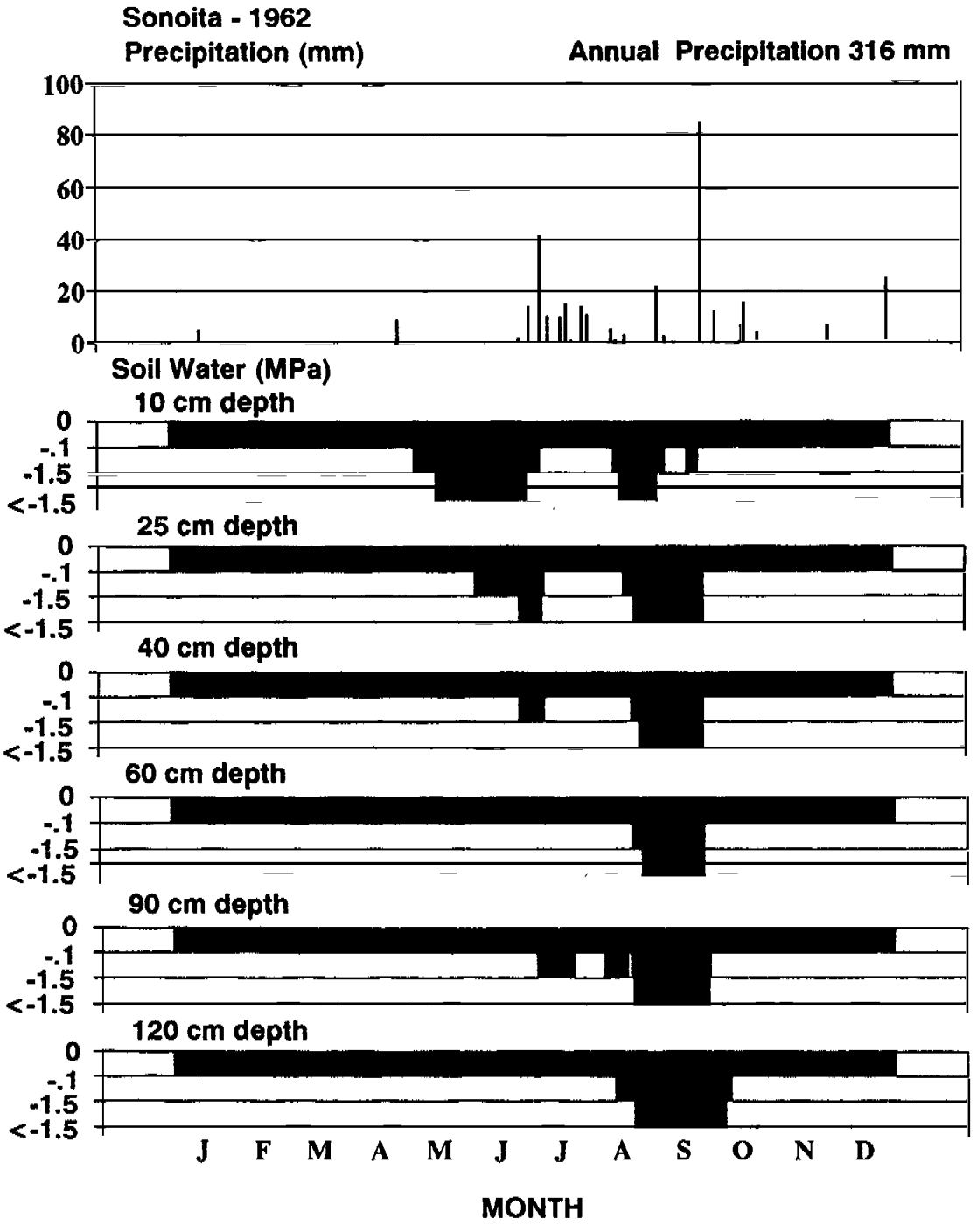


Figure 166. Annual precipitation (316 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site for 1962.

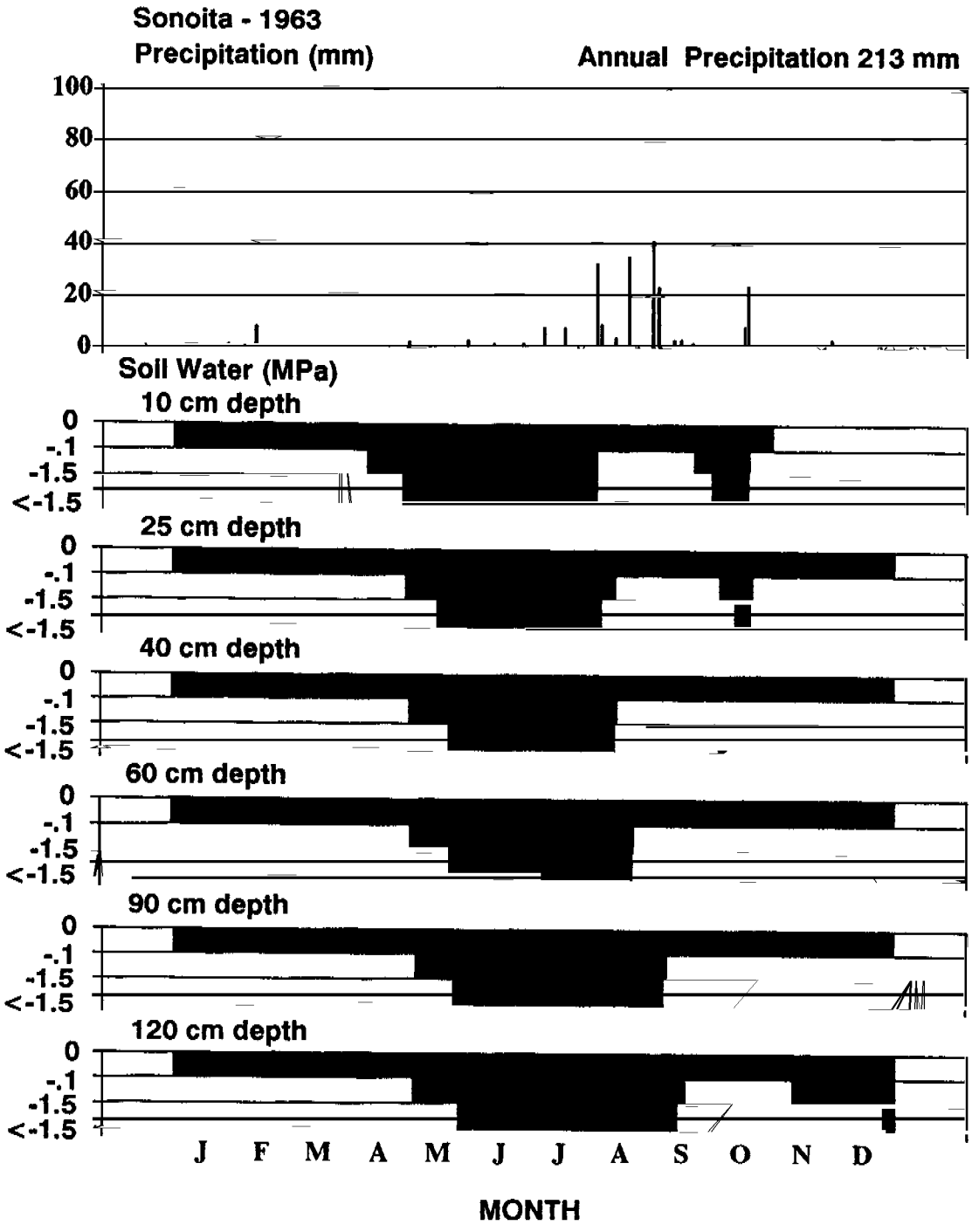


Figure 167. Annual precipitation (213 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10 (January 1-October 31), 25, 40, 60, 90, and 120 cm at the Sonoita site for 1963.

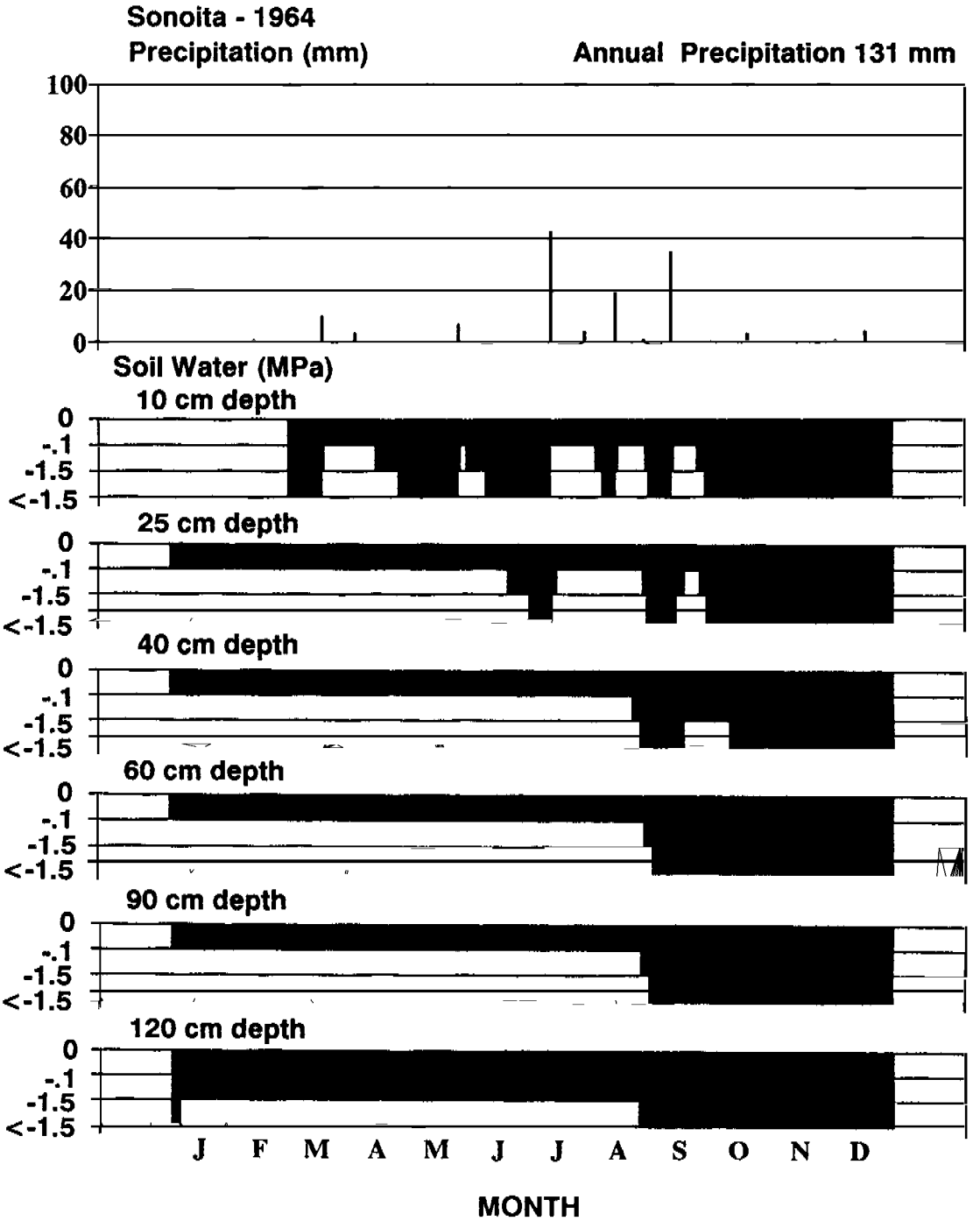


Figure 168. Annual precipitation (131 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10 (March 1-December 31), 25, 40, 60, 90, and 120 cm at the Sonoita site for 1964.

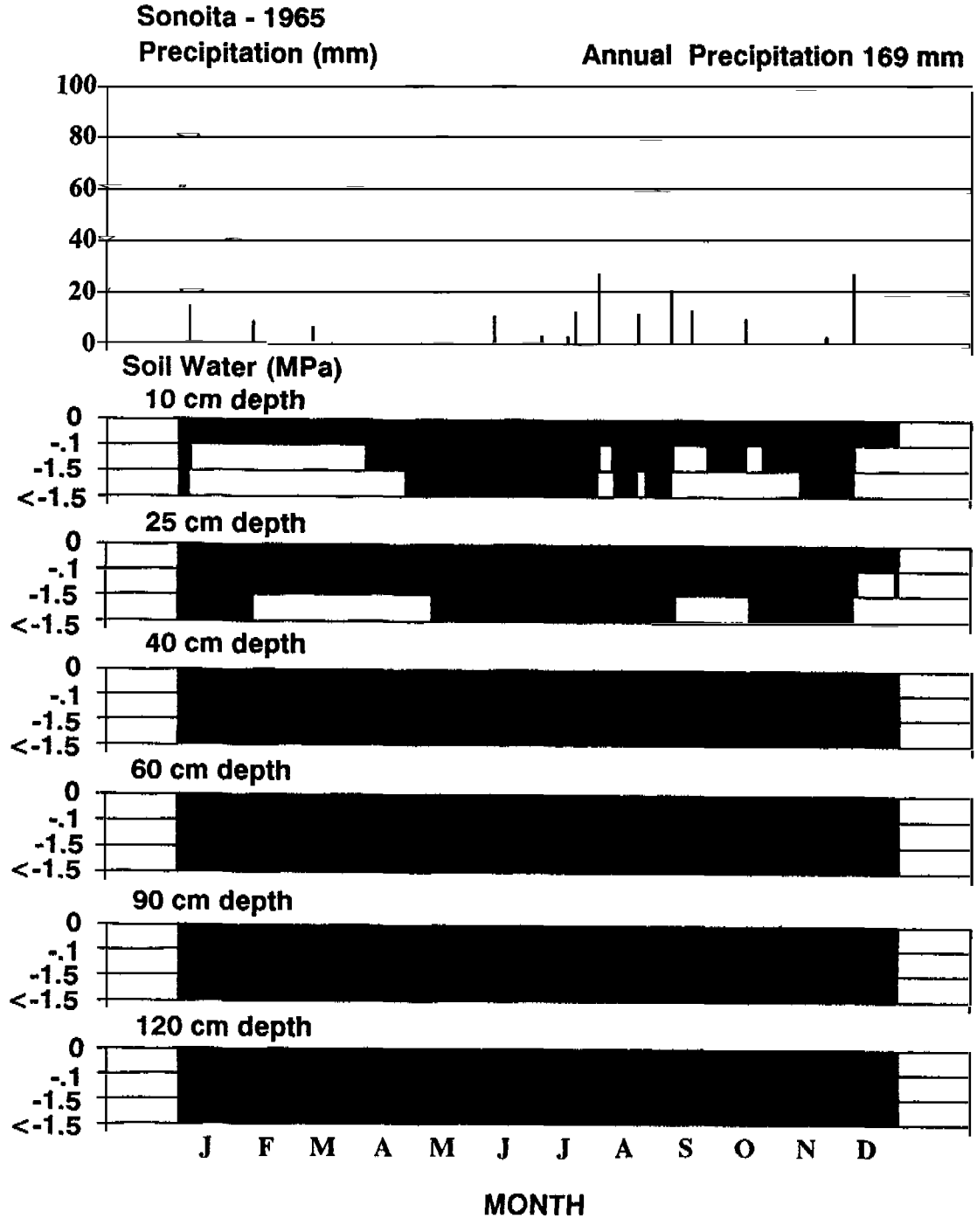


Figure 169. Annual precipitation (169 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site for 1965.

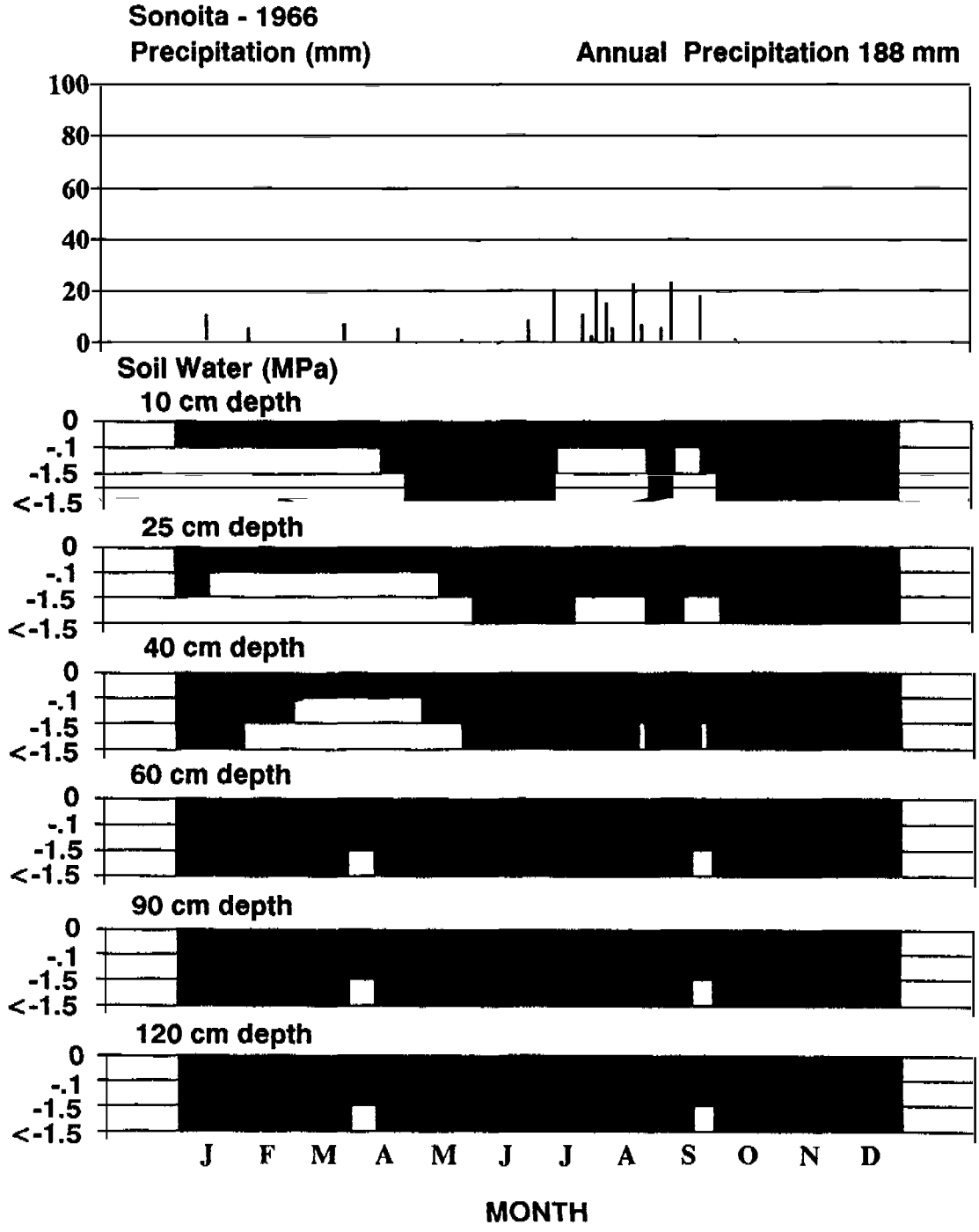


Figure 170. Annual precipitation (188 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site for 1966.

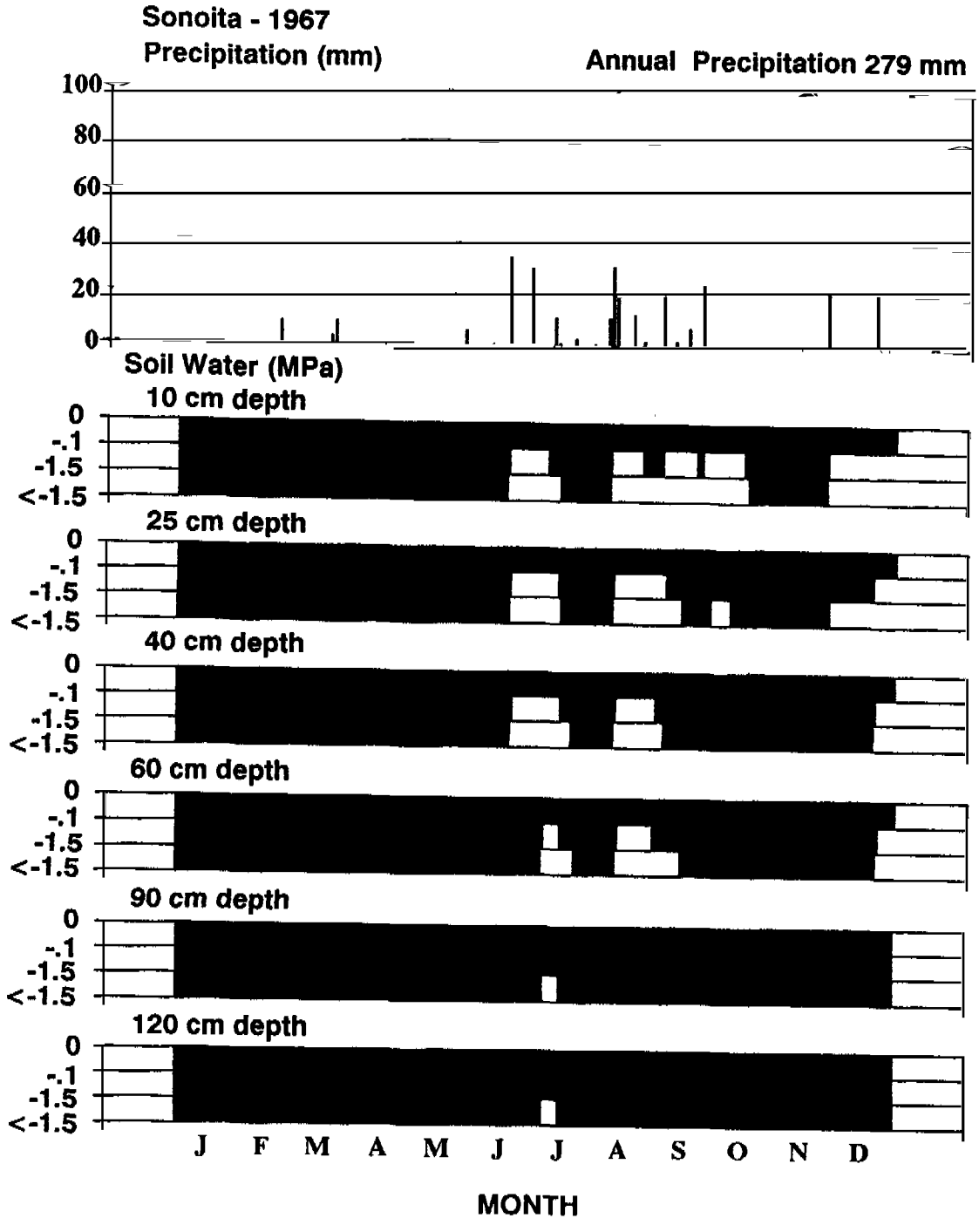


Figure 171. Annual precipitation (279 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site for 1967.

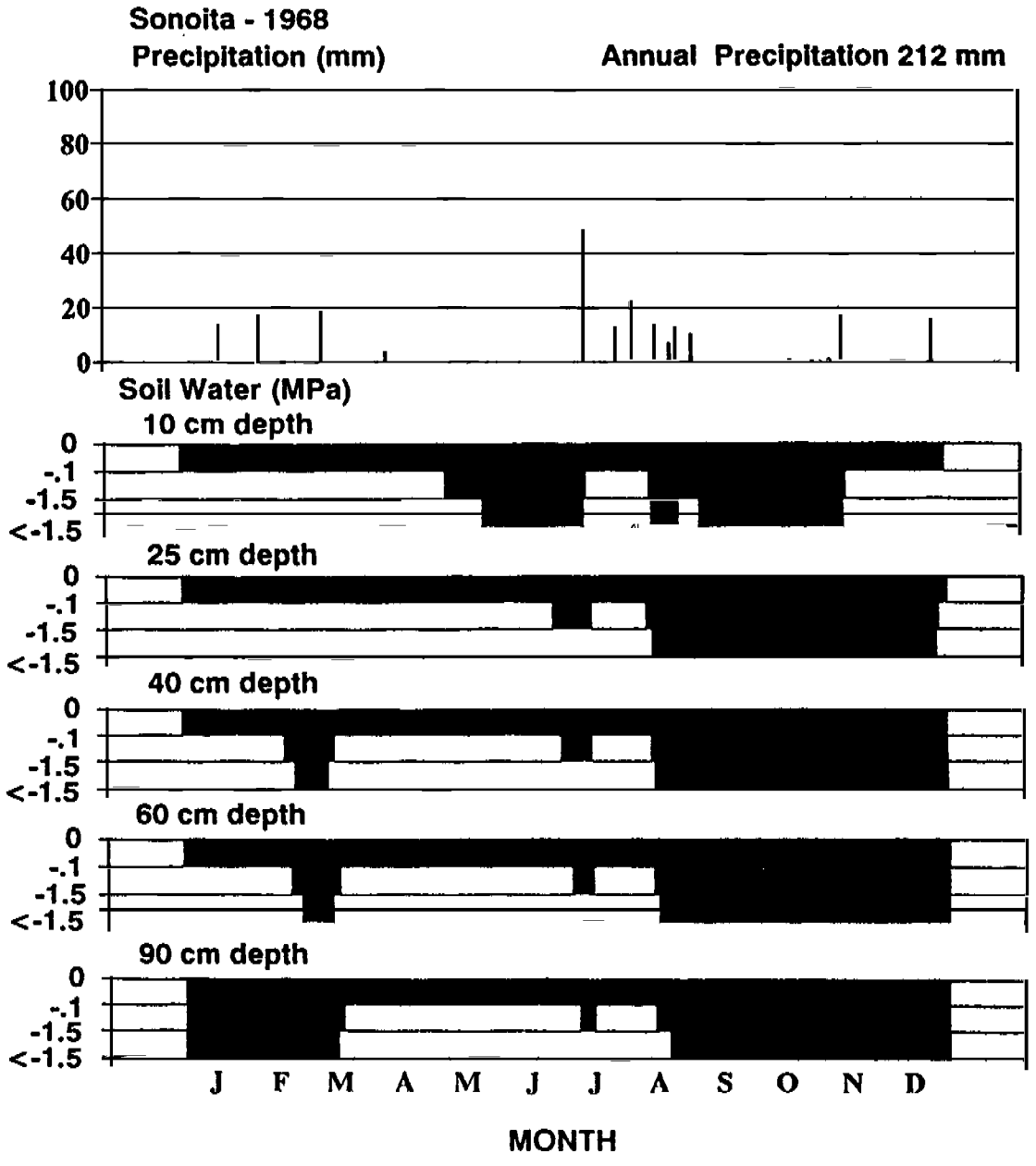


Figure 172. Annual precipitation (212 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1968.

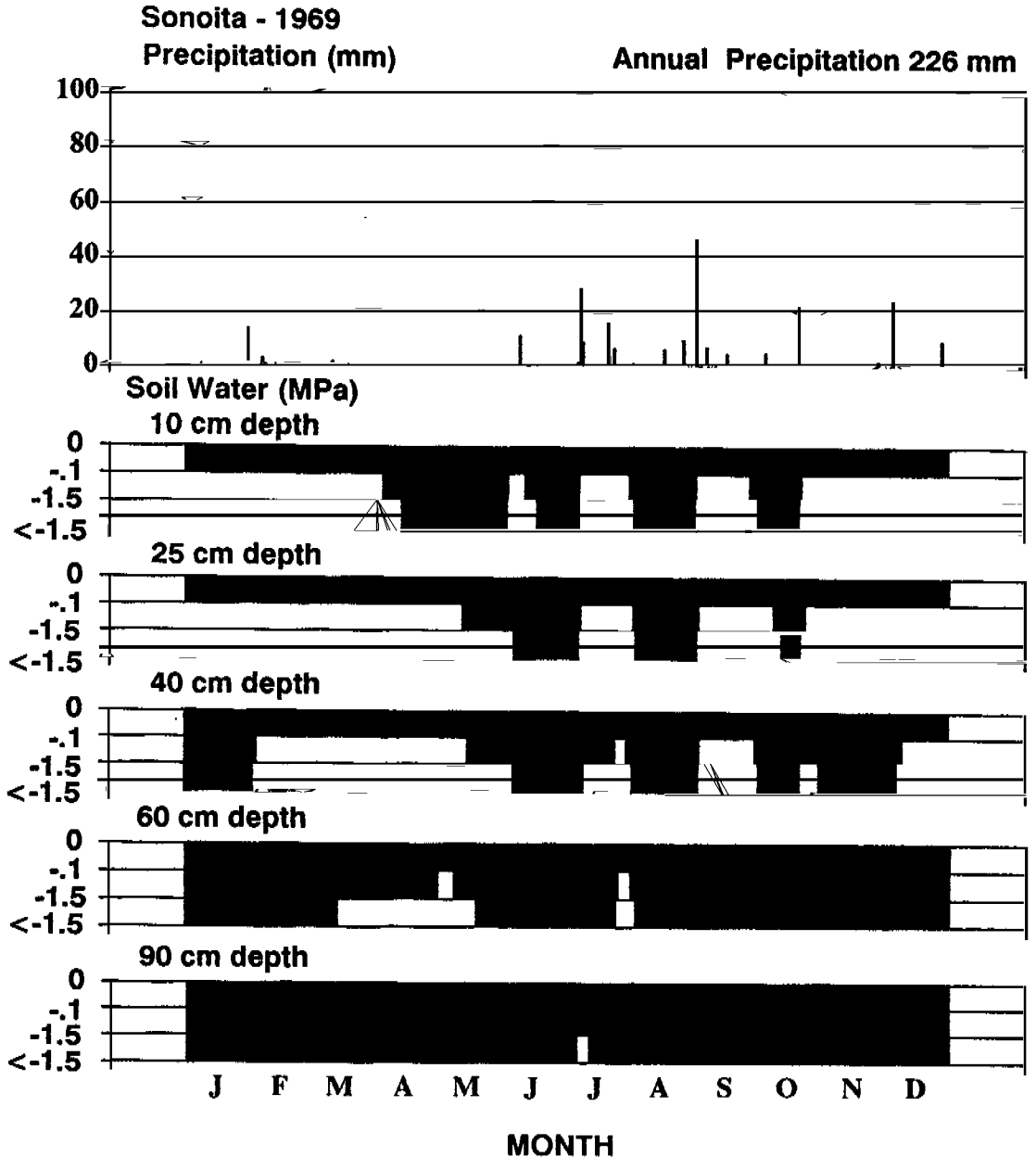


Figure 173. Annual precipitation (226 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1969.

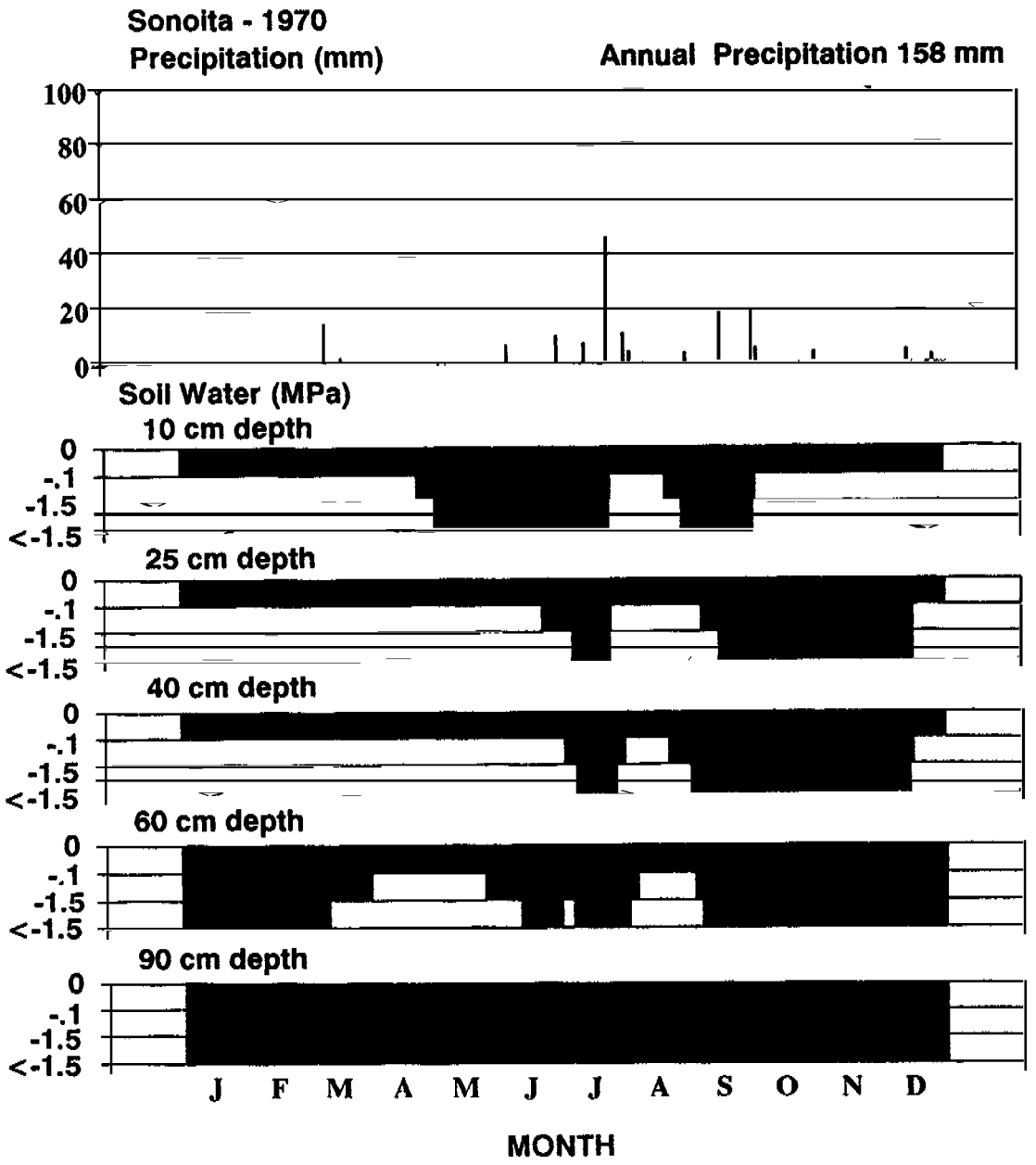


Figure 174. Annual precipitation (158 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1970.

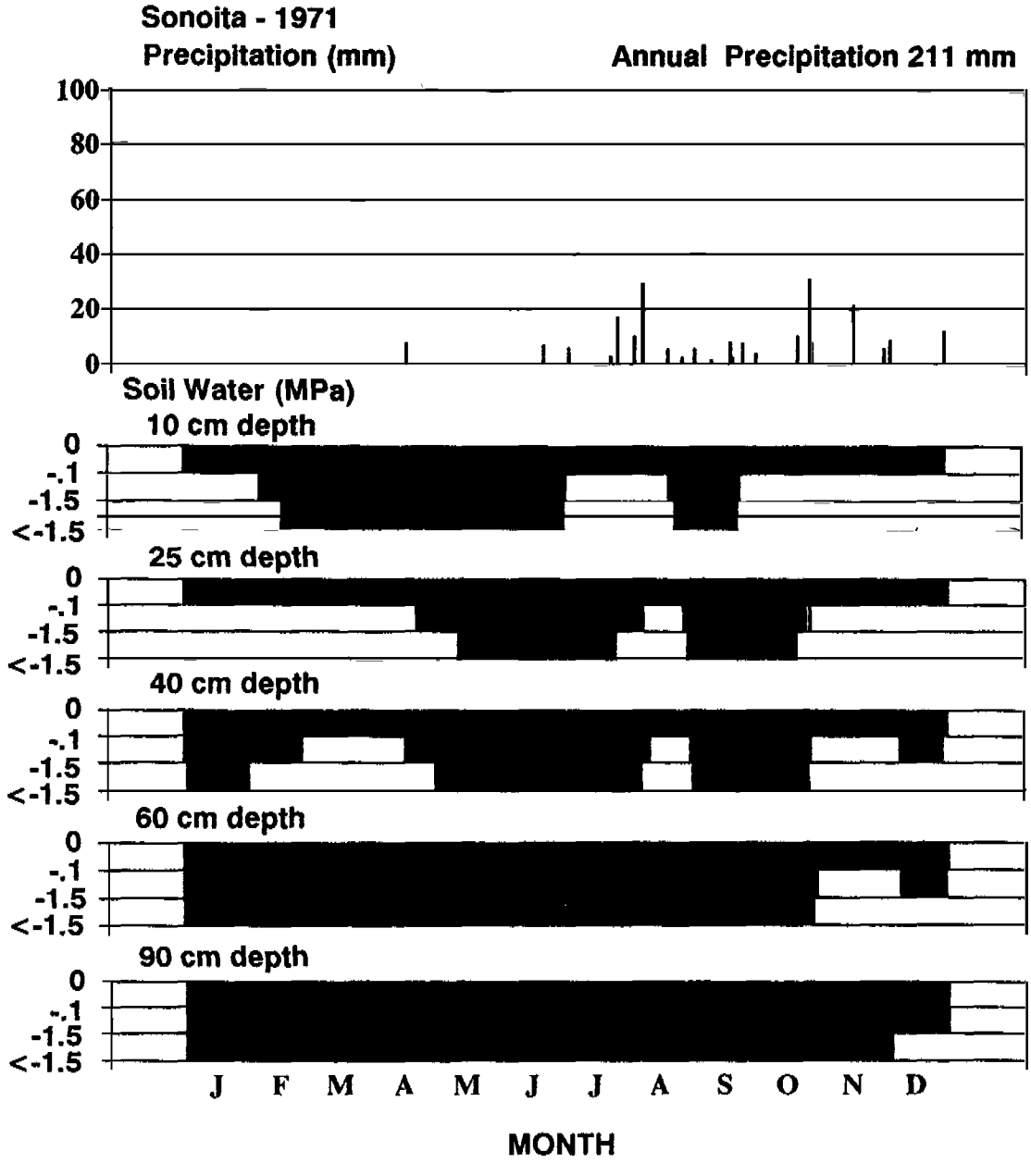


Figure 175. Annual precipitation (211 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1971.

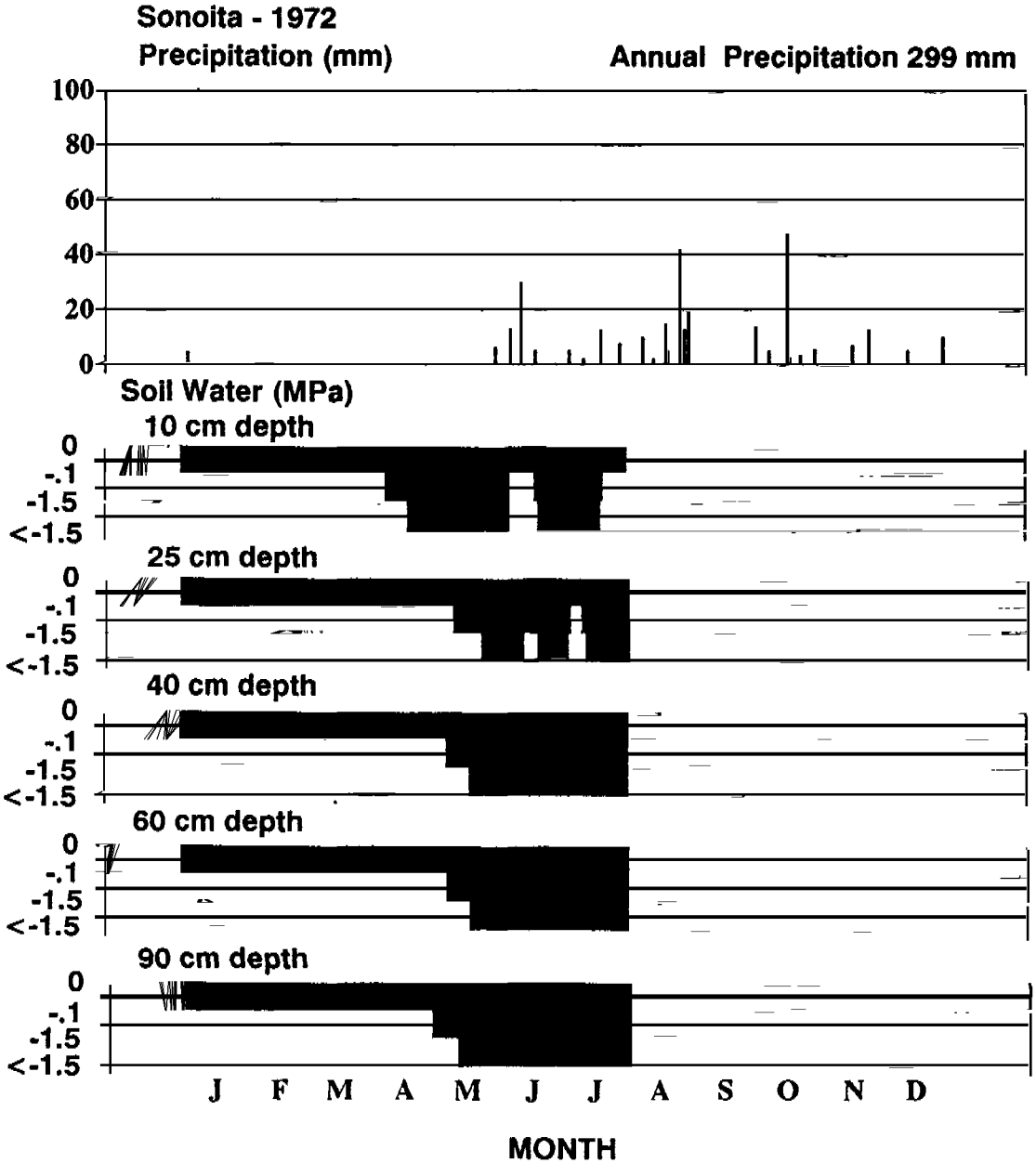


Figure 176. Annual (299 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm for January 1-August 1, 1972 at the Sonoita site.

Annual precipitation was below average in 1973 and above average in 1974. The matric potential of the soil water was measured at >-1.5 MPa at 25 cm January 7-May 23, 1973 (fig. 177); June 13-29; July 20-August 3; August 30-September 7, 1973; January 10-30, 1974 (fig. 178); March 2-28; July 13-August 23; and September 21, 1974-May 20, 1975 (figs. 178, 179).

The amount of annual precipitation for 1975 and 1976 was similar but the soil water patterns were dissimilar. Besides the soil water shown in the preceding paragraph, the 25-cm depth also had water >-1.5 MPa September 12, 1975-May 26, 1976 (figs. 179, 180); July 14-August 6; September 9-October 18; and November 30-December 31, 1976 (fig. 180).

Annual precipitation for 1957-76 at this location averaged 238 mm. It was above average for eight years, about average two years, and below average for 10 years. The probability of the matric potential of the soil water at 25 cm was 86.1% for December-April, 52.0% for May-June, 54.3% for July-September, and 54.5% for October-November (fig. 181). These probabilities were 15-20% above average because of the pipes at the sampling site.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, five of the 20 years had soil water <-1.5 MPa more than half the time at 10 and 25 cm; 7 of 19 years at 40 cm; 8 of 18 years at 60 cm; 10 of 18 years at 90 cm; and 3 of 9 years at a soil depth of 120 cm. Four of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 3 of 20 years at 25 cm; 3 of 19 years at 40 cm; 7 of 18 years at 60 and 90 cm; and 3 of 9 years at a depth of 120 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 17 of 18 years and >30 consecutive days in the four months after the summer solstice, June 21, also 17 of 18 years when the soil water data were complete for the entire year. The data at 25 cm were incomplete in 1957 and 1972 but the 60-day criterion was met in both years and the 30-day criterion was not observed in either year.

Site Wink (W)

Site W (figs. 4, 182, 183, table 9) was in a former exclosure at the Headquarters of the Jornada Experimental Range. The exclosure has now been dismantled and the rain gauge moved to another site at Headquarters. The sampled pedon is very close to the former location of the soil water blocks (personal communication, Clyde Yarbrough, 1990). The perennial vegetation is mesa dropseed, soaptree yucca, and fourwing saltbush.

Soils. The soil water blocks are in the Typic Calciorthid Wink, deep gypsum phase (fig. 183, tables 4, 9; Wink description and primary data). Diagnostic horizons are an ochric epipedon and a calcic horizon. Carbonate and organic carbon data in table 9 confirm the presence of these horizons. The Wink pedon has formed in a thin ridge-side deposit of eolian sand that overlies gypsum.

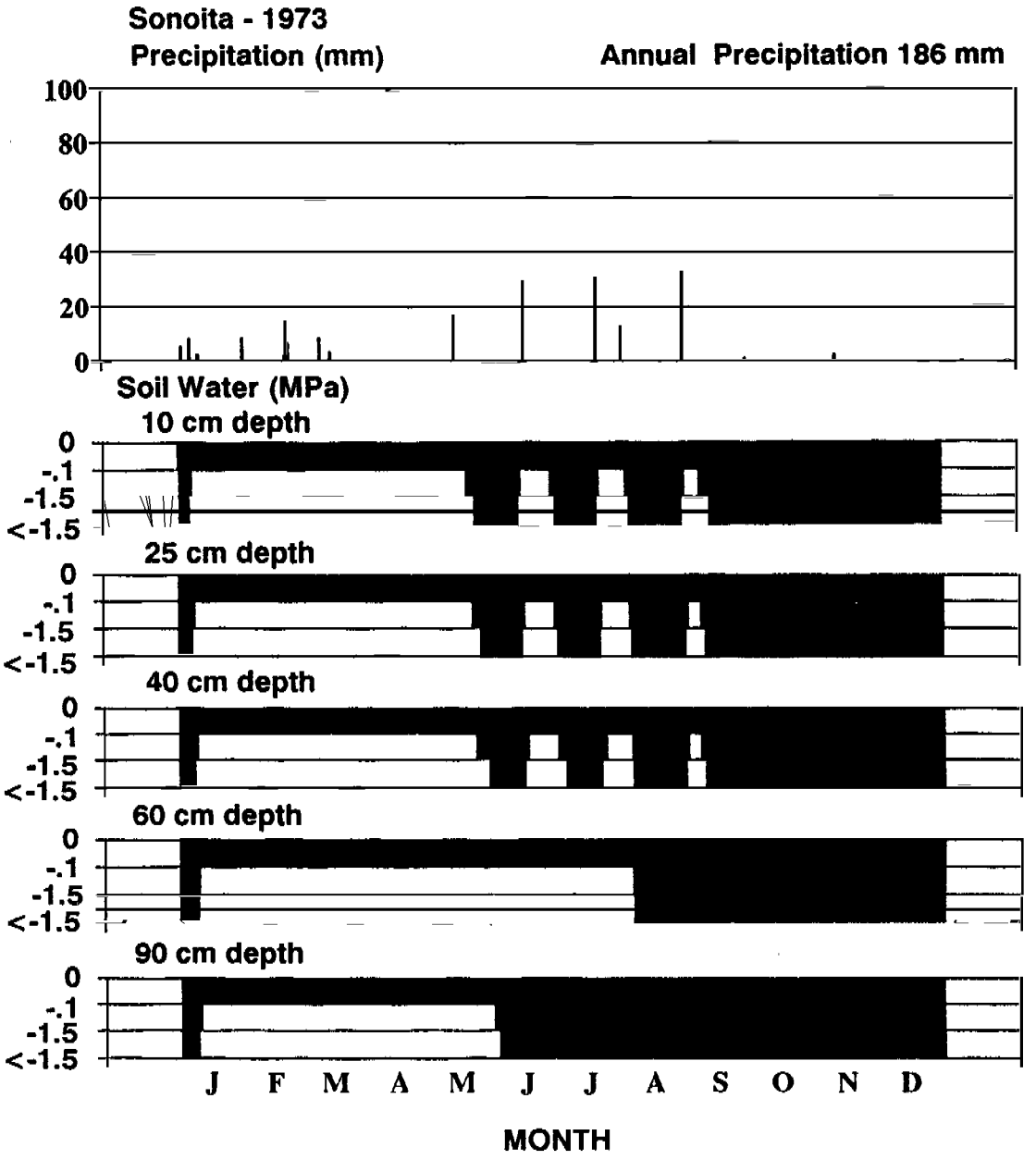


Figure 177. Annual precipitation (186 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1973.

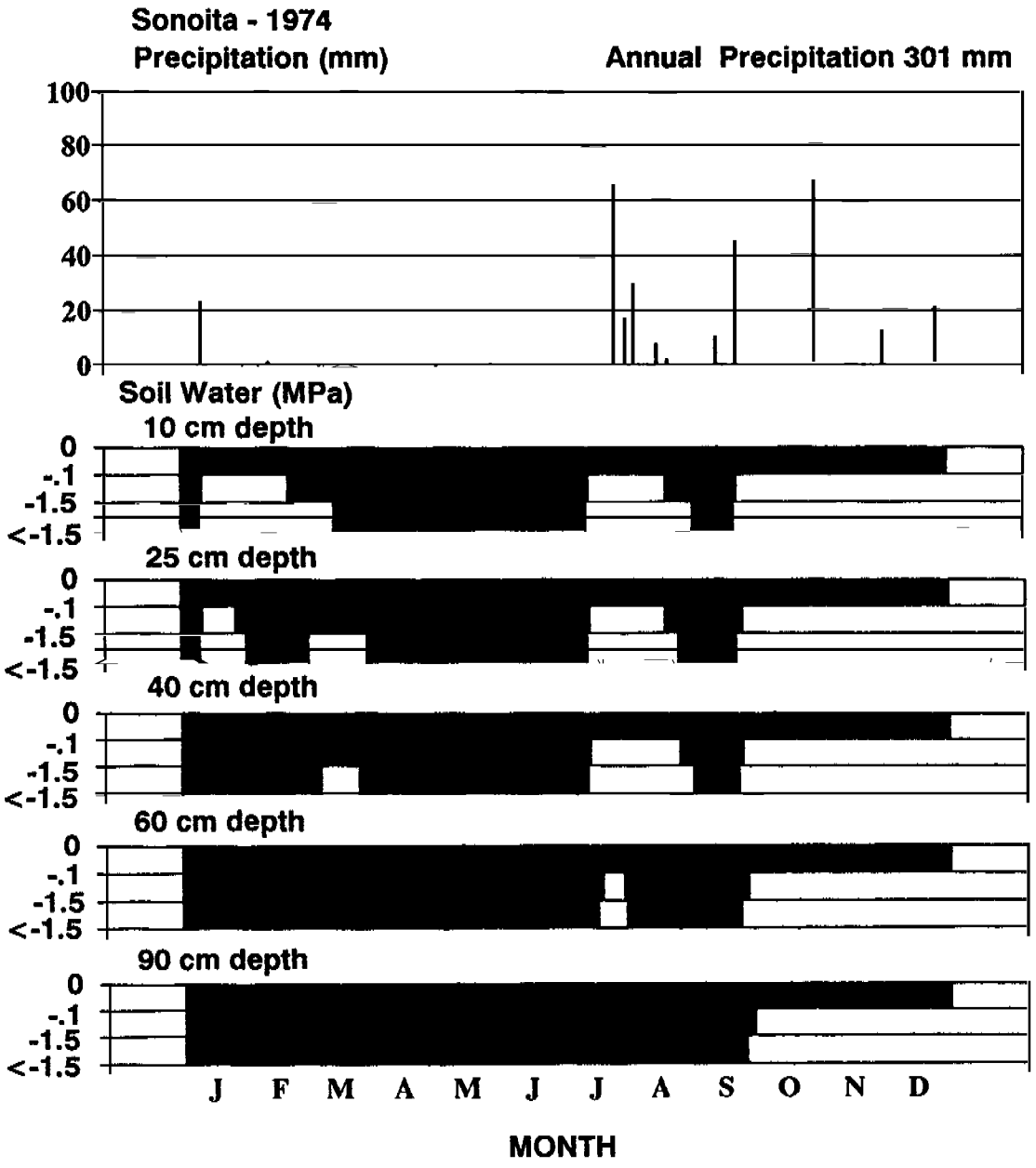


Figure 178. Annual precipitation (301 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1974.

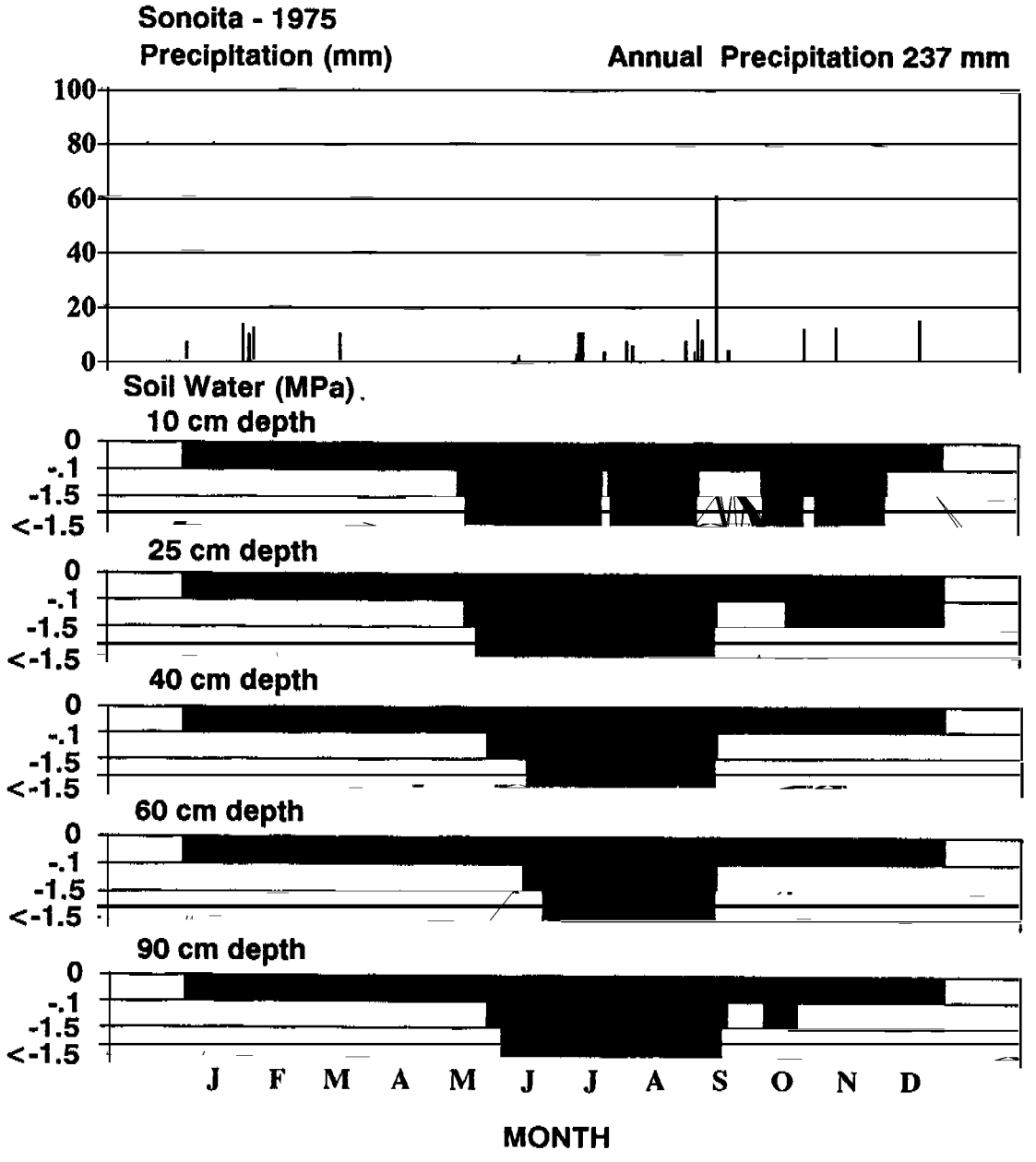


Figure 179. Annual precipitation (237 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1975.

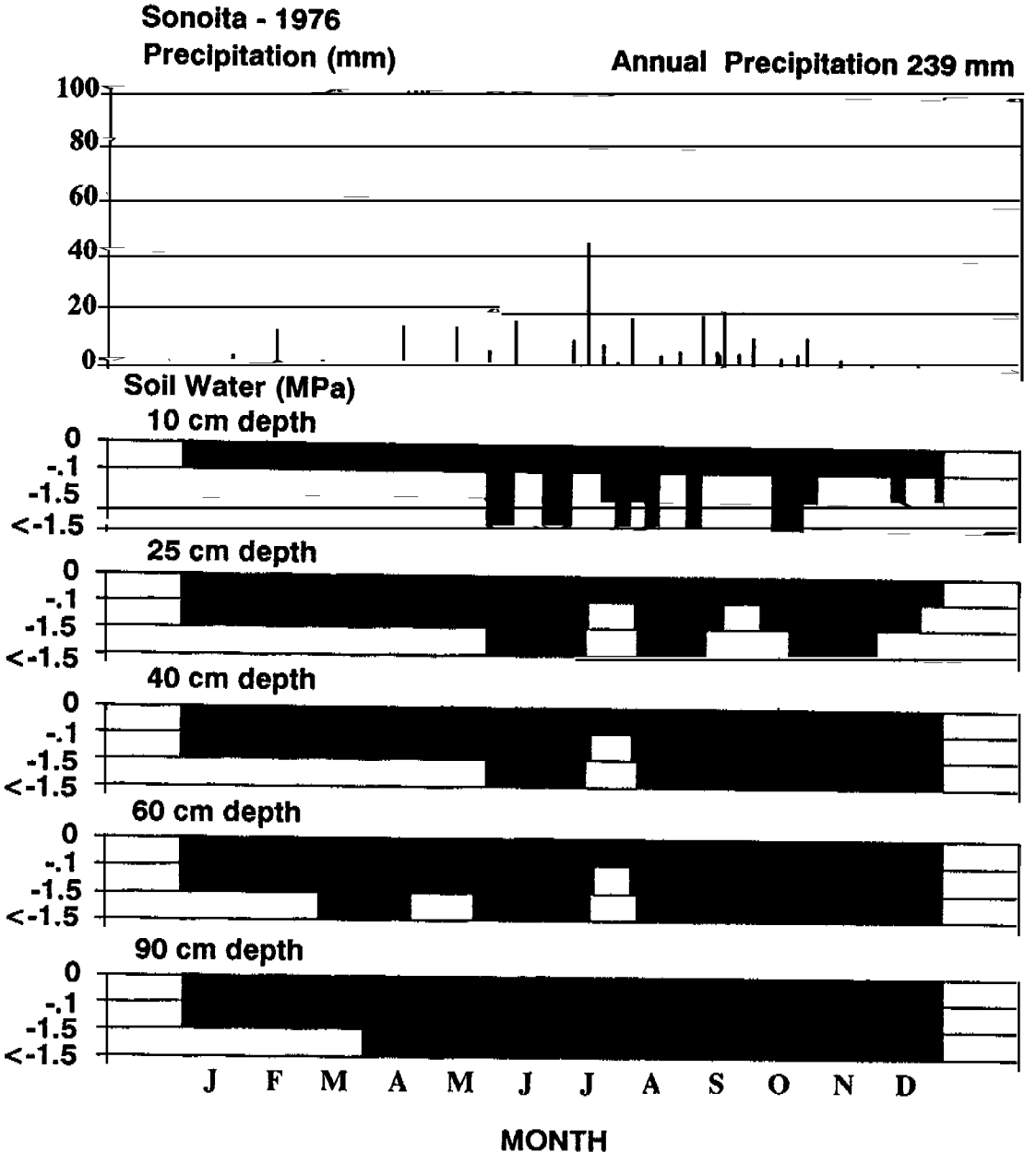


Figure 180. Annual precipitation (239 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Sonoita site for 1976.

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Wink, deep gypsum phase
Classification: Coarse-loamy, mixed, thermic Typic Calciorthid
NSSL ID#: 90P0495
Soil Survey #: S90NM-013-004
Location: The SE1/4NE1/NW1/4 section 33, T.19S., R.2E., in the former exclosure at Headquarters. This exclosure has been dismantled and the rain gauge has been moved to another site at Headquarters. ARS personnel indicate that the sampled pedon is very close to the former location of the soil moisture blocks.

Elevation: 4320 ft, 1317 m
Landform: Ridge side sloping 2% to the east
Geomorphic Surface: Eolian analogue of Jornada II, late phase?
Parent Material: Late phase Jornada II (?) sand
Veg tation: Dropseed, soaptree yucca, fourwing saltbush
Described By: L.H. Gile
Date: Jan. 29, 1990

Soil surface: A layer of loose reddish sand occurs over most of the surface.

C--0 to 9 cm; stratified pinkish gray to light brown (7.5YR 6/3) loamy sand; brown (7.5YR 4.5/3) moist; massive but with horizontal cleavage to thin and medium lenses; generally soft, with some lenses separated by soft fine granules or loose, single-grain material; few and common fine roots; 90P2736; strongly effervescent; abrupt smooth boundary.

Ab--9 to 18 cm; brown (7.5YR 5/2.5) loamy sand; dark brown (7YR 3.5/3) moist; very weak medium subangular blocky structure; slightly hard, very friable; few fine roots; 90P2737; strongly effervescent; clear wavy boundary.

Akb--18 to 30 cm; pinkish gray to light brown (7.5YR 6/3) loamy sand; brown to dark brown (7.5YR 4/3) moist; very weak medium subangular blocky structure; slightly hard, very friable; few fine roots; 90P2738; very few carbonate filaments; strongly effervescent; clear wavy boundary.

Bk1b--30 to 42 cm; pinkish gray to light brown (7.5YR 6.5/3) fine sandy loam; brown (7.5YR 5/3.5) moist; weak medium subangular blocky structure; slightly hard and hard, very friable; few fine roots; 90P2739; very few filaments; strongly effervescent; clear wavy boundary.

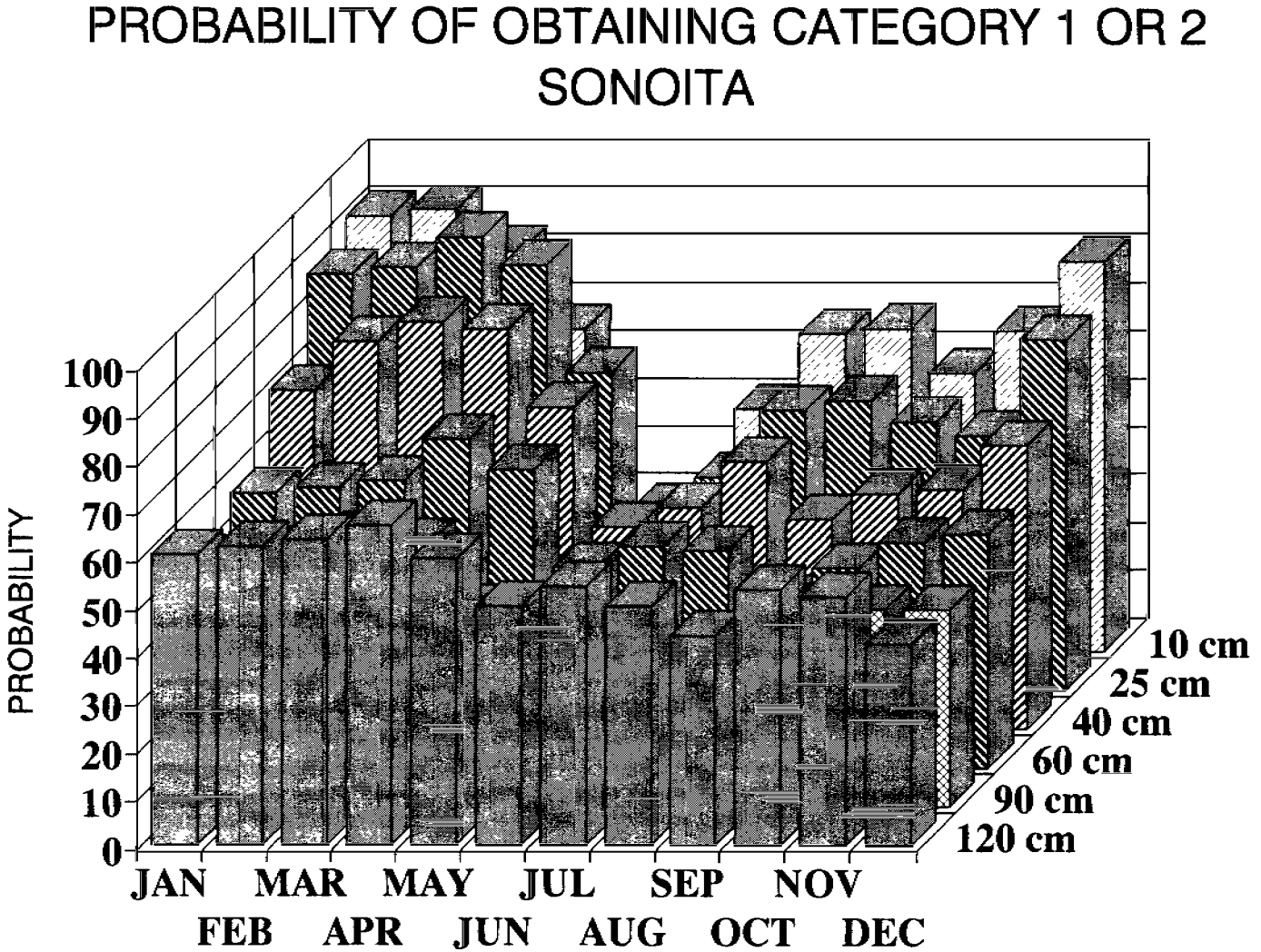


Figure 181. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm at the Sonoita site.

Figure 182. Landscape at Site W (fig. 4) and the Typic Calciorthid Wink, deep gypsum phase, in the former location of the Headquarters rain gauge. The site is a ridge side sloping from left to right. Photographed January 1990.

Figure 183. Profile of the Typic Calciorthid Wink, deep gypsum phase. The light colored layer at the bottom of the trench contains gypsum. Scale is in feet.

Bk2b--42 to 58 cm; pinkish gray to light brown (7.5YR 6.5/3) fine sandy loam; brown (7.5YR 5/3.5) moist; weak medium subangular blocky structure; slightly hard and hard, friable, few fine roots; 90P2740; few carbonate filaments; strongly effervescent; clear wavy boundary.

Bk3b--58 to 78 cm; pinkish gray to pink (7.5YR 7/3) fine sandy loam; brown (7.5YR 5/3.5) moist; weak medium subangular blocky structure; slightly hard and hard, friable; few fine roots; 90P2741; few carbonate filaments; strongly effervescent; clear wavy boundary.

K2b--78 to 101 cm; pinkish gray to pink (7.5YR 7.5/3) sandy clay loam; pinkish gray to light brown (7.5YR 6/3) moist; occurring as nodules and as internodular K-fabric, with l sser amount of 7.5YR 9/2 and 8/2; moderate medium subangular blocky structure; hard and very hard, firm; very few fine mottles; strongly effervescent; clear wavy boundary.

K3b--101 to 117 cm; pinkish gray to pink (7.5YR 7.5/3) sandy clay loam; pinkish gray to light brown (7.5YR 6/3) moist; these colors occur as carbonate nodules and as internodular K-fabric with lesser amount of 7.5YR 9/2, 8/2, and 6.5/3; moderate medium subangular blocky structure; very hard, firm; very few fine roots; 90P2743; few medium yellow and brownish yellow (10YR 7/6. 6/6) mottles; strongly effervescent; clear wavy boundary.

Bkb--117 to 127 cm; pinkish gray to light brown (7.5YR 6.5/3) sandy clay loam; brown (7.5YR 5/3) moist; weak medium subangular blocky structure; fine yellow and brownish yellow (10YR 7/6, 6/6) mottles and streaks; strongly effervescent; abrupt smooth boundary.

C--127 to 136 cm; white (10YR 9/2) sandy loam; very pale brown (10YR 8/3) moist; weak medium and coarse subangular blocky structure; very hard, firm; no roots; 90P2745; some parts noncalcareous, other parts weakly or strongly effervescent. This material appears to be primarily gypsum, and needs further study. It may be partly or wholly of lacustrine origin.

*** P R I M A R Y C H A R A C T E R I Z A T I O N D A T A ***

S90NM-013-004

PRINT DATE 11/29/91

Soil series:Wink,deep gypsum phase, COARSE-LOAMY, MIXED, THERMIC TYPIC CALCIORTHID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 495, SAMPLES 90P2736-2747
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
				(- - -TOTAL - - -)				(- -CLAY- -)	(- -SILT- -)			(- - - - -SAND- - - - -)				(-COARSE FRACTIONS(MM)-)				(>2MM)
SAMPLE NO.	DEPTH (CM)	HORIZON	CLAY LT .002	SILT .002 -.05	SAND .05 -2	FINE LT .0002		CO3 LT .002	FINE .002 -.02	COARSE .02 -.05	VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	WEIGHT 2 -5	5 -20	20 -75	.1- 75	WT PCT OF WHOLE
			<- - - - - - - - - - - - - - - PCT OF <2MM (3A1) - - - - - - - - - - - - - - ->													<- PCT OF <75MM(3B1)->				SOIL
90P2736S	0- 9	C	8.4	4.5	87.1				2.5	2.0	18.0	41.8	24.7	2.5	0.1	--	--	--	69	--
90P2737S	9- 18	AB	9.3	6.6	84.1			0.9	3.5	3.1	16.0	42.8	23.1	2.1	0.1	--	--	--	68	--
90P2738S	18- 30	AKB	10.6	3.9	85.5			0.9	3.0	0.9	16.6	40.9	25.3	2.6	0.1	--	--	--	69	--
90P2739S	30- 42	BK1B	12.7	5.9	81.4			2.4	3.8	2.1	14.0	39.5	24.4	3.3	0.2	TR	TR	--	67	--
90P2740S	42- 58	BK2B	13.4	7.2	79.4			2.7	4.5	2.7	13.8	36.0	25.7	3.7	0.2	TR	TR	--	66	--
90P2741S	58- 78	BK3B	14.3	8.4	77.3			3.0	5.6	2.8	13.9	33.8	25.5	3.8	0.3	TR	TR	--	63	TR
90P2742S	78-101	K2B	22.1	14.2	63.7			7.0	10.7	3.5	14.6	25.9	19.2	3.4	0.6	1	TR	--	50	1
90P2743S	101-117	K3B	23.3	17.1	59.6			2.8	12.3	4.8	13.3	25.4	17.0	3.2	0.7	--	--	--	46	--
90P2744S	117-127	BKB	21.4	14.1	64.5			2.5	8.8	5.3	14.2	28.1	18.0	3.5	0.7	1	--	--	51	1
90P2745S	127-136	C	8.4	30.6	61.0			1.2	19.5	11.1	21.5	24.9	12.9	1.6	0.1	--	--	--	39	--
																--	--	--		--
																--	--	--		--

	ORGN	TOTAL	EXTR	TOTAL	(- - DITH-CIT - -)			(RATIO/CLAY)		(ATTERBERG)		(- BULK DENSITY -)			COLE	(- - -WATER CONTENT - - -)				WRD
	C	N	P	S	EXTRACTABLE FE	AL	MN	CEC	15 BAR	- LIMITS - LL	PI	FIELD MOIST	1/3 BAR	OVEN DRY	WHOLE SOIL	FIELD MOIST	1/10 BAR	1/3 BAR	15 BAR	WHOLE SOIL
DEPTH (CM)	6A1c	6B3a	6S3	6R3a	6C2b	6G7a	6D2a	8D1	8D1	4F1	4F	4A3a	4A1d	4A1h	4D1	4B4	4B1c	4B1c	4B2a	4C1
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM	-->			PCT	<0.4MM	<- -	G/CC	- - ->	CM/CM	<- - -	-PCT OF	<2MM	- ->	CM/CM
0- 9	0.26							0.76	0.35										2.9	
9- 18	0.26							0.81	0.34				1.69	1.73	0.008			4.5	3.2	0.02
18- 30	0.23							0.67	0.33										3.5	
30- 42	0.23							0.60	0.35				1.59	1.62	0.006			5.3	4.4	0.01
42- 58	0.21							0.55	0.34										4.5	
58- 78	0.18							0.53	0.34										4.8	
78-101	0.22							0.43	0.30				1.52	1.61	0.019			11.2	6.7	0.07
101-117	0.18							0.55	0.33				1.59	1.65	0.025			13.2	7.7	0.08
117-127	0.19							0.61	0.36										7.7	
127-136	0.08							0.46	0.71				1.30	1.30	--			19.7	6.0	0.18

AVERAGES, DEPTH 25-100: PCT CLAY 12 PCT .1-75MM 61

	(- NH4OAC EXTRACTABLE BASES -)					ACID-	(- -CEC- -)		EXCH	SAR	BASE SATURATION		CO3 AS CACO3	RES. OHMS	CASO4 AS GYPSUM		(- - - -PH - - -)		
	CA	MG	NA	K	SUM	ITY	SUM	NH4- OAC	NA		SUM	NH4OAC	<2MM	/CM	<2MM	<20MM	SAT PASTE	CACL2 .01M	H2O
DEPTH (CM)	6N2a	6B5a	6B5a	6B5a	BASES	6H5a	CATS	5A8b	5B5b	5E	5C3	5C1	6E1g	8E1	6F1a	6F4	8C1b	8C1f	8C1f
	<- - - - - - - - - -MEQ / 100 G - - - - - - - - - ->								PCT		<- -PCT- >		PCT		<- -PCT ->			1:2	1:1
0- 9		0.8	--	0.6				6.4	TR		100	100	1					7.8	8.4
9- 18		0.8	--	0.6				7.5	TR		100	100	1					7.8	8.5
18- 30		0.7	TR	0.4				7.1	1		100	100	2					7.8	8.3
30- 42		0.8	--	0.3				7.6	TR		100	100	5					7.8	8.4
42- 58		0.8	TR	0.3				7.4	TR		100	100	7					7.8	8.4
58- 78		0.9	TR	0.3				7.6	1		100	100	6					7.8	8.2
78-101		1.0	0.1	0.3				9.6	1	TR	100	100	17	2000			7.6	7.8	8.1
101-117		1.2	0.3	0.4				12.8	2	1	100	100	12		--		7.5	7.7	7.8
117-127		1.2	0.3	0.4				13.0	2	1	100	100	10		TR		7.5	7.7	7.8
127-136		0.4	0.1	0.1				3.9	1	TR	100	100	2		54		7.6	7.6	7.6

	(- - - - - - - -WATER EXTRACTED FROM SATURATED PASTE- - - - - - - - -)											
	CA	MG	NA	K	CO3	HCO3	CL	SO4	NO3	H2O	TOTAL SALTS EST.	ELEC. COND.
DEPTH (CM)	6N1b	6O1b	6P1b	6Q1b	6I1b	6J1b	6K1c	6L1c	6M1c	8A	8D5	8A3a MMHOS /CM
	< - - - - - - - - - -MEQ / LITER - - - - - - - - - ->									<- -PCT ->		
0- 9												0.22
9- 18												0.16
18- 30												0.15
30- 42												0.16
42- 58												0.16
58- 78												0.18
78-101	10.5	0.9	0.9	0.2	--	1.4	2.4	7.5	--	35.0	TR	1.12
101-117	20.5	1.5	2.1	0.2	--	1.5	5.5	15.2	--	39.3	0.1	1.96
117-127	31.3	1.9	3.1	0.3	--	1.4	3.7	29.5	--	44.1	0.1	2.68
127-136	28.0	1.1	1.5	0.3	--	1.0	1.1	26.9	--	52.2	0.1	2.28

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 1, 2, 3, 4, 5, 6,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

The deposit may be an eolian analogue of a late phase of the Jornada II sediments of late Pleistocene age (table 2). The site is on a ridge side sloping 2% to the east.

Although clay increases from the A to the B horizon, some of the clay increase is attributed to carbonate of clay size because carbonate also increases with depth (table 9). The carbonate maximum is thin and occurs in a weak K horizon (table 9).

This soil is calcareous throughout, although the percentage of carbonate in upper horizons is slight (table 9). Lack of a noncalcareous zone may reflect the presence of enough carbonates in the parent materials that precipitation in the late Holocene could not form a noncalcareous zone in upper horizons. However, the modest percentage of carbonate in the K horizon suggests that the percentage of carbonate in the parent materials could only have been slight. Dustfall may have contributed a somewhat higher percentage of carbonate than for the other soils shown in tables 3 and 4. High-carbonate calcic and petrocalcic horizons occur at or very near the surface to the windward, and may have supplied carbonate both to the parent materials and to the dustfall.

Soil Water and Precipitation. The gypsum resistance blocks were installed at soil depths of 10 and 25 cm on July 26, 1957; 40 cm on August 14, 1957; and at the 60- and 90-cm depths on July 29, 1959 within a livestock exclosure at the Headquarters Weather Station. The rain gauge at Headquarters was established in 1914. The soil water at 10 cm was >-1.5 MPa July 26-August 22, 1957 (fig. 184), as a result of 26 mm precipitation July 22-25 and subsequent rainfall. The 10-cm depth also had soil water >-1.5 MPa August 30-September 9 because of 61 mm rainfall on August 29-31. Then after a dry September and early October, the matric potential of the soil water at 10 cm was >-1.5 MPa October 11, 1957-April 30, 1958 (figs. 184, 185). The moisture control section, 25-cm depth, had soil water >-1.5 MPa August 14-22, 1957 (fig. 184); August 26-27; September 1-12; and November 8, 1957-May 2, 1958 (figs. 184, 185). There was soil water >-1.5 MPa at the 40-cm depth August 14-20 and September 2-19, 1957 (fig. 184).

Annual precipitation for 1958 was 341 mm but soil water at 10 cm was <-1.5 MPa May 1-August 22 (fig. 185). The 25-cm depth had soil water >-1.5 MPa August 29-September 9 and September 14, 1958-February 26, 1959 (figs. 185, 186).

The precipitation in 1959 was about average but 71% occurred in August. The 25-cm depth had soil water >-1.5 MPa July 29-September 23 (fig. 186).

The 1960 precipitation was below average and the soil water at 25 cm was >-1.5 MPa February 8-May 2 and briefly August 31-September 2 (fig. 187). December 9, 1960 had 30 mm precipitation and both 1961 and 1962 had above average precipitation. There was water >-1.5 MPa at the 25-cm soil depth December 18, 1960-May 15, 1961 (figs. 187, 188); August 14-September 4; September 8, 1961-May 6, 1962 (figs. 188, 189); July 14-August 27; and September 26, 1962-April 20, 1963 (figs. 189, 190).

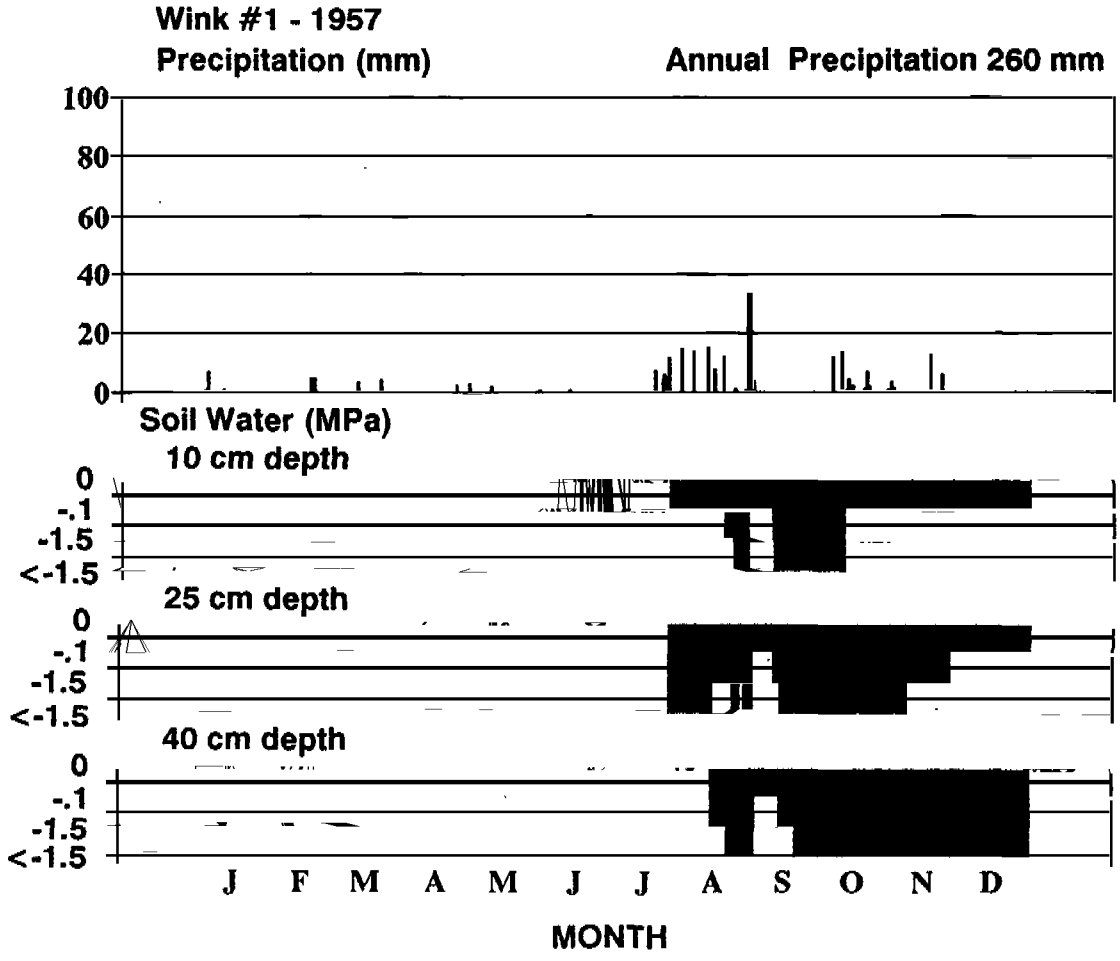


Figure 184. Annual (260 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10 and 25 cm for July 26-December 31 and at a depth of 40 cm for August 14-December 31, 1957 at the Wink site.

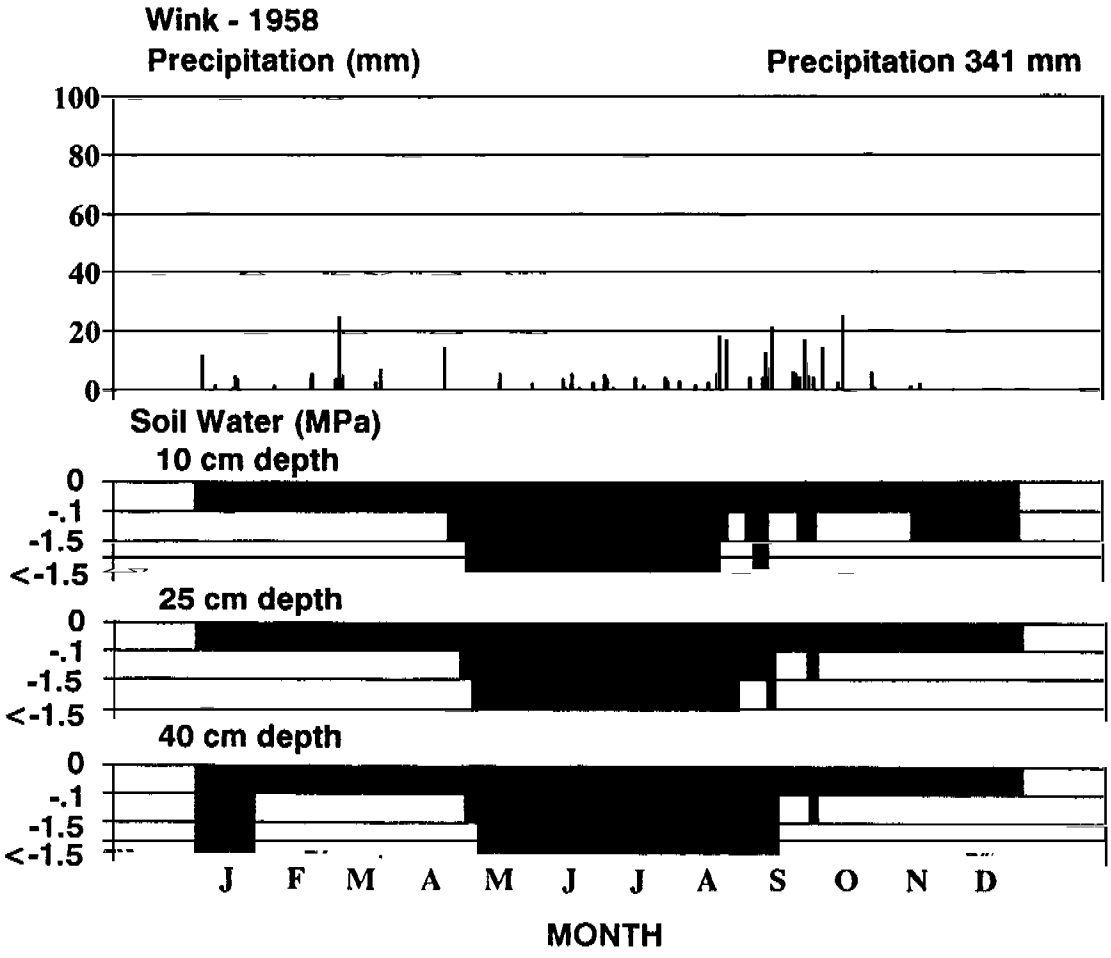


Figure 185. Annual precipitation (341 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Wink site for 1958.

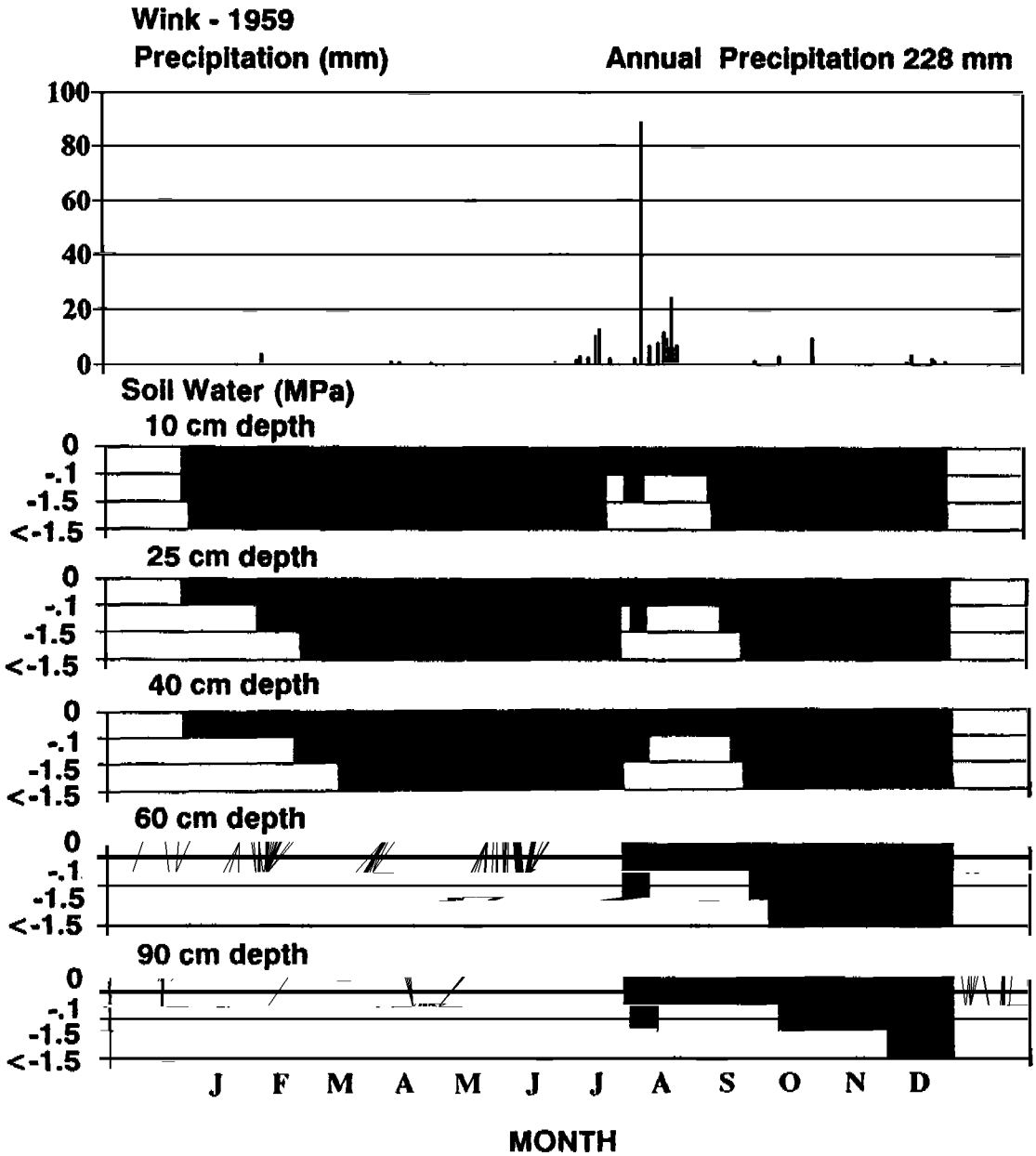


Figure 186. Annual precipitation (228 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Wink site for 1959. Also shown is the soil water at depths of 60 and 90 cm July 29-December 31, 1959.

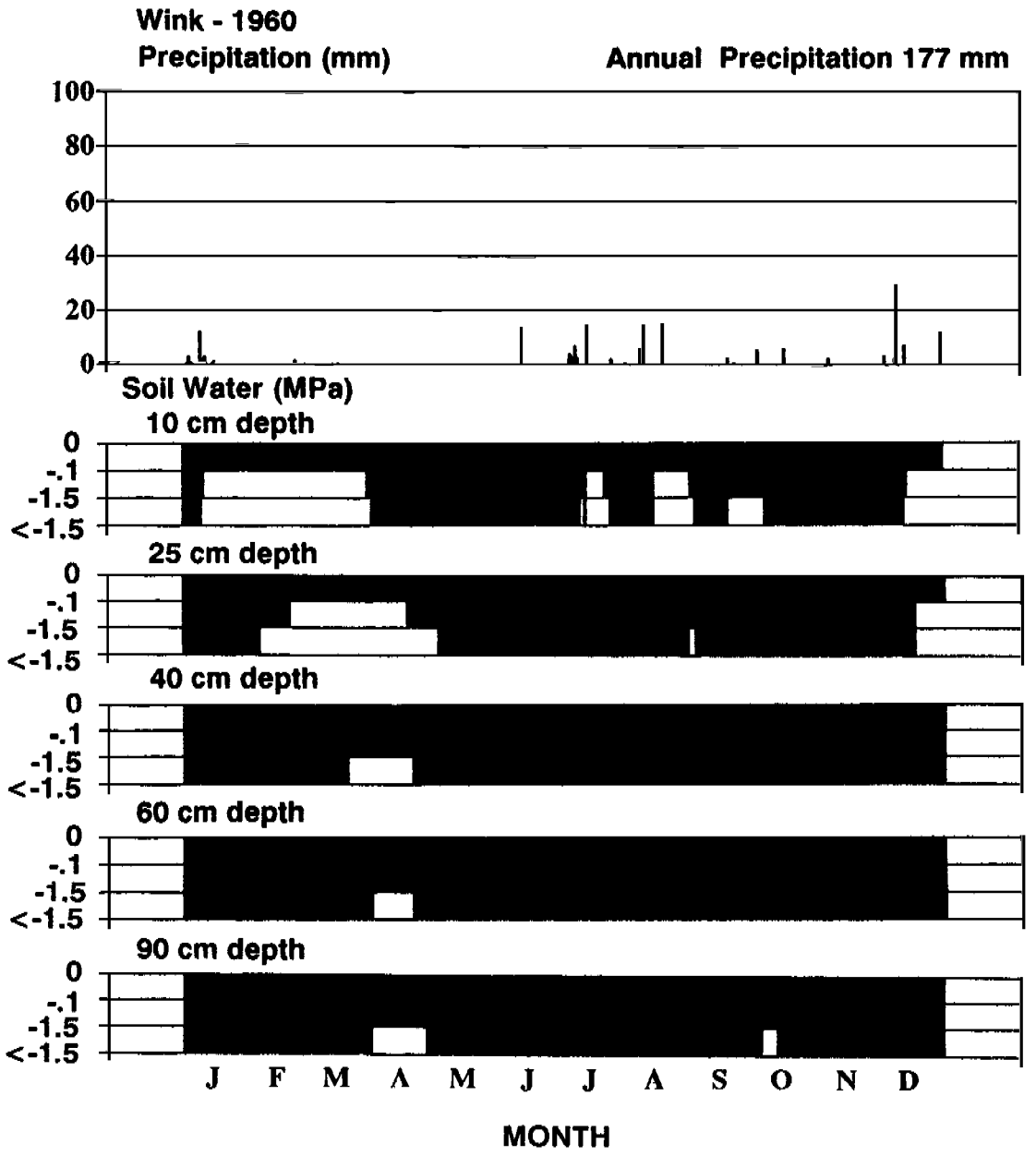


Figure 187. Annual precipitation (177 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1960.

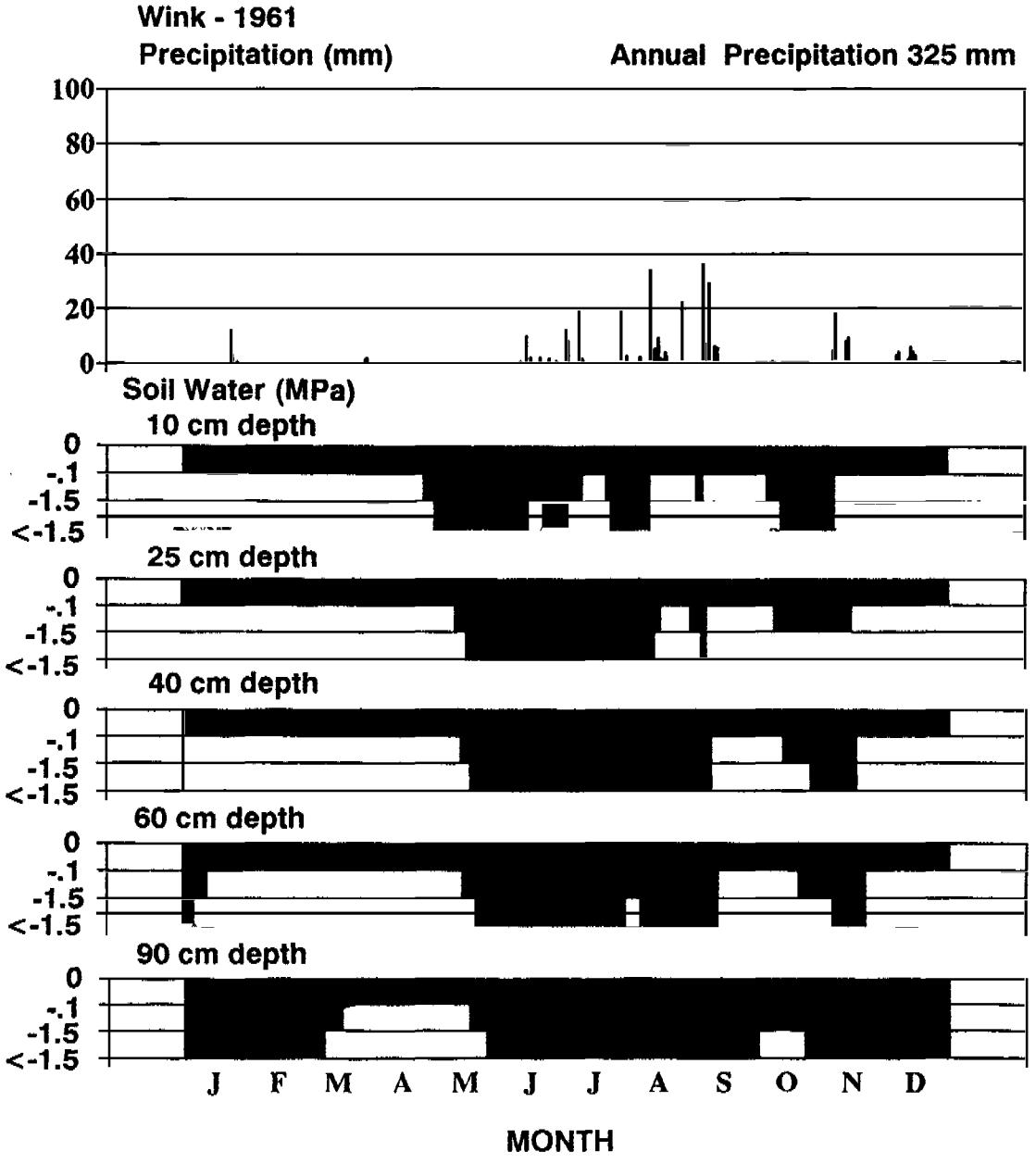


Figure 188. Annual precipitation (325 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1961.

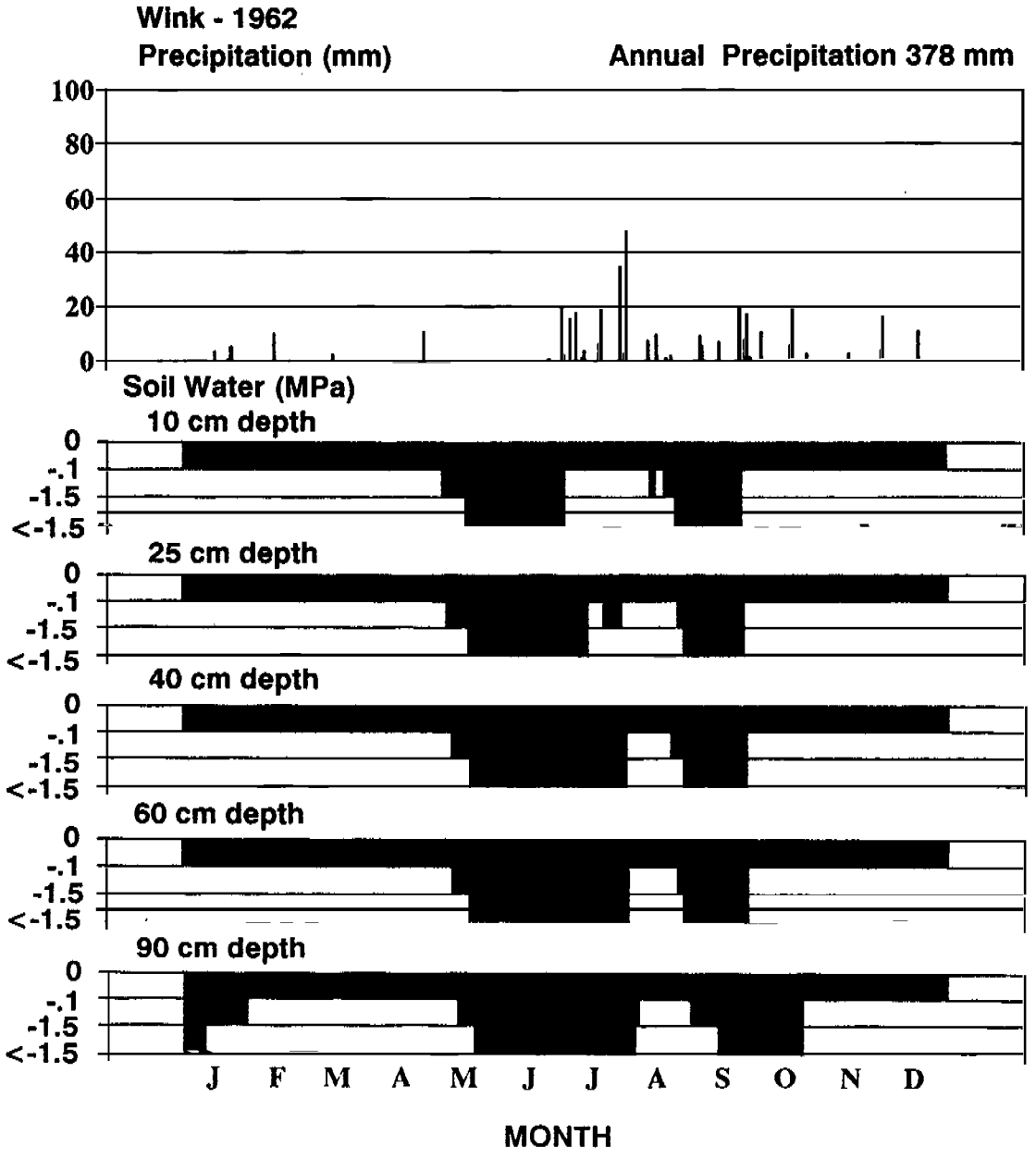


Figure 189. Annual precipitation (378 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1962.

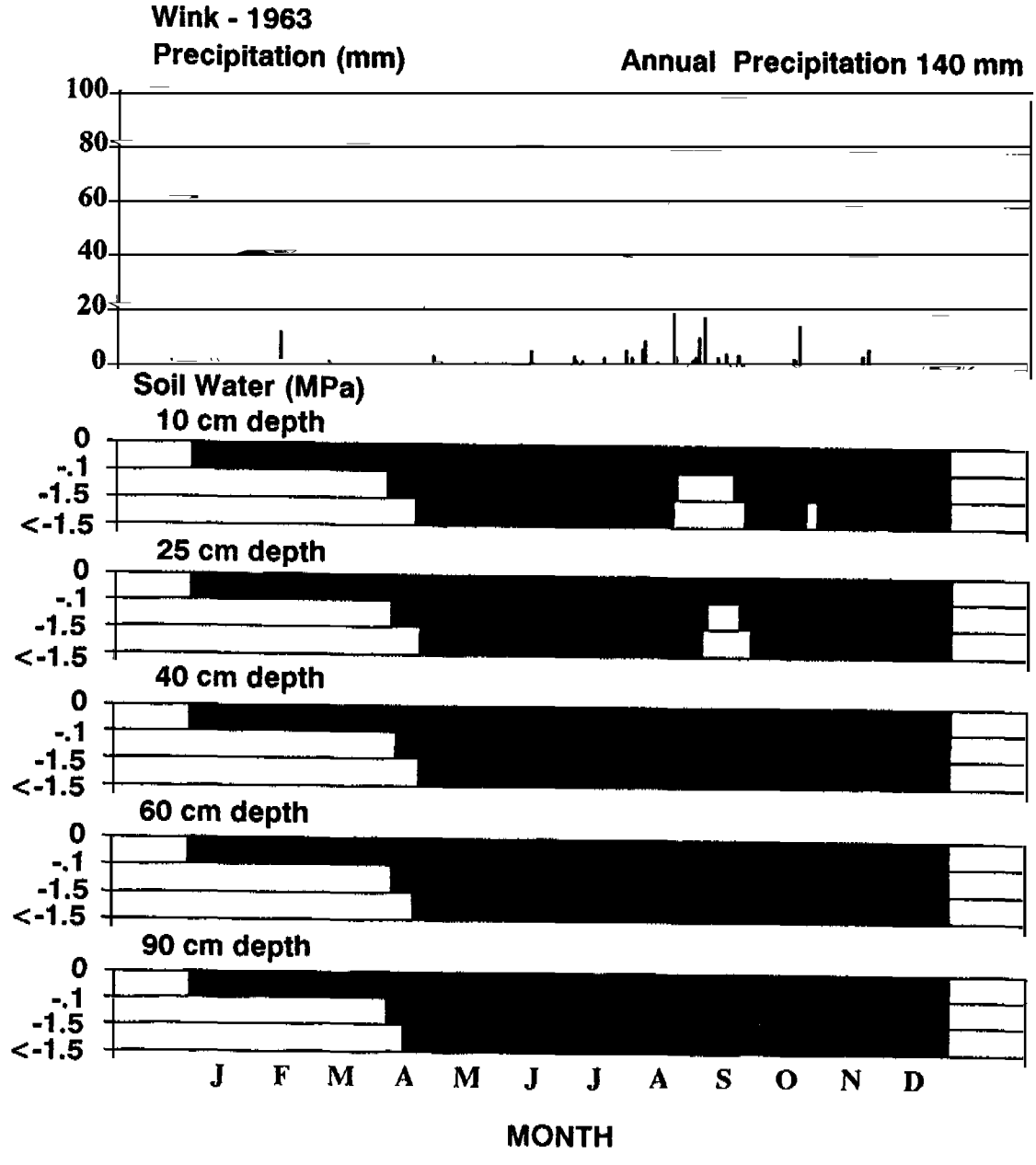


Figure 190. Annual precipitation (140 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1963.

Annual precipitation for the next five years, 1963-67, was below average. The matric potential of the soil water at 25 cm was >-1.5 MPa September 4-26, 1963 (fig. 190); May 28, 1964-May 18, 1965 (figs. 191, 192); December 11, 1965-May 22, 1966 (figs. 192, 193); June 20-July 23, 1967 (fig. 194); and December 16, 1967-June 19, 1968 (figs. 194, 195). A high percentage (92%) of the precipitation in 1964 occurred in late May and July-September resulting in the initiation of a long period of soil water >-1.5 MPa at 25 cm (figs. 191, 192).

The annual precipitation for 1968 and 1969 was above average and similar. The major difference in soil water >-1.5 MPa occurred at depths of 60 and 90 cm where there was a longer period of soil water >-1.5 MPa in 1968 (figs. 195, 196). Both years had soil water >-1.5 MPa at the 10-, 25-, and 40-cm depths during winter-spring and for brief period(s) during the summer.

Precipitation was below average in both 1970 and 1971. There was soil water >-1.5 MPa at 25 cm during the winter and early spring of 1970 (fig. 197); July 26-August 24, 1970; and October 26, 1971-April 5, 1972 (figs. 198, 199).

There was 345 mm precipitation in 1972 (fig. 199) but no soil water data were available August 1-December 31. Precipitation was particularly high in June, July, August, and October.

Precipitation in 1973 was below average but wet conditions during the fall and winter of 1972-73 resulted in water >-1.5 MPa at the 25-cm depth January 1-April 30, 1973 (fig. 200). Soil water was also >-1.5 MPa at 25 cm June 16-August 28. No soil water estimates were obtained at this location after December 31, 1973.

Annual precipitation for 1957-73 was below average nine years, about average one year, and above average seven years. The probability of soil water >-1.5 MPa at the 25-cm depth averaged 70.0% for December-April, 26.5% for May and June, 33.1% for July-September, and 31.1% for October and November (fig. 201).

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regimes, seven of 17 years had soil water <-1.5 MPa more than half the time at 10 cm; 9 of 17 years at 25 cm; 11 of 17 years at 40 cm; 10 of 15 years at 60 cm; and 12 of 15 years at a soil depth of 90 cm. Five of 17 years had soil water <-1.5 MPa for >90 consecutive days at 10, 25, and 40 cm; 6 of 15 years at 60 cm; and 10 of 15 years at a depth of 90 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 13 of 15 years and >30 consecutive days in the four months after June 21, eight of 15 years when the soil water data were complete for the entire calendar year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was also observed in 1972.

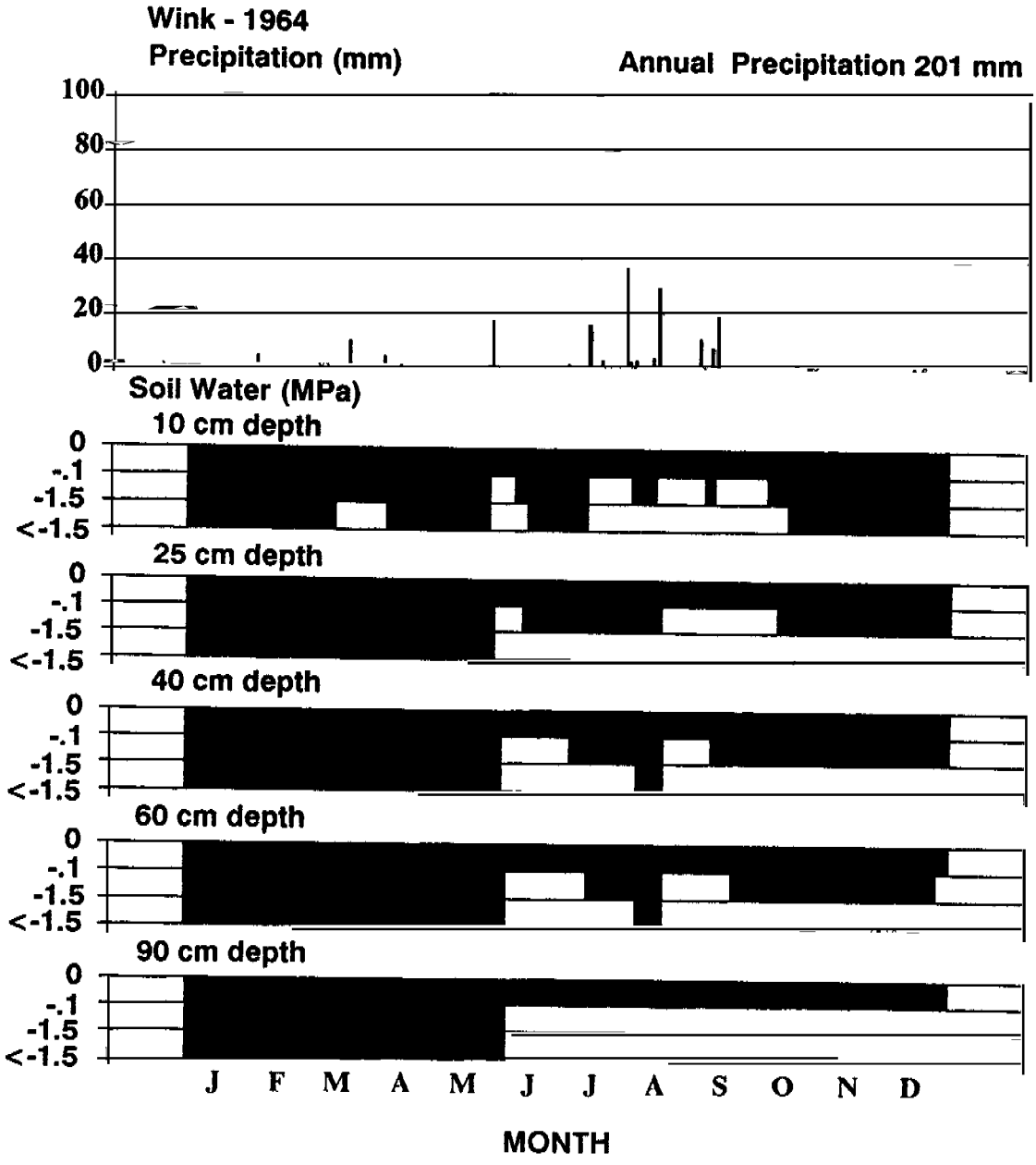


Figure 191. Annual precipitation (201 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1964.

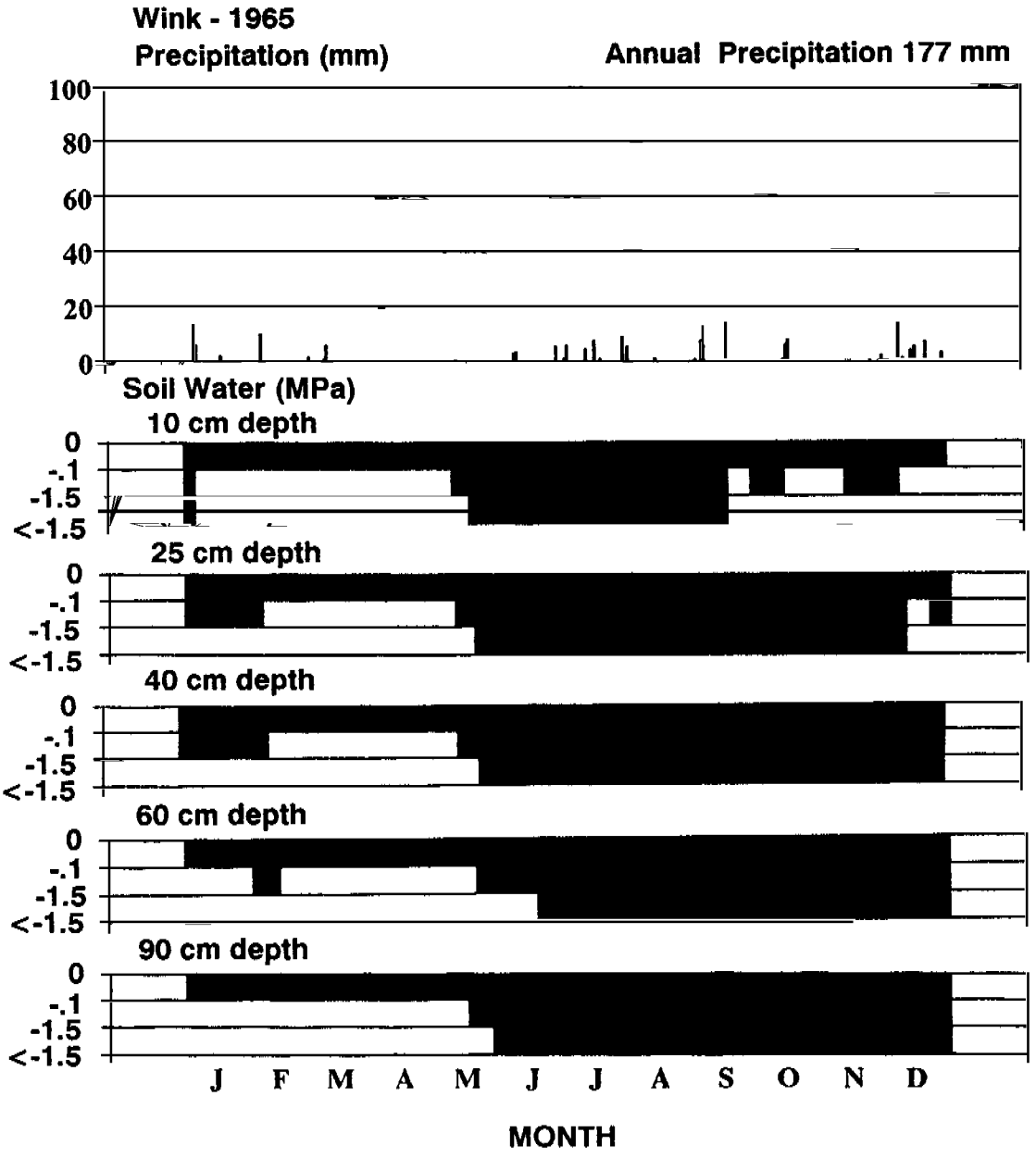


Figure 192. Annual precipitation (177 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1965.

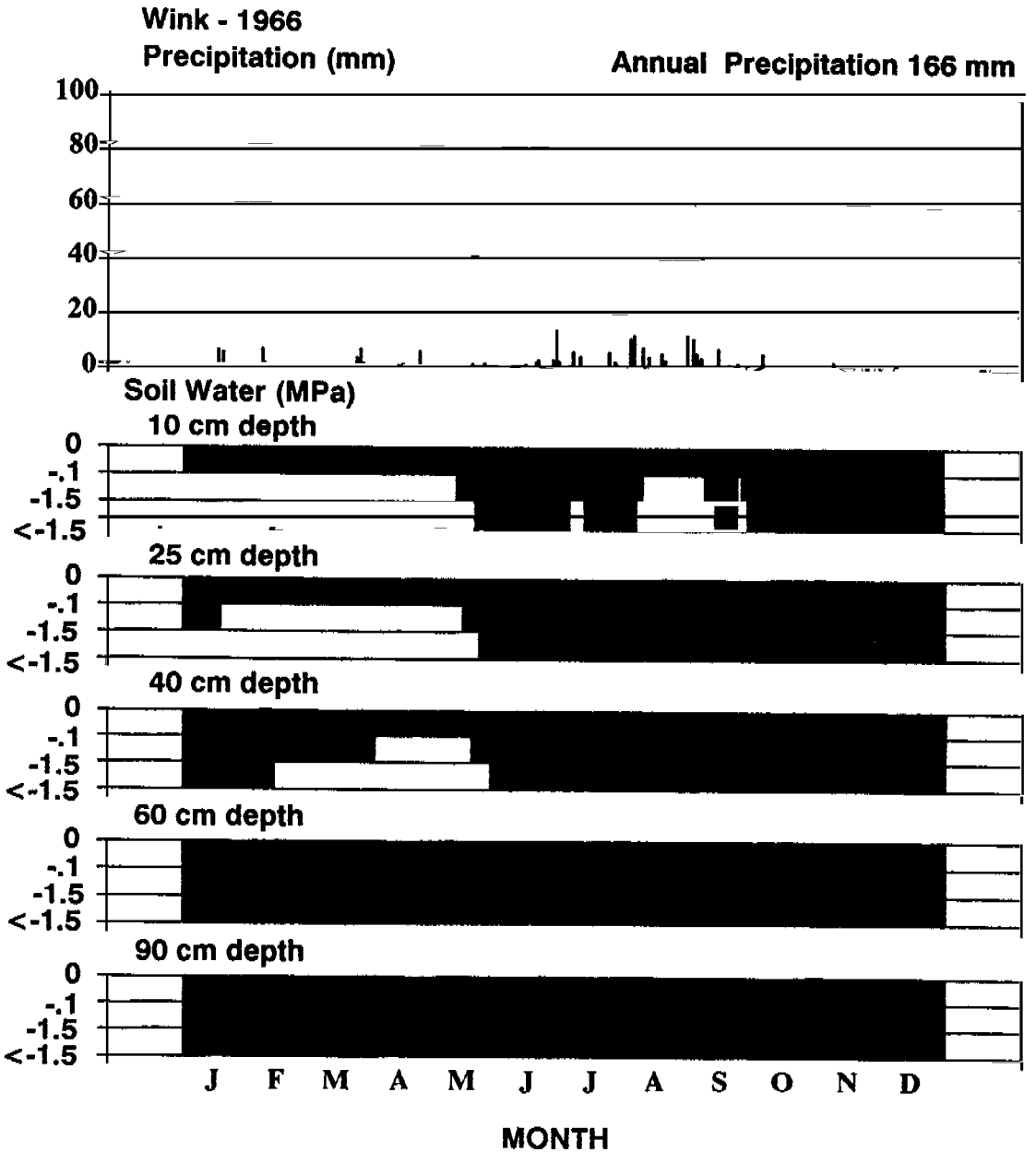


Figure 193. Annual precipitation (166 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1966.

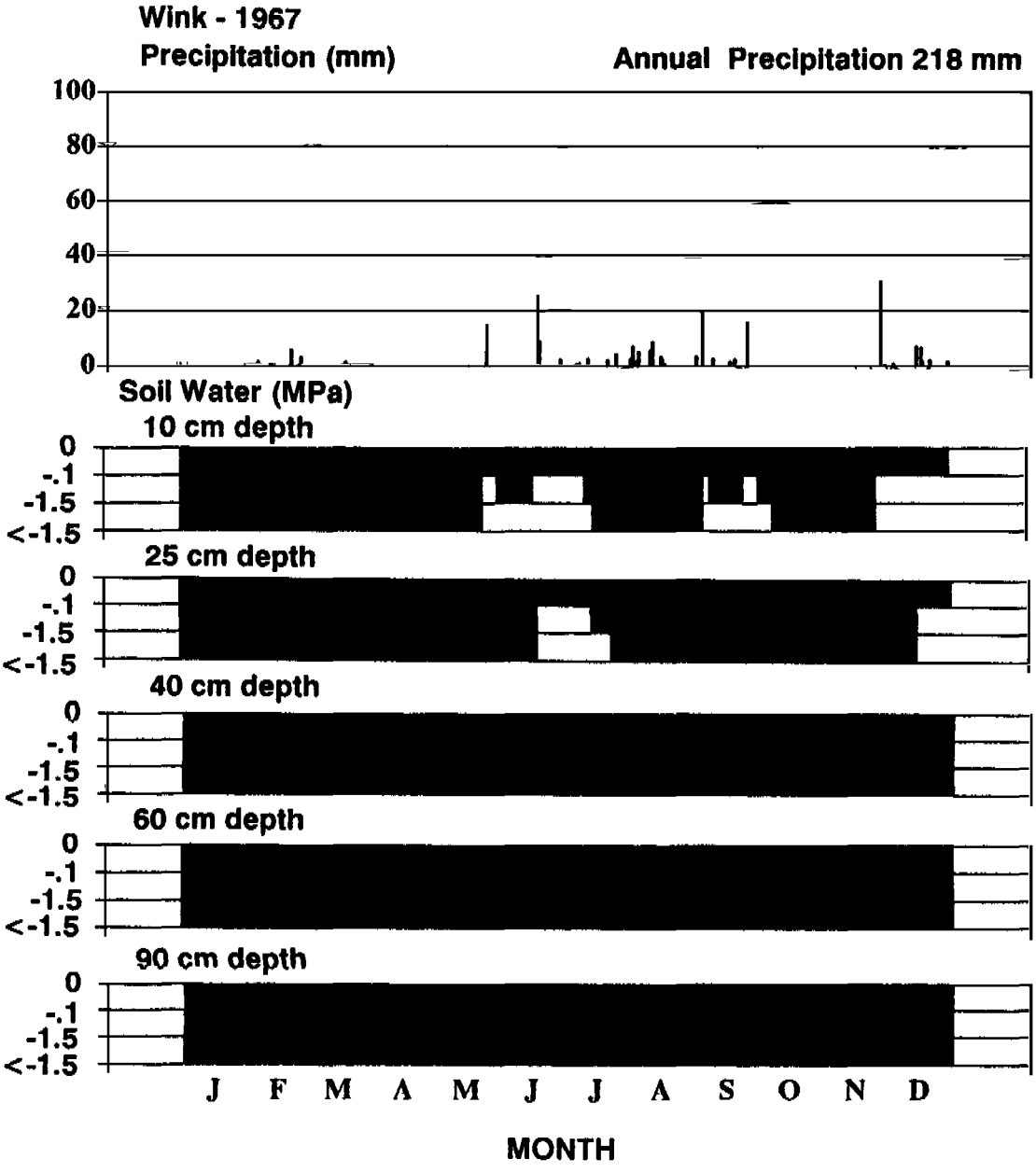


Figure 194. Annual precipitation (218 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1967.

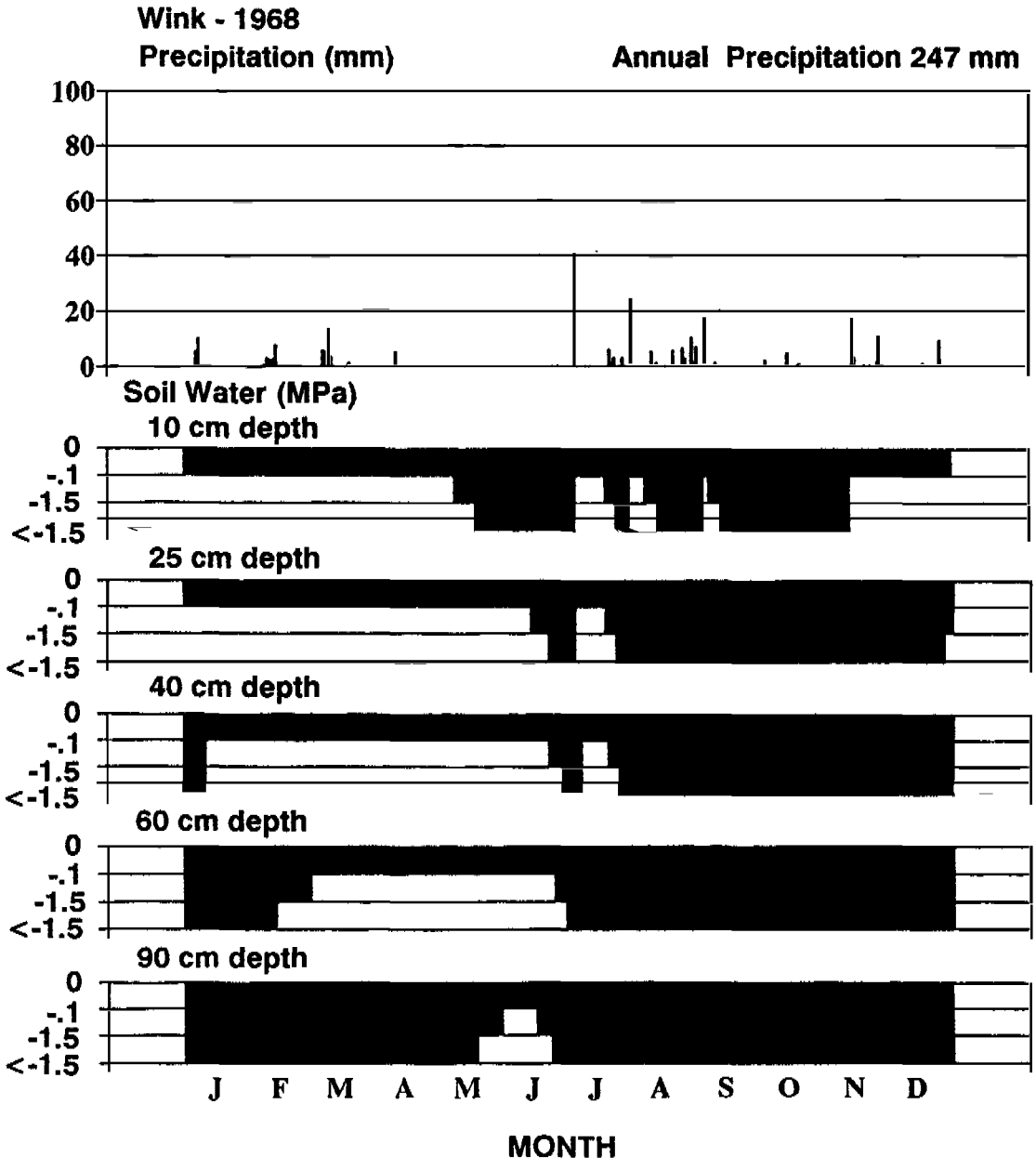


Figure 195. Annual precipitation (247 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1968.

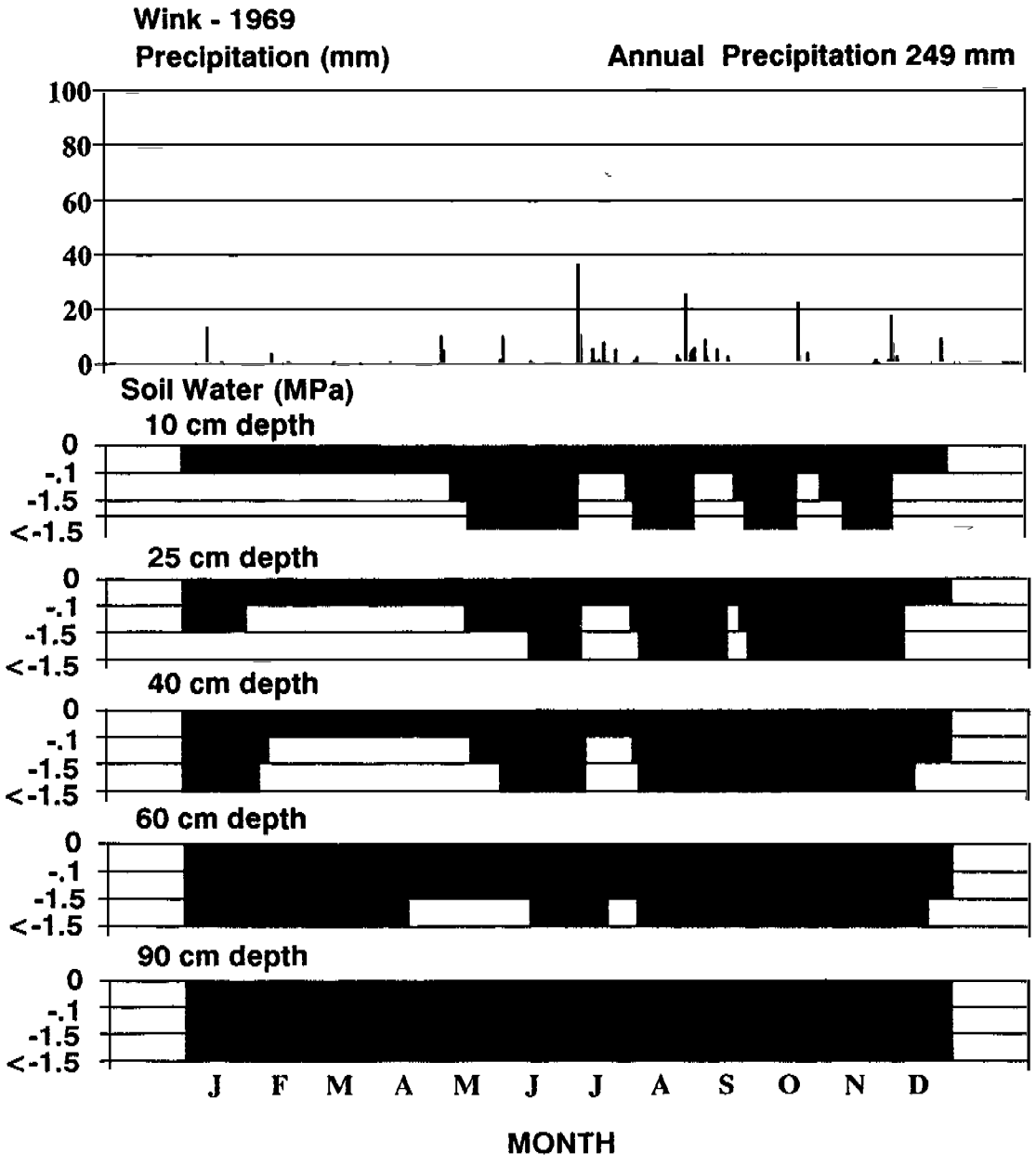


Figure 196. Annual precipitation (249 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1969.

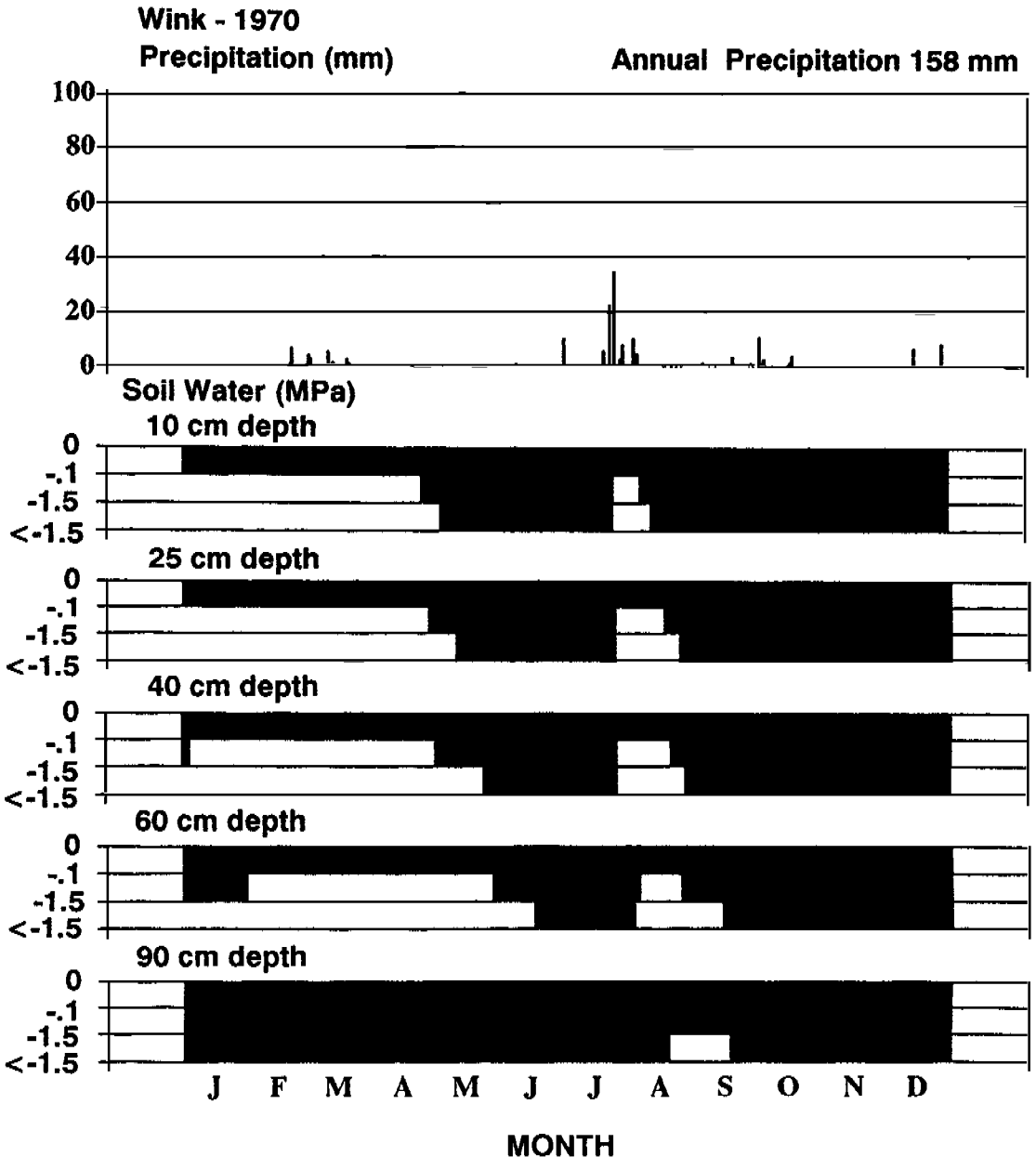


Figure 197. Annual precipitation (158 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1970.

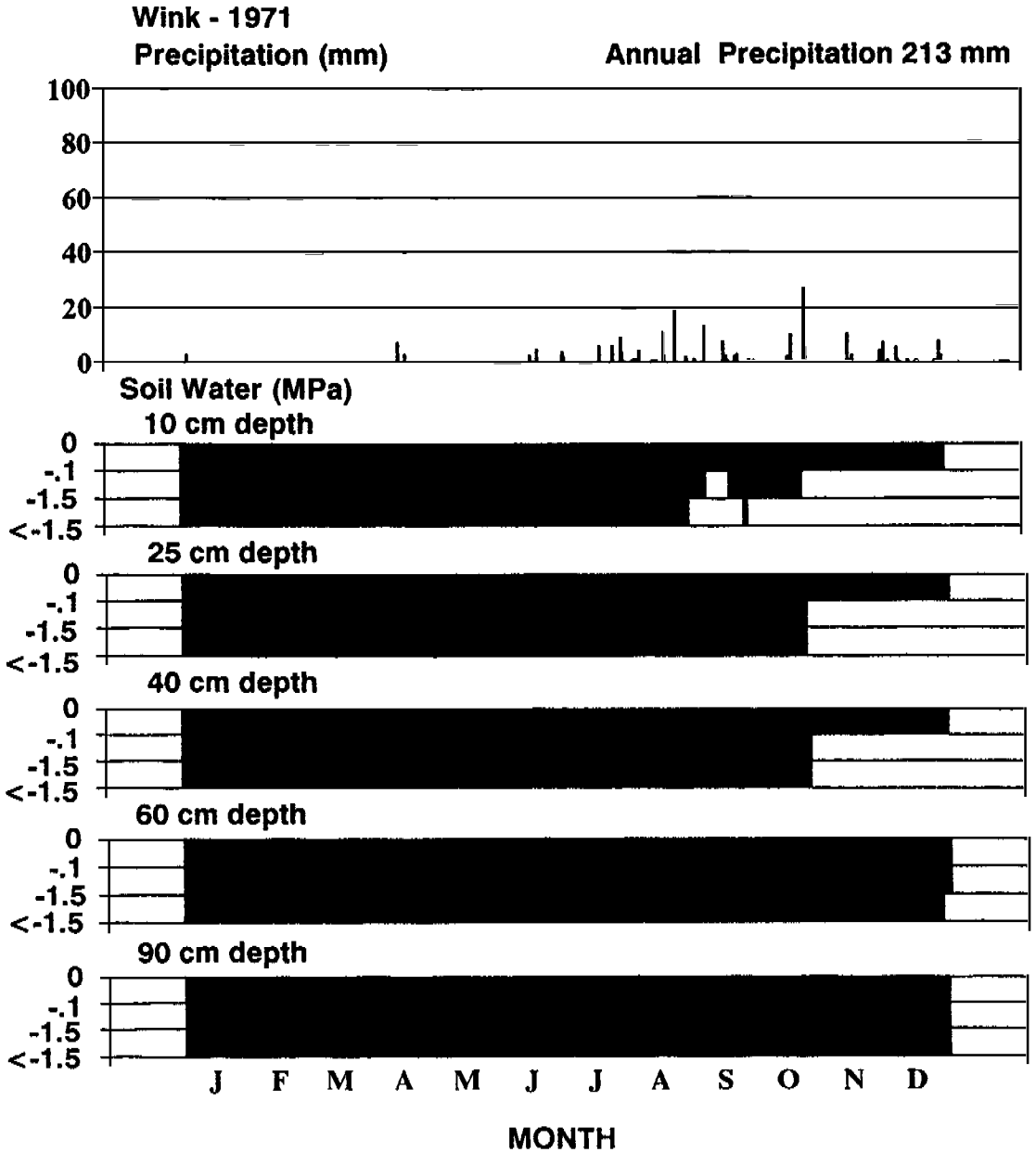


Figure 198. Annual precipitation (213 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1971.

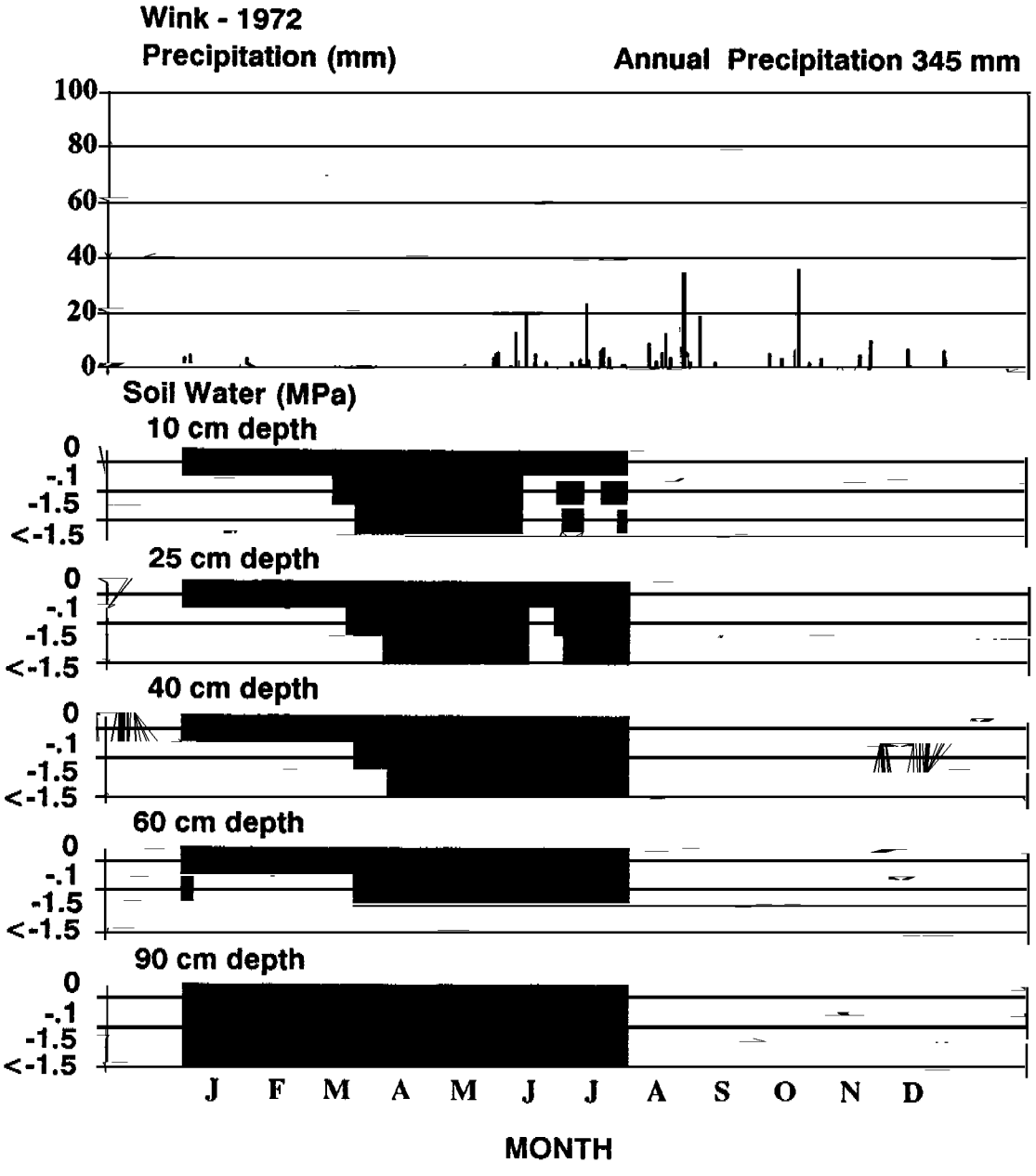


Figure 199. Annual (345 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm for January 1-August 1, 1972 at the Wink site.

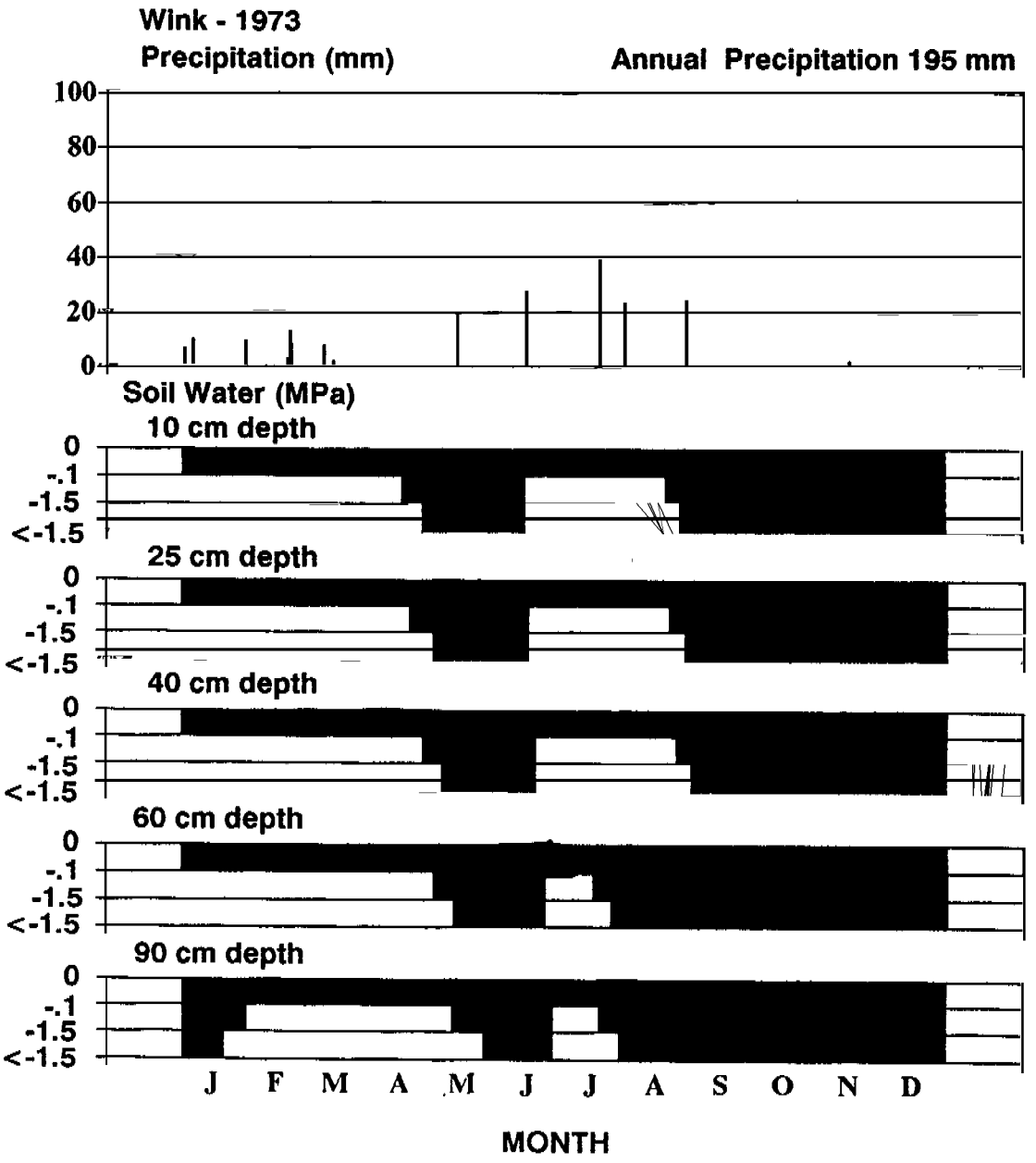


Figure 200. Annual precipitation (195 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Wink site for 1973.

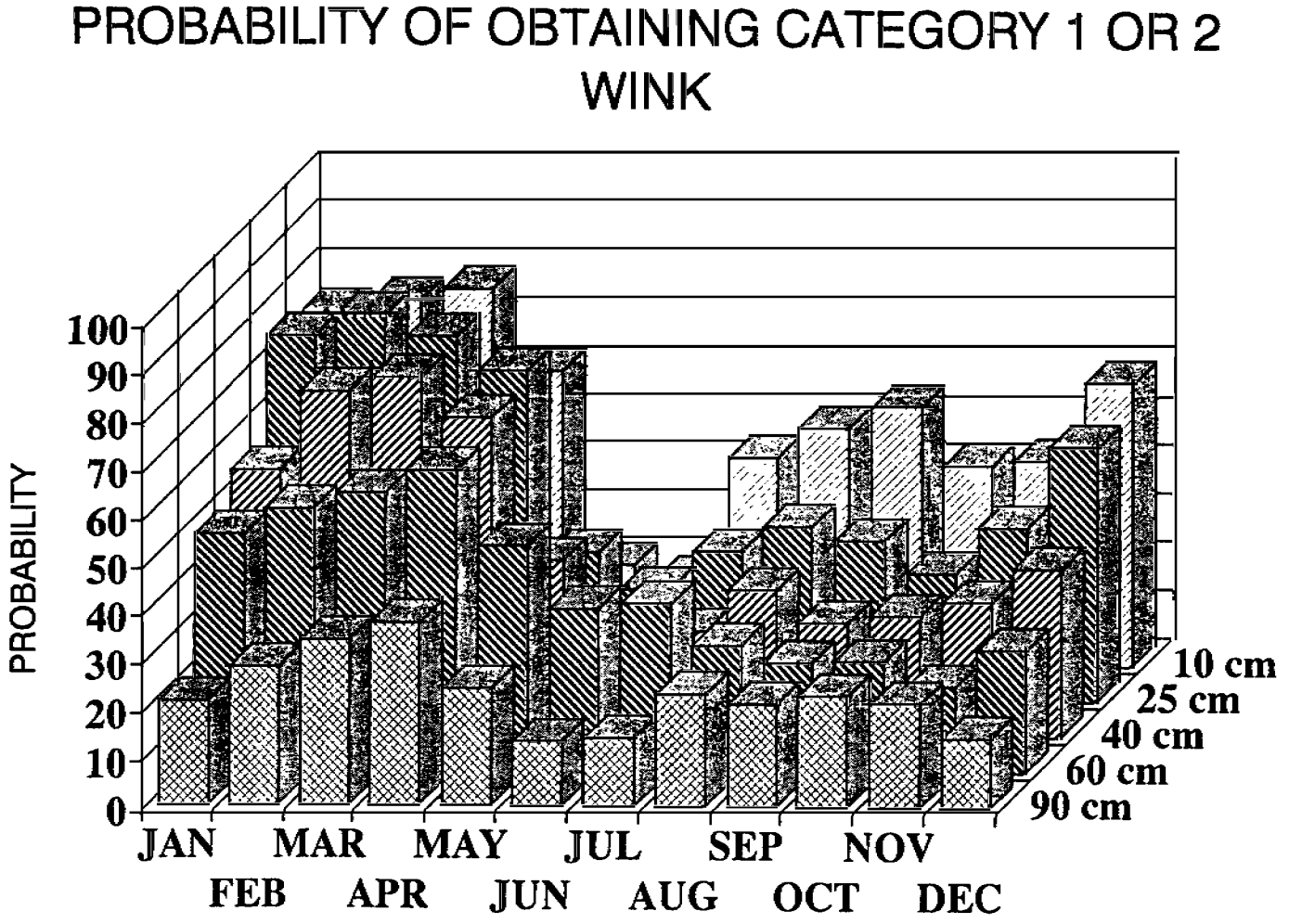


Figure 201. The probability (% days/month) of obtaining the matric potential of soil water >-1.5 MPa at depths of 10, 25, 40, 60, and 90 cm at the Wink site.

Site Turney (T)

Site T (figs. 4, 202, 203, table 9) is in the South Well exclosure on the Jornada Experimental Range. The sampled pedon is 2.8 m south of the recording rain gauge, 7 m east of the nonrecording rain gauge, and 2.2 m southwest of the wires to the soil water blocks. The perennial vegetation is mesquite, mesa dropseed, bush muhly (*Muhlenbergia porteri* Scribn. ex W. J. Beal), longleaf ephedra, broom snakeweed, tarbush, and soaptree yucca.

Soils. The soil water blocks are in the Typic Calciorthid Turney taxadjunct (fig. 203, table 9; Turney description and primary data). Diagnostic horizons are an ochric epipedon and a calcic horizon. Carbonate and organic carbon data (table 9) confirm the presence of these horizons. The site is on the Jornada-La Mesa surface. The area is level.

This pedon is of particular interest from the standpoint of classification because an argillic horizon occurs below the K horizon at a depth of 92-111 cm. The argillic horizon has reddish brown peds that are known from thin section studies to have enough oriented clay for an argillic horizon. Similar soils are Argic Calciorthids (Soil Survey Staff, 1975, p. 168). However, the Argic Calciorthids must have reddish peds that are weakly calcareous or noncalcareous; in this argillic horizon, all peds are either weakly or strongly calcareous (Turney description). For this reason the pedon is classified as a Typic Calciorthid instead of an Argic Calciorthid. Discontinuous cementation characteristic of Turney soils occurs in the K horizon (Turney description), and the soil is designated Turney taxadjunct.

Soil Water and Precipitation. The gypsum resistance blocks were installed at 10-, 25-, and 40-cm soil depths within a livestock exclosure at the South Well Rain Gauge on August 1, 1957; and at the 60- and 90-cm depths on July 29, 1959. The rain gauge at this location was established in 1918. The annual precipitation in 1957 was 320 mm (fig. 204). The matric potential of the soil water at 10 cm was >-1.5 MPa August 1-September 17 and October 5, 1957-May 11, 1958 (figs. 204, 205). The moisture control section, 25-cm depth, had soil water >-1.5 MPa August 5, 1957-September 17 and October 9, 1957-May 13, 1958. There was soil water >-1.5 MPa at 40 cm August 1-4; August 7-9; August 16-20; August 30-September 19; and October 10, 1957-May 21, 1958 (figs. 204, 205).

The 1958 precipitation was 380 mm (fig. 205). In addition to moist conditions in the winter-spring, the 25-cm depth had soil water >-1.5 MPa August 22-September 2 and September 13-November 17, 1958.

The annual precipitation for 1959 was 298 mm but 88% occurred in July and August (fig. 206). The winter-spring was very dry. The 25-cm depth had soil water >-1.5 MPa July 1-9 and July 19-September 5.

The 1960 precipitation was 201 mm (fig. 207). Soil water at the 60- and 90-cm depths remained <-1.5 MPa throughout the year. Soil water at 25 cm was >-1.5 MPa February 1-28, July 8-August 1, August 22-24, and December 13, 1960-May 11, 1961.

Figure 202. Landscape at Site T (fig. 4) and the Typic Calciorthid Turney taxadjunct, in the South Well exclosure at the Jornada Experimental Range. The recording rain gauge is at right. The San Andres Mountains are on the skyline at right. Photographed January 1990.

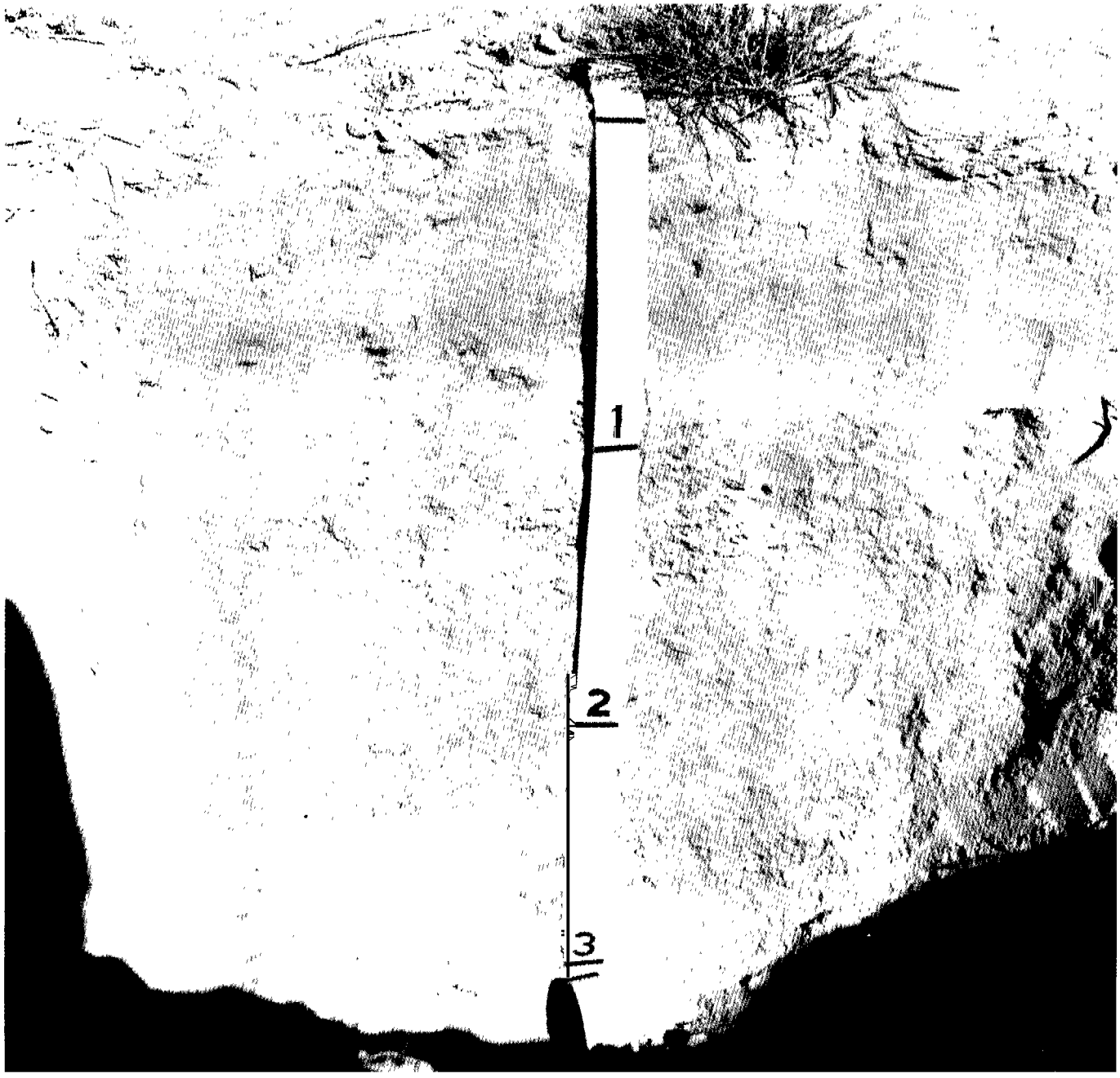


Figure 203. Profile of upper horizons of the Typic Calciorthid Turney taxadjunct. Scale is in feet.

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Turney taxadjunct
Classification: fine-loamy, mixed, thermic Typic Calciorthid
NSSL ID#: 90P0498
Soil Survey #: S90NM-013-007
Location: The SE1/4NW1/4SW1/4 section 28, T.21S., R.2E., in the South Well exclosure on the Jornada Experimental Range. The west side of the exclosure is on the east edge of the Jornada Road. The sampled pedon is 2.8 m south of the recording rain gauge, 7 m east of the nonrecording rain gauge, and 2.3 m southeast of the wires to the soil moisture blocks.
Elevation: 4310 ft, 1314 m
Landform: level basin floor
Geomorphic Surface: Jornada - La Mesa
Parent Material: sand of the Upper Camp Rice Formation
Vegetation: Mesquite, dropseed, bush muhly, Mormon tea, snakeweed, tarbush, soaptree yucca
Described By: L.H. Gile
Date: Feb 20, 1990

Soil surface: alternating areas of loose sand and smooth crust that is cracked into polygons about 5 to 10 cm in diameter.

A--0 to 5 cm; pinkish gray to pink (7.5YR 7/3) loamy sand; brown (7.5YR 5/3) moist; weak medium and coarse platy structure and soft, with some plates separated by soft fine granules or loose, single-grain material; few fine roots; 90P2770; strongly effervescent; abrupt smooth boundary.

C--5 to 19 cm; light reddish brown (6YR 6/3.5) loamy sand; reddish brown (6YR 4.5/3.5) moist; massive; soft, very friable; few fine roots; 90P2771; abrupt smooth boundary.

Bk1b--19 to 34 cm; pinkish gray (7.5YR 6/2.5) fine sandy loam; brown (7.5YR 4.5/3) moist; weak medium and coarse subangular blocky structure; hard, friable; few carbonate filaments; few fine roots; 90P2772; strongly effervescent; clear wavy boundary.

Bk2b--34 to 46 cm; pinkish gray to light brown (7YR 6/3) sandy clay loam; brown to dark brown (7YR 4.5/3) moist; weak medium subangular blocky structure; slightly hard and hard, friable; few fine roots, 90P2773; strongly effervescent; clear wavy boundary.

Bk3b--46 to 57 cm; light reddish brown (6YR 6/3) sandy clay loam; reddish brown (6YR 4.5/3) moist; weak medium subangular blocky structure; slightly hard and hard, friable; few fine roots; 90P2774; clear wavy boundary.

Bk4b--57 to 67 cm; light reddish brown (6YR 6/3) sandy clay loam; reddish brown (6YR 4.5/3) moist; dominantly moderate fine and medium subangular blocky structure, with soft, massive parts between some blocks; slightly hard and hard, friable; few fine roots; 90P2775; common insect burrows, ranging from about 2 mm to 1 cm in diameter, some empty and some partly or completely filled with fine earth; strongly effervescent; clear wavy boundary.

K21b--67 to 77 cm; pinkish white (7.5YR 8/2) clay loam; pink (7.5YR 7/4) moist; lesser amount of pink (7.5YR 7/4); dominantly moderate medium subangular blocky, with some soft, massive parts between the blocks; hard and very hard, friable; very few fine roots; 90P2776; common insect burrows, ranging from about 2 mm to 1 cm in diameter, some empty and some partly or completely filled with fine earth; strongly effervescent; clear wavy boundary.

K22b--77 to 92 cm; pink (7.5YR 7/4) clay loam; light brown (7.5YR 6/4) moist; lesser amount of pinkish white (7.5YR 8/2); moderate medium subangular blocky structure; very hard, friable; very few fine roots, 90P2777; strongly effervescent; clear wavy boundary.

Btkb--92 to 111 cm; light reddish brown (5YR 6/4), reddish brown (5YR 5/4) moist; clay loam; lesser amount reddish brown (5YR 5/4) dry and pinkish gray to pink (8.5YR 7/3), dry, moderate medium subangular blocky; very hard; 90P2778; weakly and strongly effervescent; abrupt wavy boundary.

K2b--111 to 115 cm; pinkish white to pink (7.5YR 8/3) carbonate-cemented material; pink (7.5YR 7/4) moist; with lesser amount white (7.5YR 9/2) moist; parts can be removed with the spade; breaks out as coarse blocks; extremely hard; extremely firm; very few roots; strongly effervescent.

S90NM-013-007

*** PRIMARY CHARACTERIZATION DATA ***

PRINT DATE 11/29/91

Soil series: Turney taxadjunct, fine-loamy, mixed, thermic Typic Calciorthid

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 498, SAMPLES 90P2770-2781
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
				(- - -TOTAL - - -)			(- -CLAY- -)		(- -SILT- -)			(- - - - -SAND- - - - -)				(-COARSE FRACTIONS(MM)-)				(>2MM)
				CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC	- - - - WEIGHT - - - -				WT
SAMPLE NO.	DEPTH (CM)	HORIZON		LT .002	.002 -.05	.05 -2	LT .0002	LT .002	.002 -.02	.02 -.05	.05 -.10	.10 -.25	.25 -.50	.5 -1	1 -2	2 -5	5 -20	20 -75	.1- 75	PCT OF WHOLE SOIL
				<- - - - - - - - - - - - PCT OF <2MM						(3A1)		- - - - - - - - - - - - ->				<- PCT OF <75MM(3B1)->				
90P2770S	0- 5	A		8.1	8.6	83.3		2.1	3.8	4.8	17.0	33.9	29.6	6.6	0.2	--	--	--	66	--
90P2771S	5- 19	C		7.5	7.3	85.2		1.2	3.2	4.1	19.6	38.3	23.5	3.7	0.1	TR	TR	--	66	TR
90P2772S	19- 34	BK1B		15.5	15.1	69.4		4.0	8.8	7.1	14.5	26.7	20.8	7.2	0.2	--	--	--	55	--
90P2773S	34- 46	BK2B		19.0	15.8	65.2		4.6	8.5	7.3	11.3	20.7	21.3	11.2	0.7	1	TR	--	54	1
90P2774S	46- 57	BK3B		20.7	17.7	61.6		4.9	9.5	8.2	11.1	19.1	19.5	10.5	1.4	1	1	--	51	2
90P2775S	57- 67	BK4B		27.9	19.8	53.1		8.9	11.8	7.2	11.3	15.1	16.7	8.9	1.1	1	--	--	42	1
90P2776S	67- 77	K21B		32.9	26.9	40.2		16.2	20.0	6.9	8.7	12.5	12.2	6.2	0.6	TR	TR	--	31	--
90P2777S	77- 92	K22B		33.0	30.4	36.6		16.5	23.4	7.0	8.5	12.4	11.2	4.1	0.4	TR	--	--	28	TR
90P2778S	92-111	BTKB		29.7	27.1	43.2		11.6	17.8	9.3	11.0	13.7	11.3	5.1	2.1	2	1	--	34	3
																--	--	--		--
																--	--	--		--
																--	--	--		--

	ORGN	TOTAL	EXTR	TOTAL	(- - DITH-CIT - -)			(RATIO/CLAY)		(ATTERBERG)		(- BULK DENSITY -)			COLE	(- - -WATER CONTENT - - -)				WRD
	C	N	P	S	EXTRACTABLE				15	- LIMITS -		FIELD	1/3	OVEN	WHOLE	FIELD	1/10	1/3	15	WHOLE
DEPTH (CM)	6A1c	6B3a	6S3	6R3a	FE 6C2b	AL 6G7a	MN 6D2a	CEC 8D1	BAR 8D1	LL 4F1	PI 4F	MOIST 4A3a	BAR 4A1d	DRY 4A1h	SOIL 4D1	MOIST 4B4	BAR 4B1c	BAR 4B1c	BAR 4B2a	SOIL 4C1
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM -->				PCT	<0.4MM	<- - G/CC - - ->			CM/CM	<- - -PCT OF <2MM - ->				CM/CM
0- 5	0.18							0.78	0.44										3.6	
5- 19	0.19							0.85	0.47				1.58	1.60	0.004			6.5	3.9	0.05
19- 34	0.38							0.67	0.42				1.54	1.61	0.015			10.2	6.5	0.06
34- 46	0.32							0.51	0.37				1.48	1.57	0.020			10.7	7.1	0.05
46- 57	0.26							0.48	0.34				1.54	1.64	0.021			8.7	7.1	0.02
57- 67	0.33							0.41	0.32				1.42	1.52	0.023			15.6	8.8	0.10
67- 77	0.30							0.31	0.26				1.40	1.51	0.026			18.0	8.6	0.13
77- 92	0.20							0.27	0.26				1.68	1.83	0.029			15.8	8.5	0.12
92-111	0.14							0.34	0.28				1.76	1.89	0.024			13.2	8.4	0.08

	(- NH4OAC EXTRACTABLE BASES -)				ACID-	(- -CEC- -)		EXCH	SAR	BASE		CO3 AS	RES.	CASO4 AS		(- - - -PH - - - -)		
	CA	MG	NA	K	SUM	ITY	SUM	NH4-	NA		SATURATION	CACO3	OHMS	GYPSUM		SAT	CACL2	H2O
DEPTH (CM)	5B5a 6N2e	5B5a 6O2d	5B5a 6P2b	5B5a 6Q2b	BASES	6H5a	CATS 5A3a	OAC 5A8b	5B5b	5E	SUM NH4OAC 5C3 5G1	<2MM 6E1g	/CM 8E1	<2MM 6F1a	<20MM 6F4	PASTE 8G1b	.01M 8G1f	8G1f
	<- - - - - - - - - -MEQ / 100 G - - - - - - - - - ->								PCT		<- -PCT- >	PCT		<- -PCT ->			1:2	1:1
0- 5		1.0	TR	0.7				6.3	1		100 100	3					7.8	8.3
5- 19		1.2	TR	1.2				6.4	1		100 100	3					7.9	8.5
19- 34		1.7	0.1	1.1				10.4	1		100 100	6					7.9	8.4
34- 46		1.8	0.2	0.6				9.7	2		100 100	11					7.8	8.5
46- 57		2.6	0.2	0.8				9.9	2		100 100	12					7.8	8.1
57- 67		2.9	0.3	0.7				11.5	2	TR	100 100	18				7.7	7.8	8.1
67- 77		3.2	0.2	0.6				10.1	2	TR	100 100	34				7.7	7.8	8.2
77- 92		3.8	0.3	0.6				9.0	2	1	100 100	38		--		7.7	7.8	8.2
92-111		4.8	0.4	0.7				10.0	3	1	100 100	31	1300	--		7.7	7.8	7.9

	(- - - - - - - -WATER EXTRACTED FROM SATURATED PASTE- - - - - - - - - -)											
	CA	MG	NA	K	CO3	HCO3	CL	SO4	NO3	H2O	TOTAL SALTS EST.	ELEC. COND.
DEPTH (CM)	6N1b	6O1b	6P1b	6Q1b	6I1b	6J1b	6K1c	6L1c	6N1c	8A	8D5	8A3a MMHOS /CM
	< - - - - - - - - - - -MEQ / LITER - - - - - - - - - - - >									<- -PCT ->		
0- 5												0.16
5- 19												0.16
19- 34												0.19
34- 46												0.21
46- 57												0.22
57- 67	5.8	1.2	0.6	0.2	--	1.7	1.7	3.5	0.1	43.4	TR	0.78
67- 77	7.1	2.0	1.0	0.3	--	1.6	1.9	4.9	1.3	44.6	TR	1.08
77- 92	11.0	4.0	1.9	0.4	--	1.2	3.2	7.3	3.4	45.0	TR	1.67
92-111	12.3	6.1	3.6	0.5	--	1.0	6.3	5.4	10.0	45.9	0.1	2.30

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 1, 2, 3, 4, 5,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

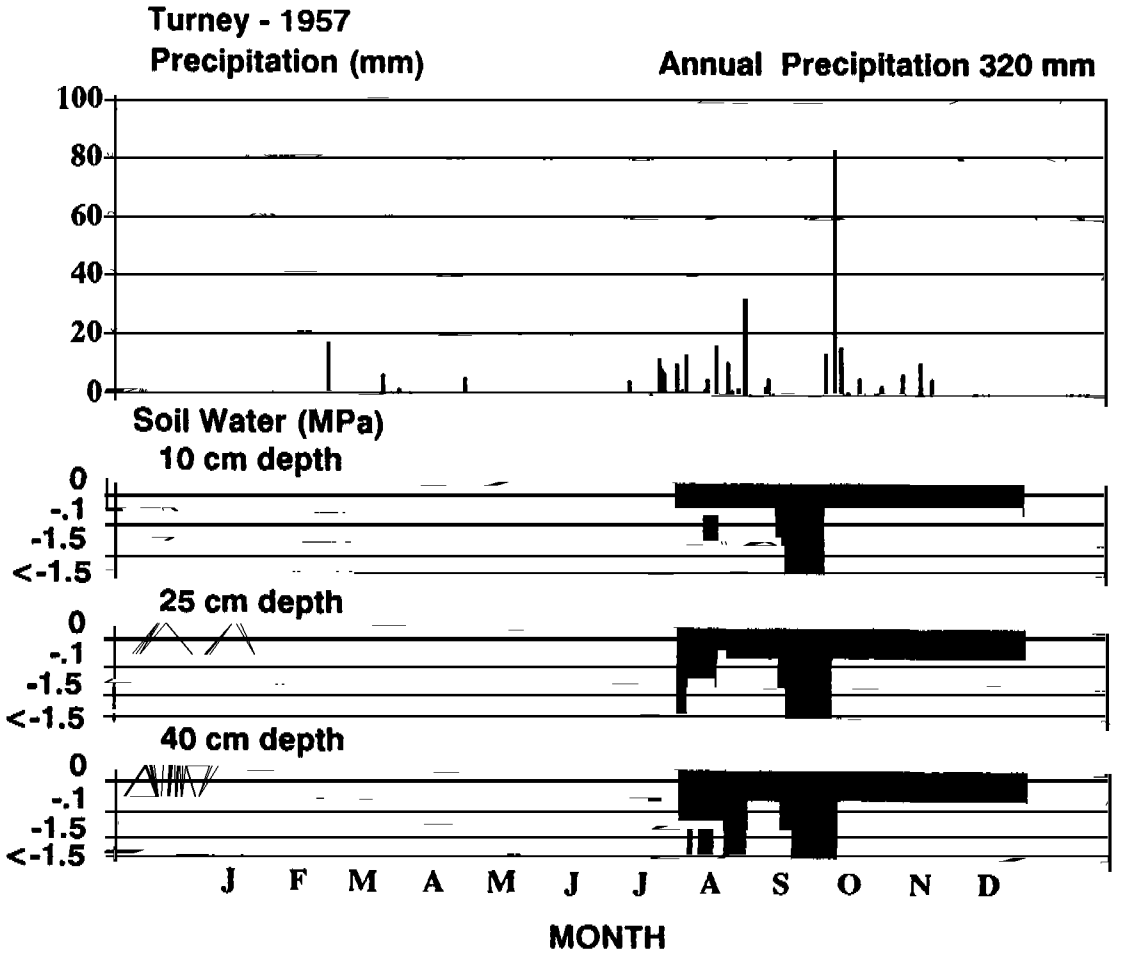


Figure 204. Annual (320 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 1-December 31, 1957 at the Turney site.

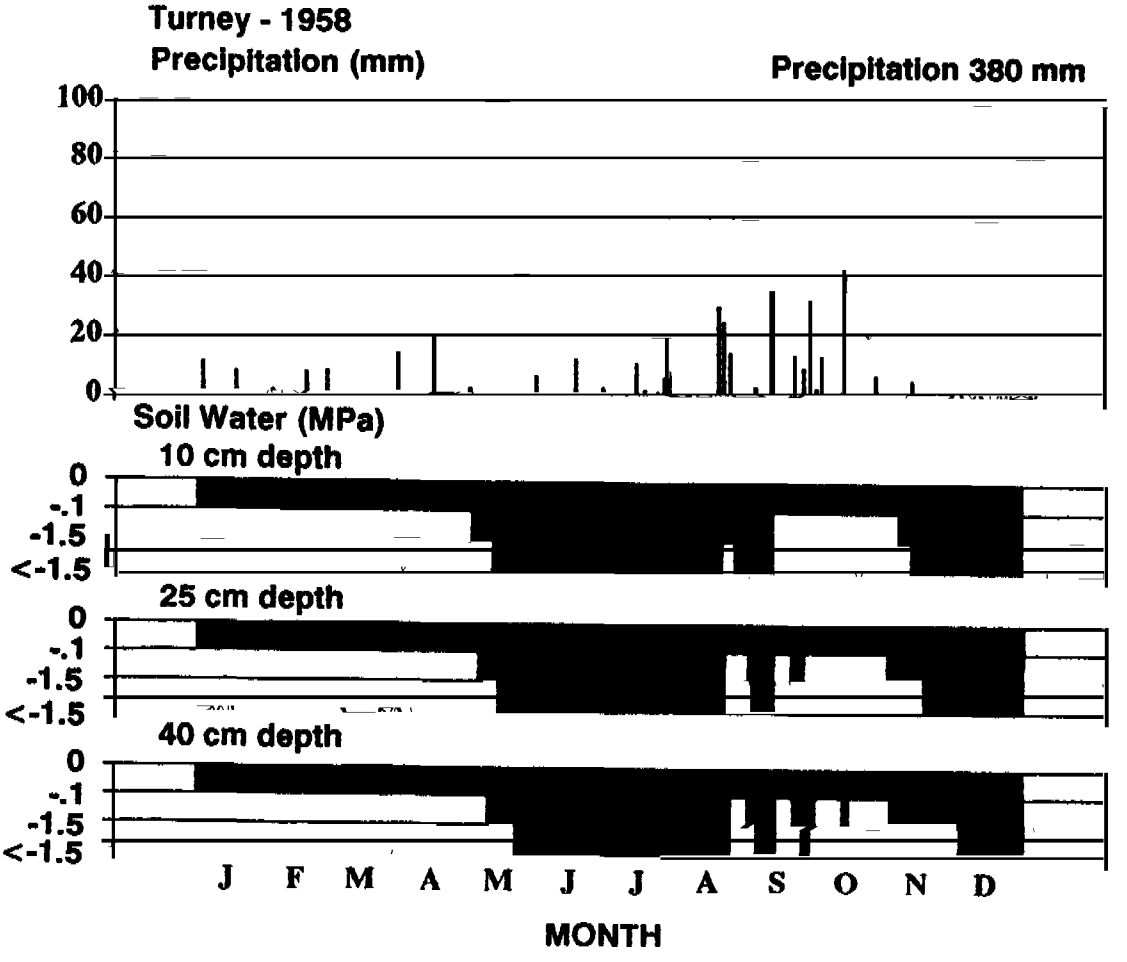


Figure 205. Annual precipitation (380 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Turney site for 1958.

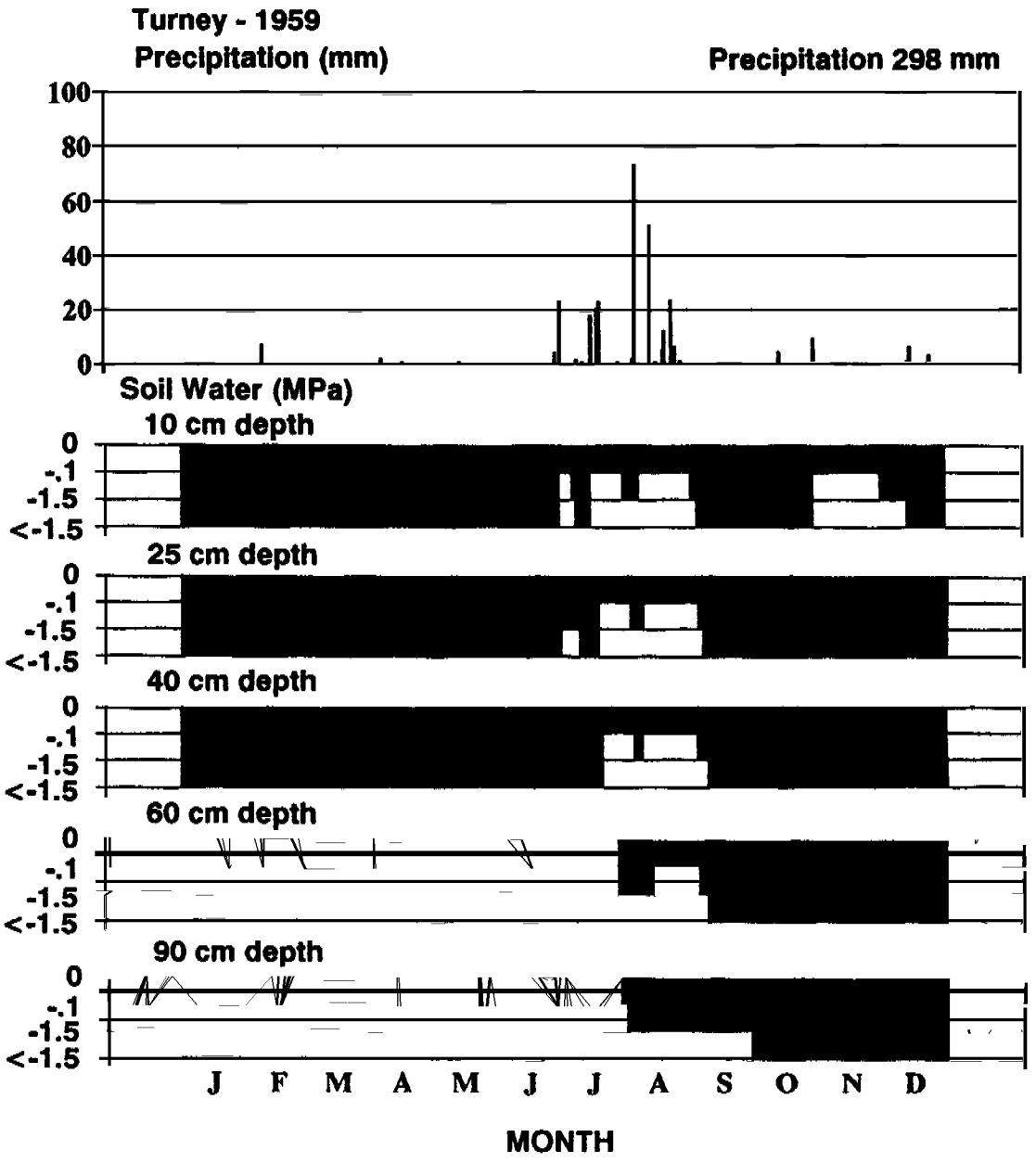


Figure 206. Annual precipitation (298 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Turney site for 1959. Also shown is the soil water at depths of 60 and 90 cm July 29-December 31, 1959.

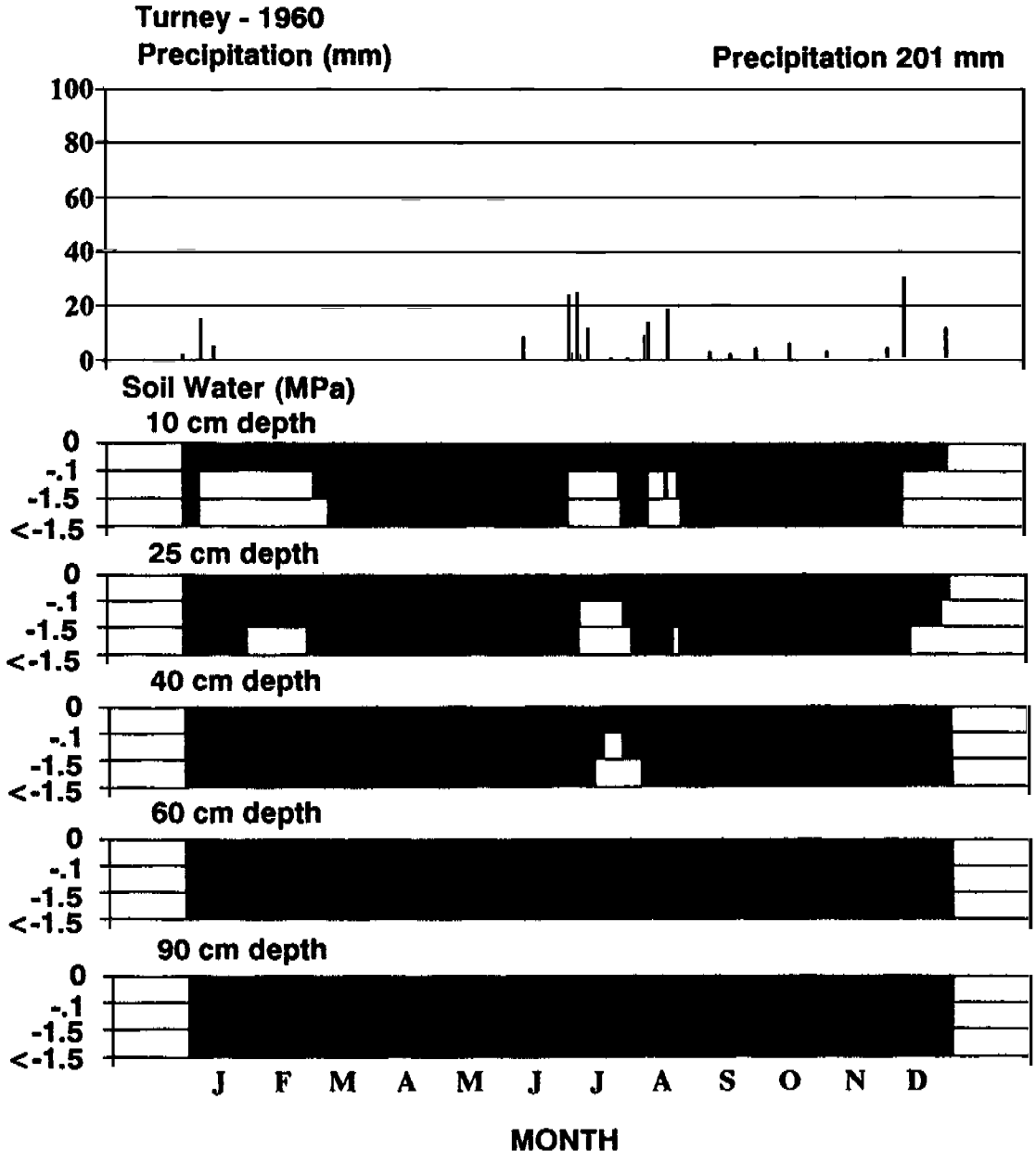


Figure 207. Annual precipitation (201 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1960.

Precipitation for 1961 and 1962 was above average. Besides the wet conditions early in 1961, the soil water at 25 cm was >-1.5 MPa July 11-23 (fig. 208); August 17-September 4; September 7-30; November 13, 1961-May 15, 1962 (figs. 208, 209); July 21-August 7; September 27-October 28; and December 30, 1962-April 14 1963 (figs. 209, 210).

Annual precipitation for the next four years, 1963-66, was below average. Besides the soil water mentioned in the preceding paragraph, the 25-cm depth had water >-1.5 MPa September 3-27, 1963 (fig. 210); October 21-November 8, 1963; July 15, 1964-August 3 (fig. 211); August 17-25; September 13-29, 1964; January 10, 1965-May 5 (fig. 212); September 11-24, 1965; January 25, 1966-March 21 (fig. 213); April 26-May 2; and September 10-26, 1966. Water at 60 and 90 cm was <-1.5 MPa 1964-67 (figs. 211-214).

Precipitation for 1967-68 was above average, while the 1969 precipitation was below average for 1957-76 for this location. The 25-cm soil depth had water >-1.5 MPa June 30-July 19, 1967 (fig. 214); September 25-October 11; December 7, 1967-May 15, 1968 (figs. 214, 215); July 26-August 15; December 29, 1968-April 8, 1969 (figs. 215, 216); July 10-29; and October 24, 1969-April 30, 1970 (figs. 216, 217).

Precipitation for 1970 and 1971 was 203 and 244 mm, respectively (figs. 217, 218). Besides the soil water >-1.5 MPa in the winter and early spring, the other soil water >-1.5 MPa at 25 cm occurred July 26-August 29, 1970; October 3-31, 1970 (fig. 217); June 22-29, 1971 (fig. 218); July 29-August 8; October 26-November 21; and November 25, 1971-April 6, 1972 (figs. 218, 219).

Annual precipitation was above average 1972-76 except for 1973. However, no soil water data were obtained August 1-December 31, 1972 because the ohmmeter was inoperative. The matric potential of the soil water was measured at >-1.5 MPa at 25 cm June 13-July 1, 1972 (fig. 219); January 3-June 7, 1973 (fig. 220); June 16-August 23, 1973; January 14-February 19, 1974 (fig. 221); July 15-August 10; September 23, 1974-April 20, 1975 (figs. 221, 222); July 21-26; September 8-October 8, 1975; June 9-22, 1976 (fig. 223); and September 7-20, 1976.

Annual precipitation for 1957-76 was below average nine years and above average 11 years. The probability of the matric potential of the water >-1.5 MPa at the 25-cm soil depth was 54.2% for December-April, 13.3% for May-June; 33.5% for July-September, and 29.9% for October-November (fig. 224).

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, 13 of 20 years had soil water <-1.5 MPa more than half the time at 10 cm; 14 of 20 years at 25 and 40 cm; and 16 of 18 years at soil depths of 60 and 90 cm. Ten of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 9 of 20 years at 25 cm; 11 of 20 years at 40 cm; 11 of 18 years at 60 cm; and 12 of 18 years at a soil depth of 90 cm.

For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 11 of 18 years and >30 consecutive days in

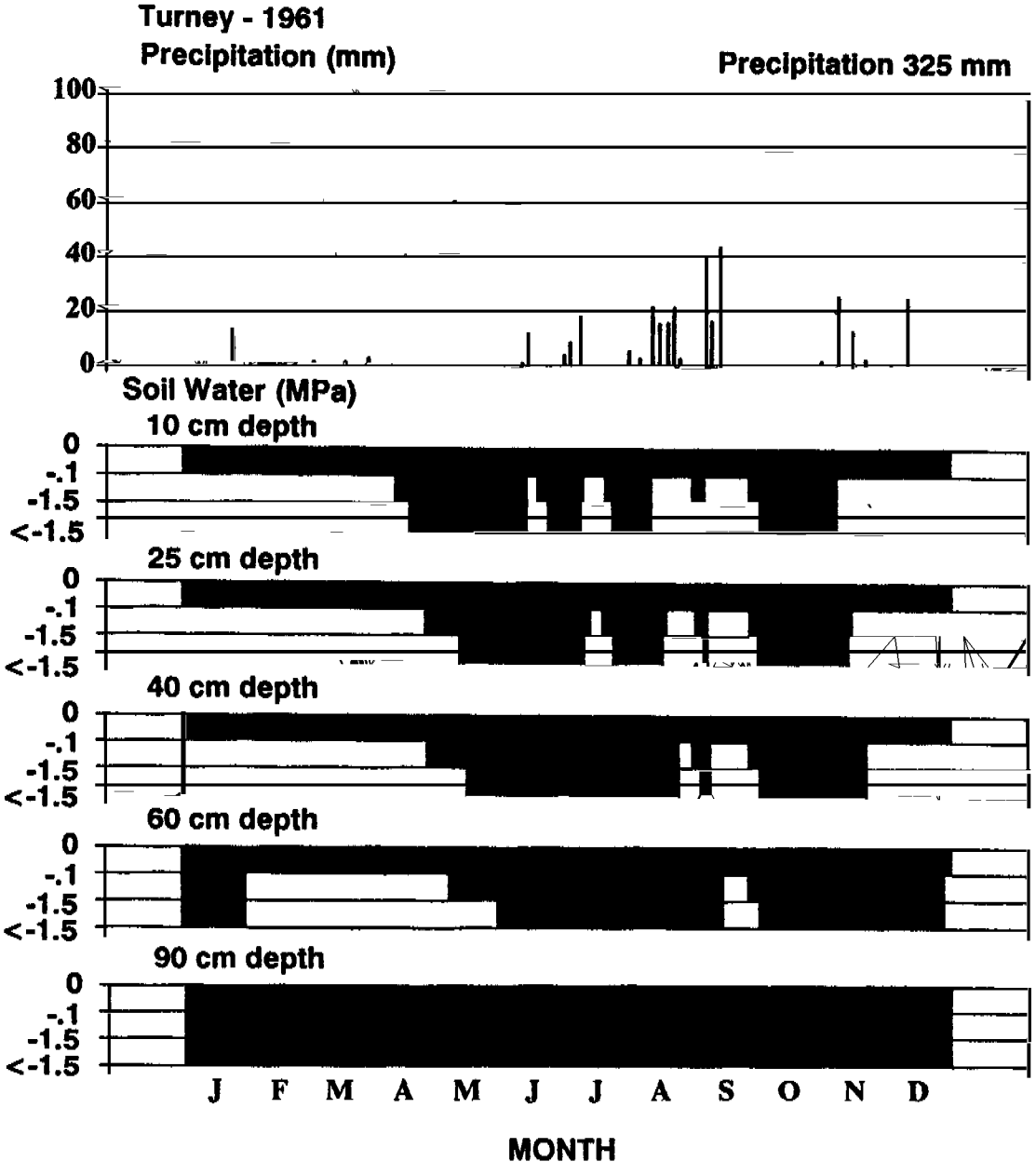


Figure 208. Annual precipitation (325 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1961.

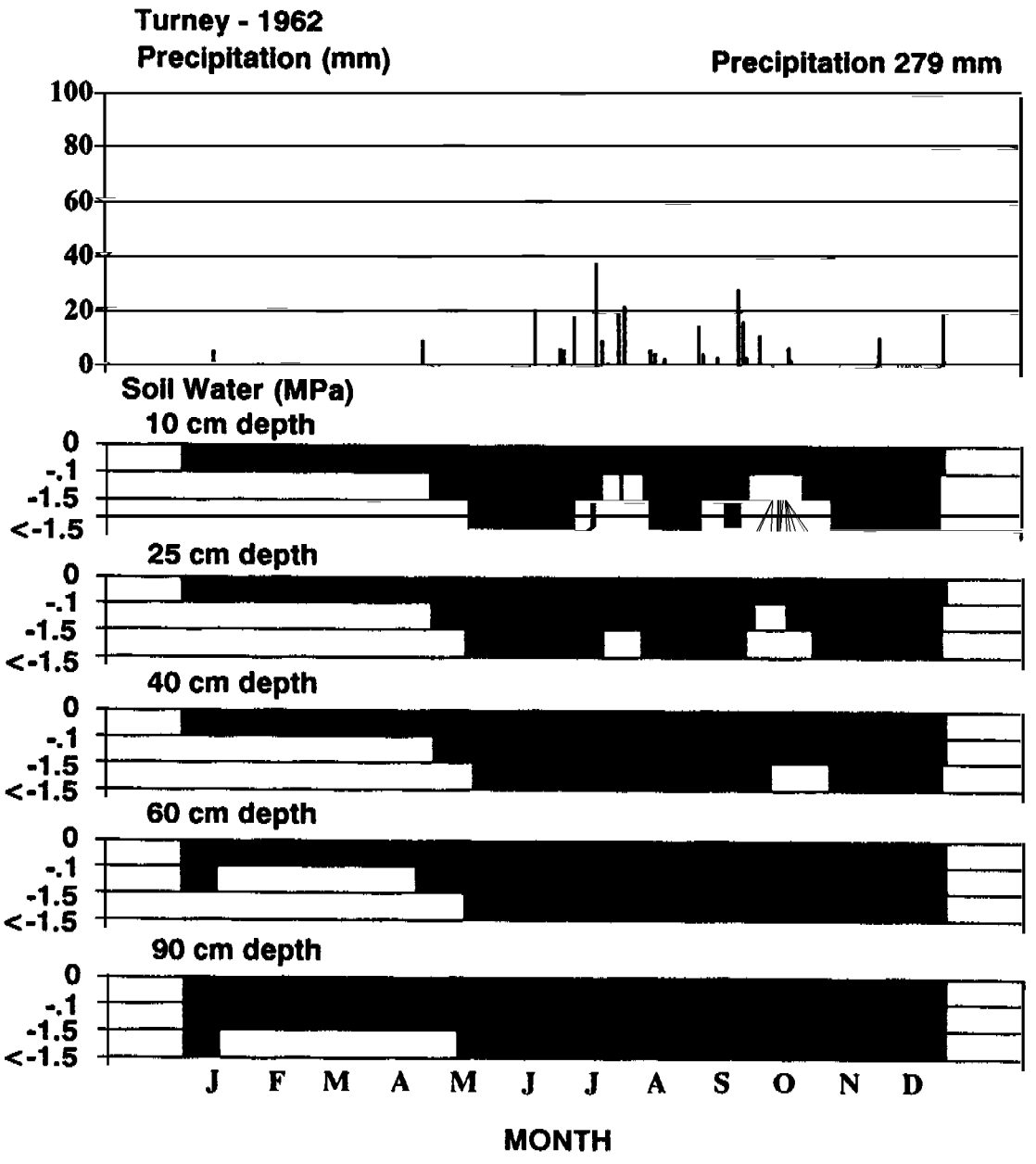


Figure 209. Annual precipitation (279 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1962.

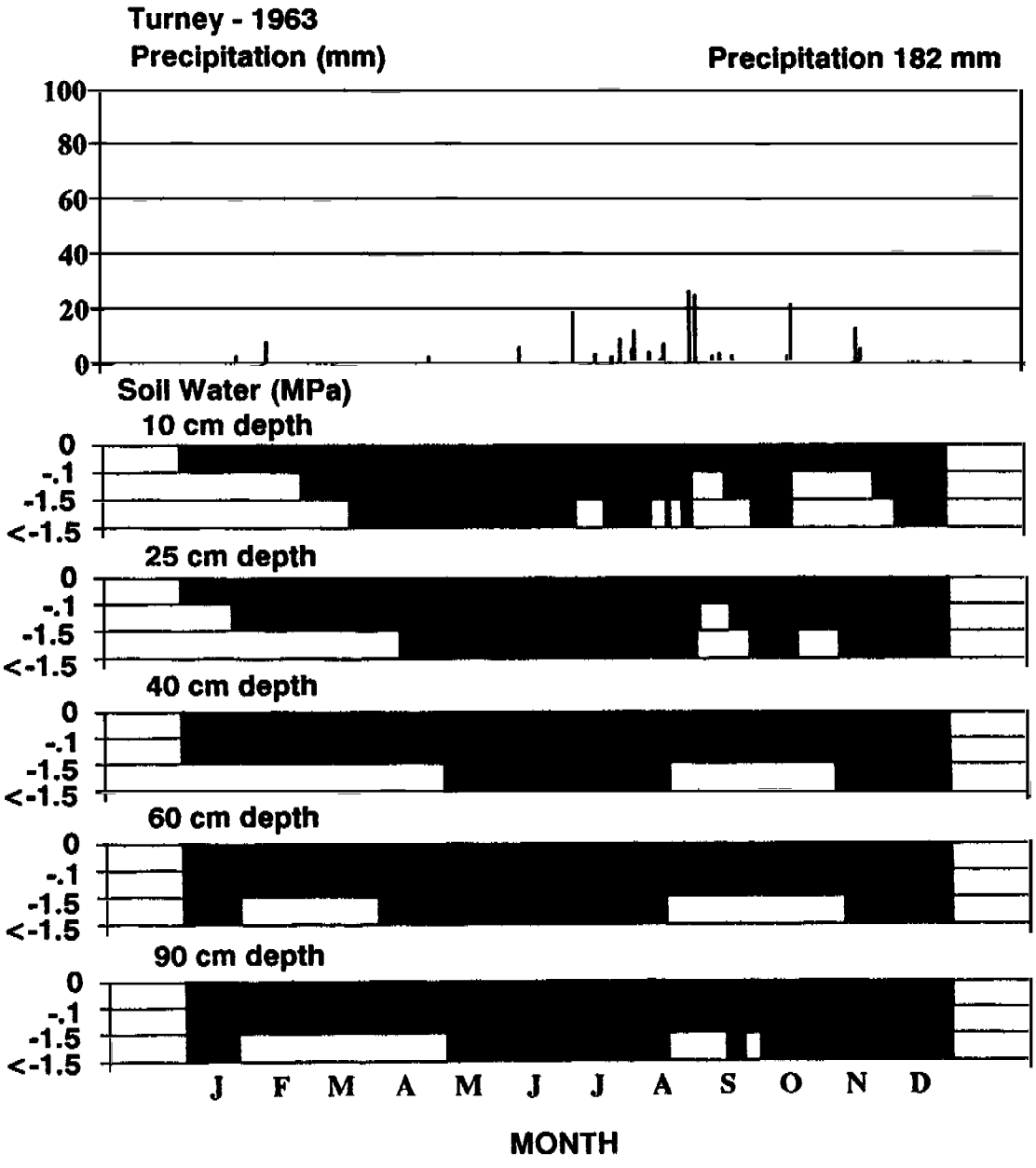


Figure 210. Annual precipitation (182 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1963.

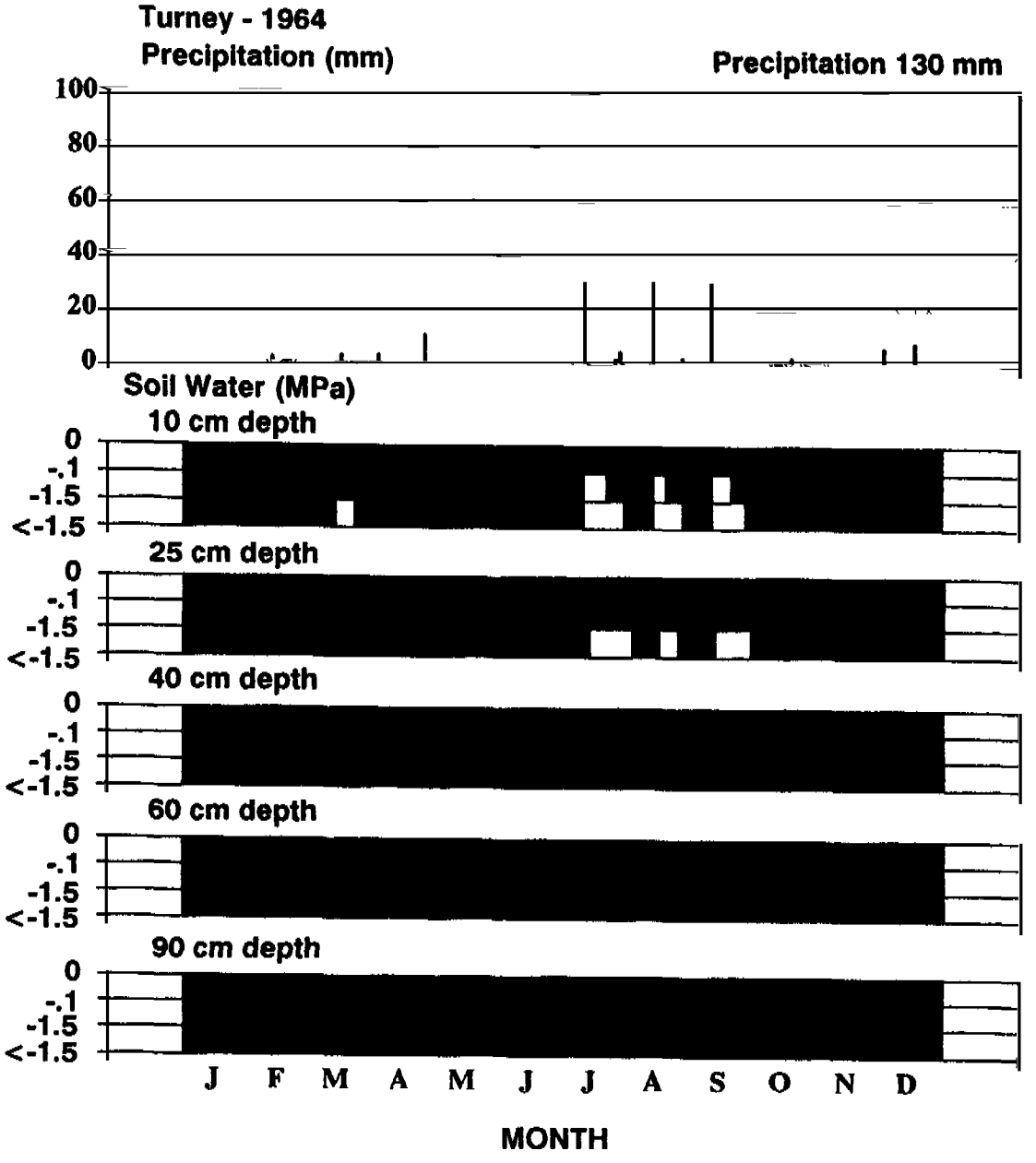


Figure 211. Annual precipitation (130 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1964.

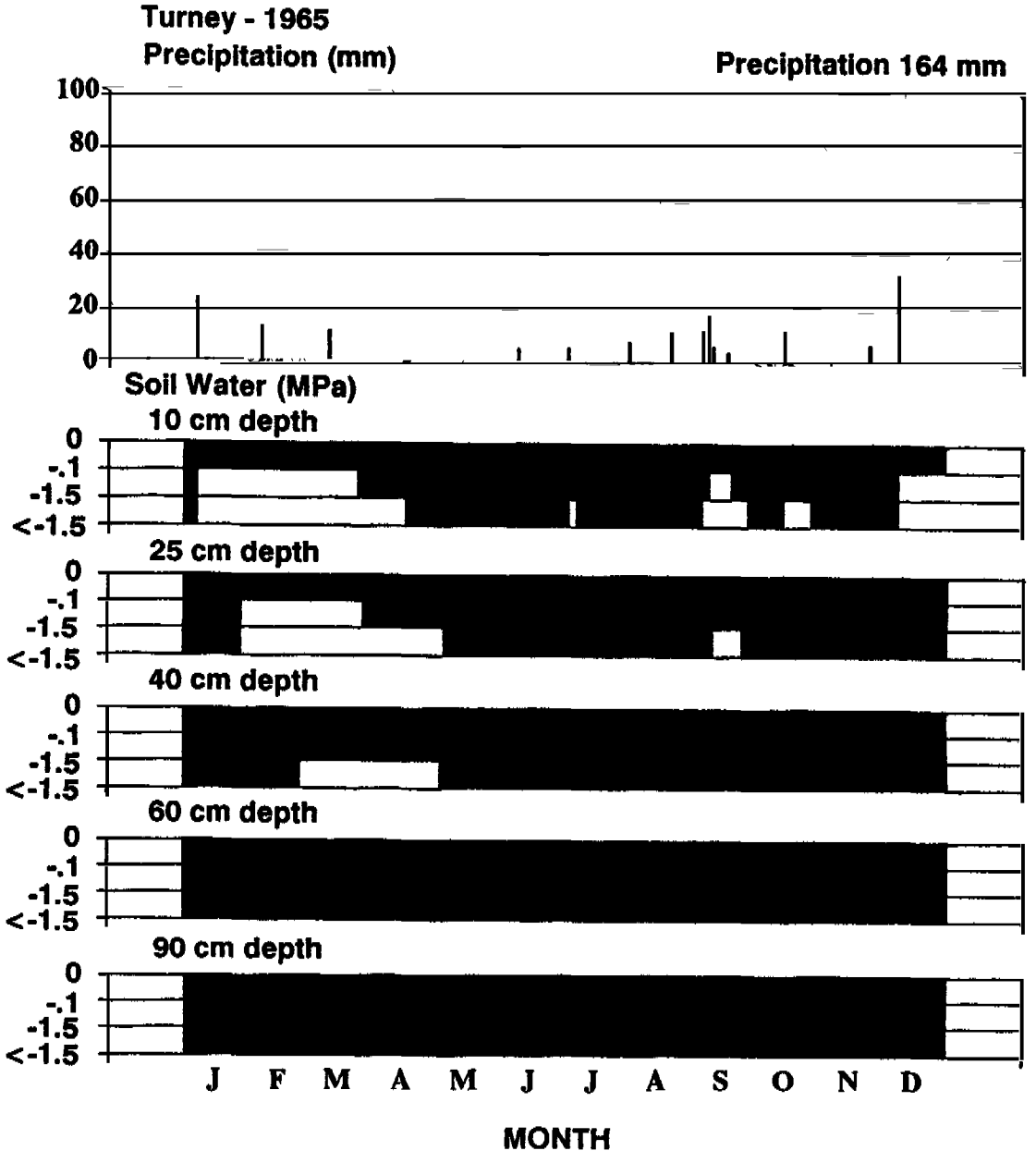


Figure 212. Annual precipitation (164 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1965.

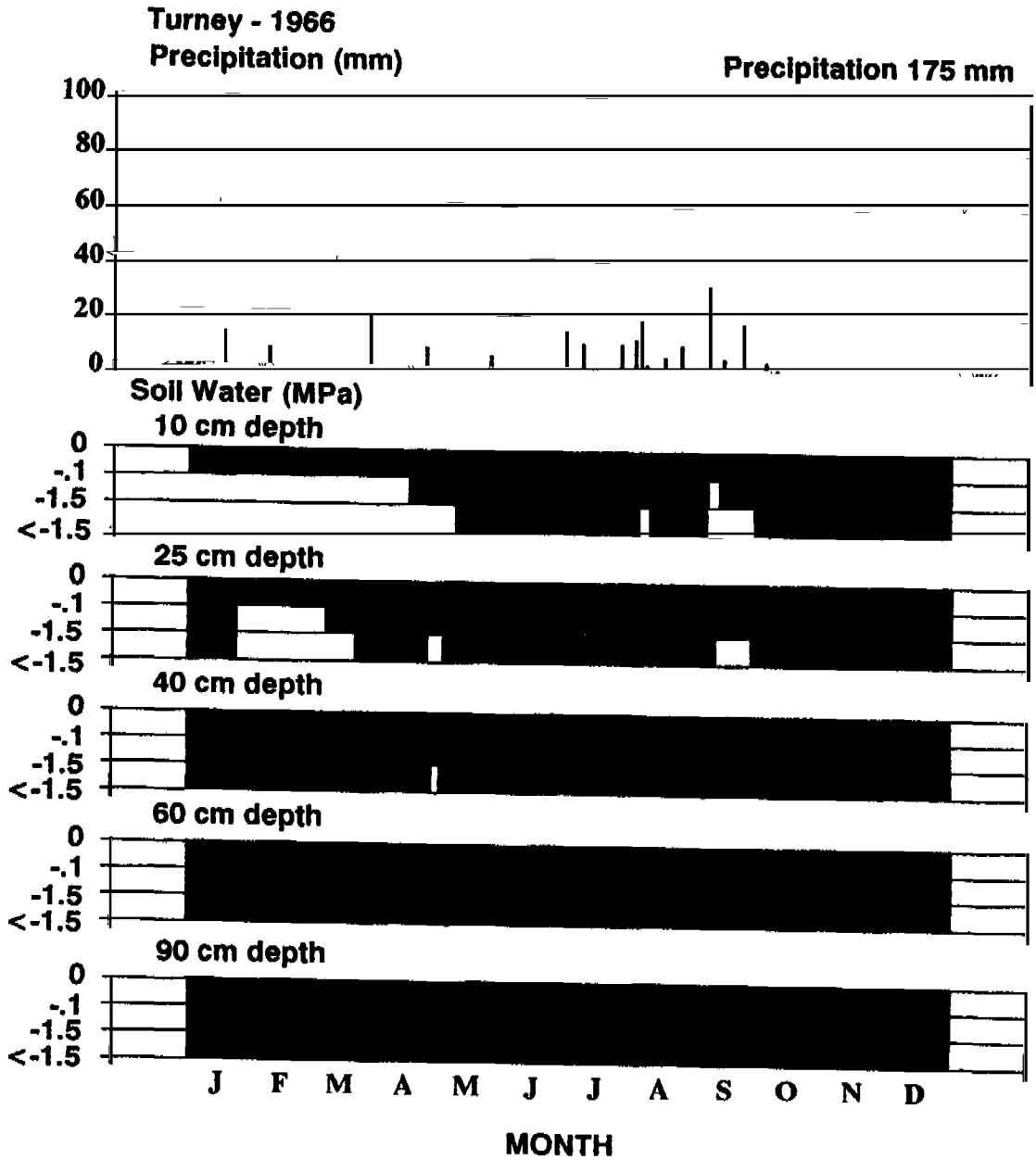


Figure 213. Annual precipitation (175 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1966.

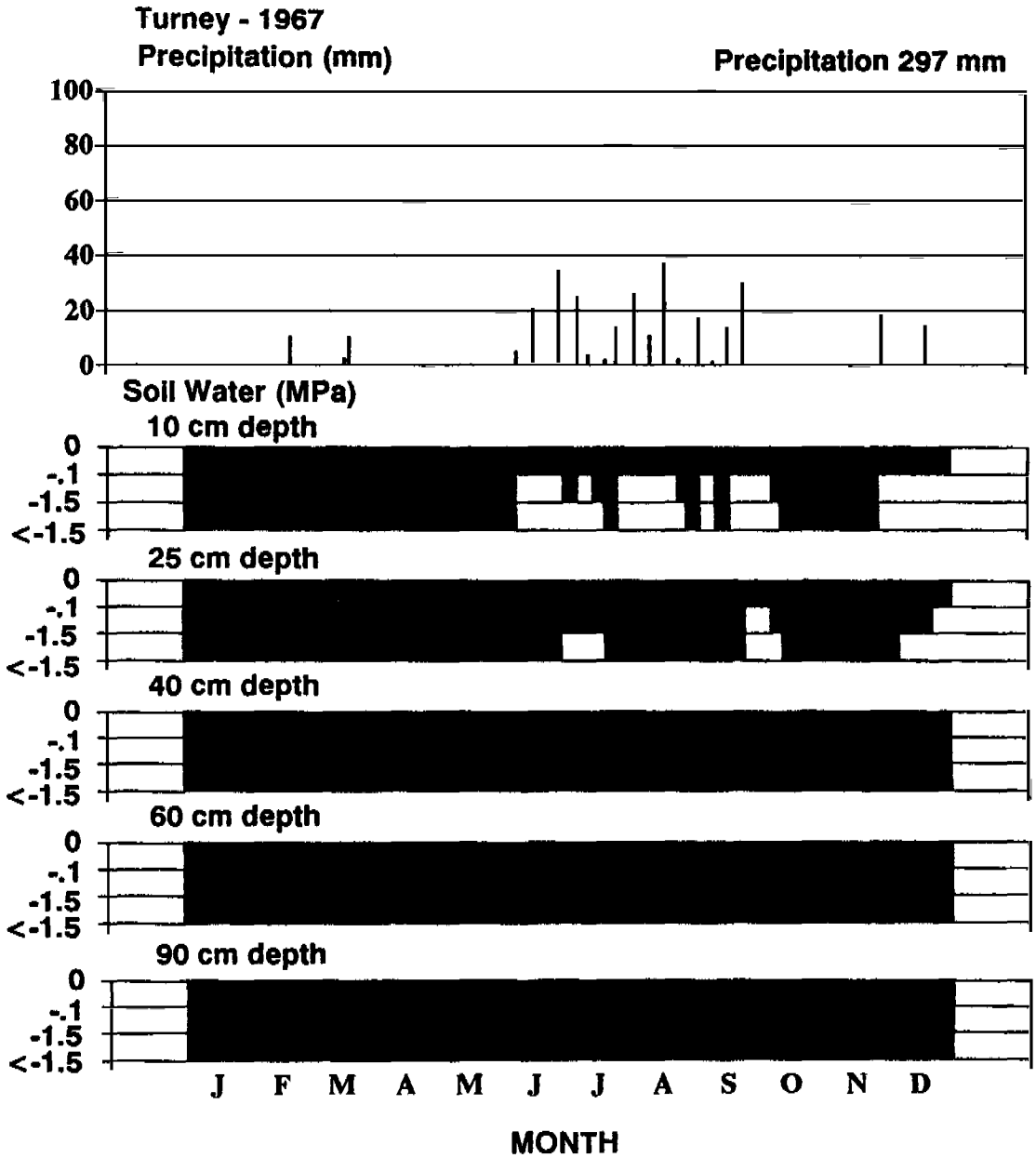


Figure 214. Annual precipitation (297 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1967.

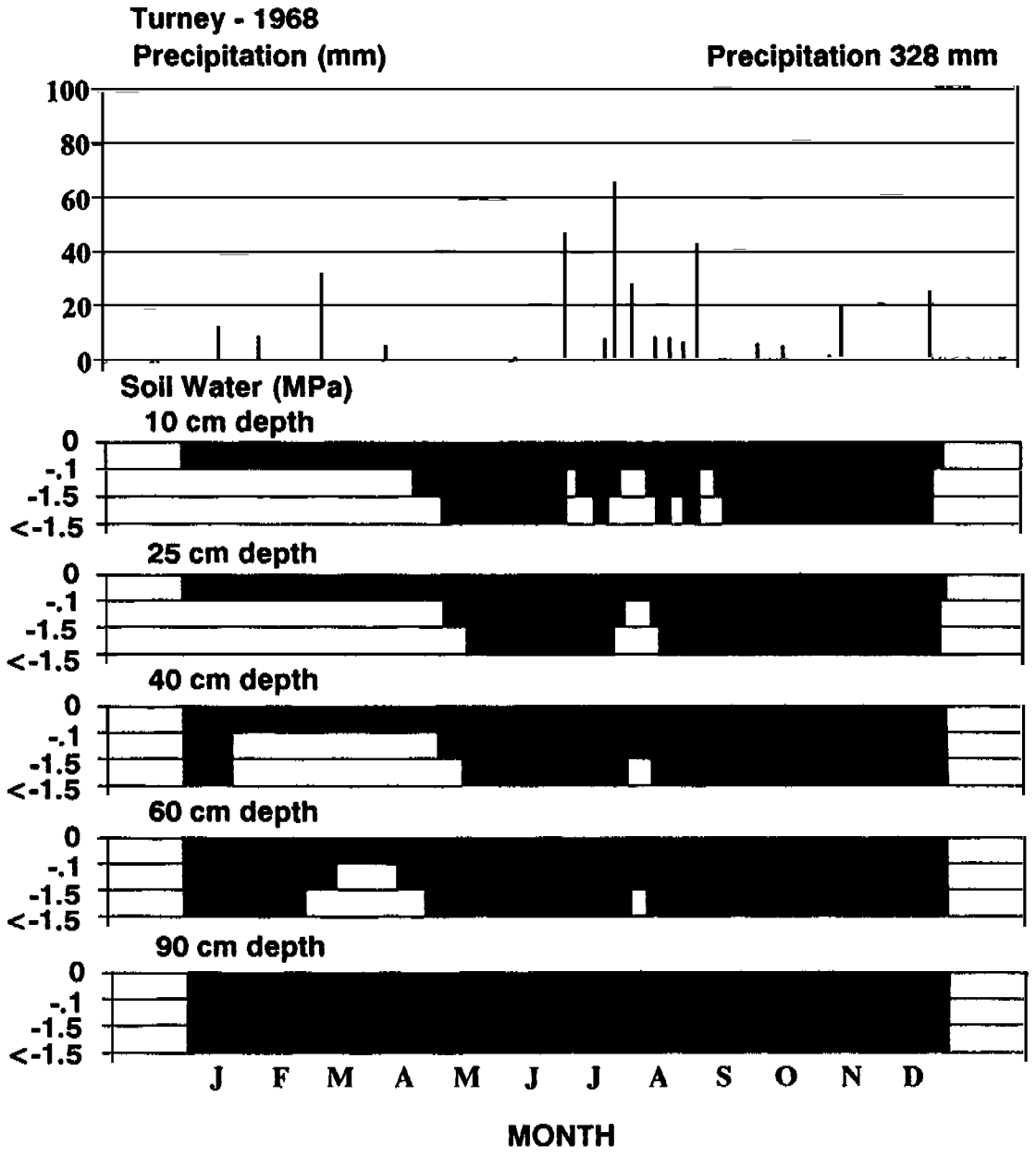


Figure 215. Annual precipitation (328 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1968.

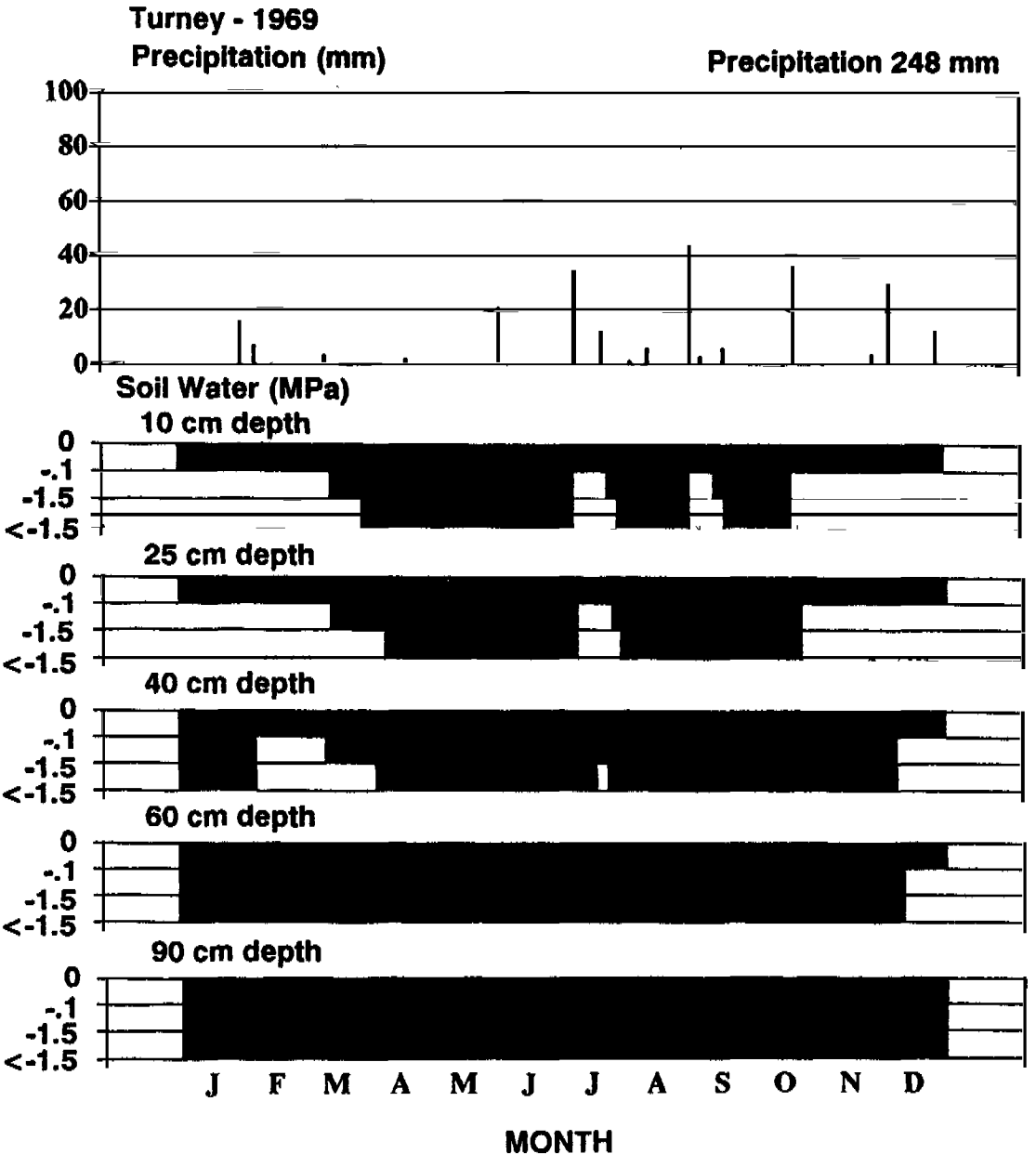


Figure 216. Annual precipitation (248 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1969.

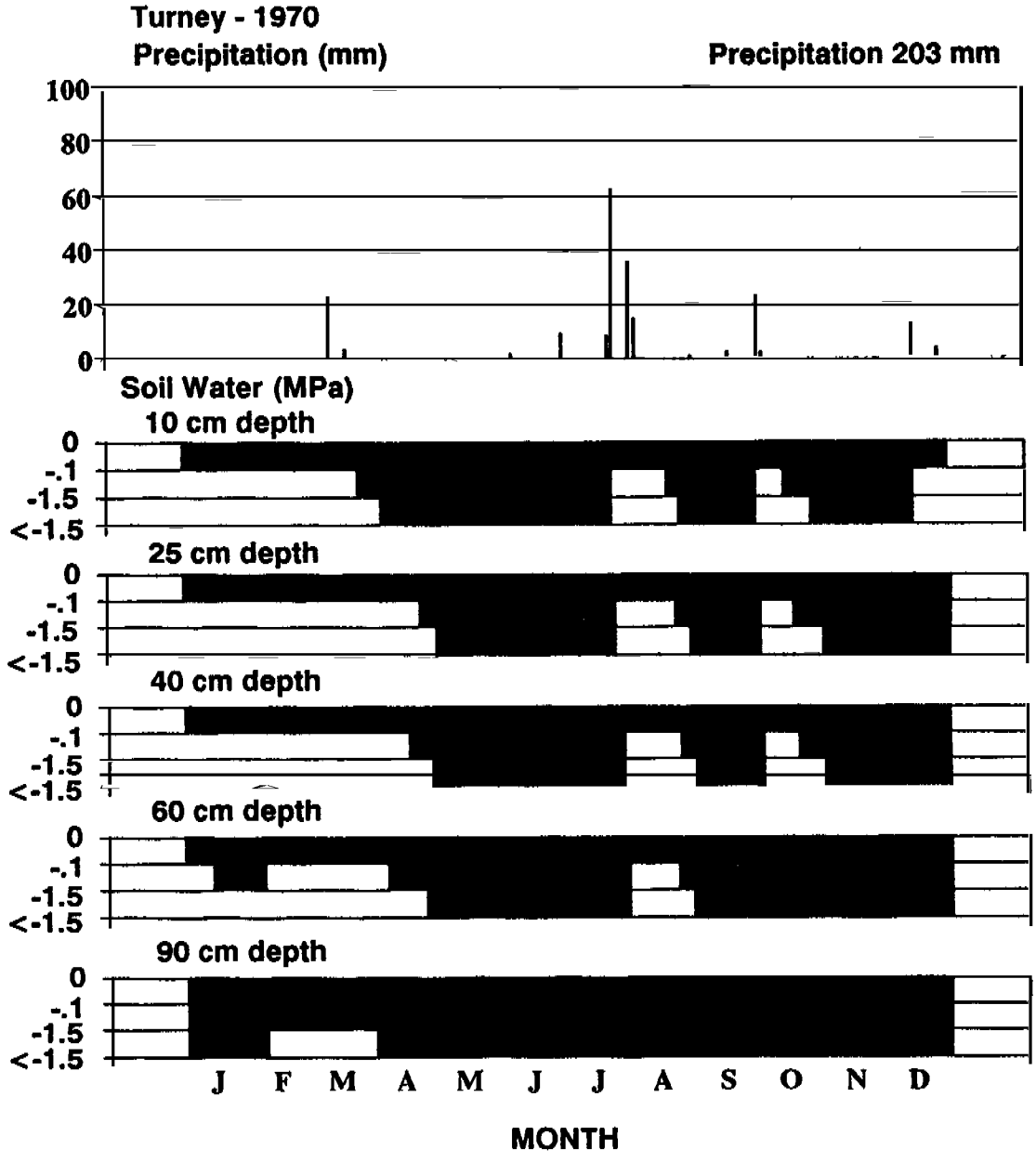


Figure 217. Annual precipitation (203 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1970.

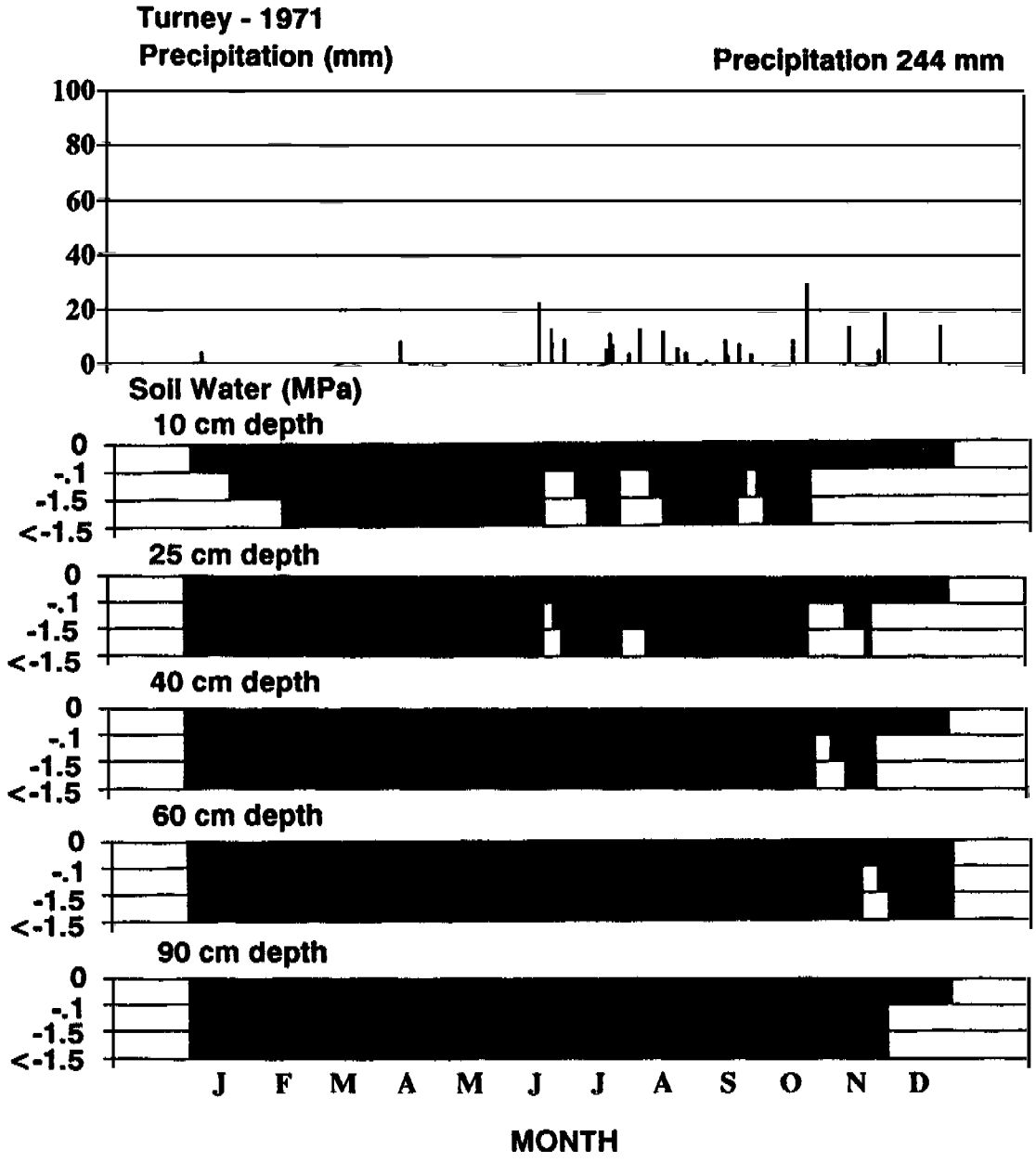


Figure 218. Annual precipitation (244 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1971.

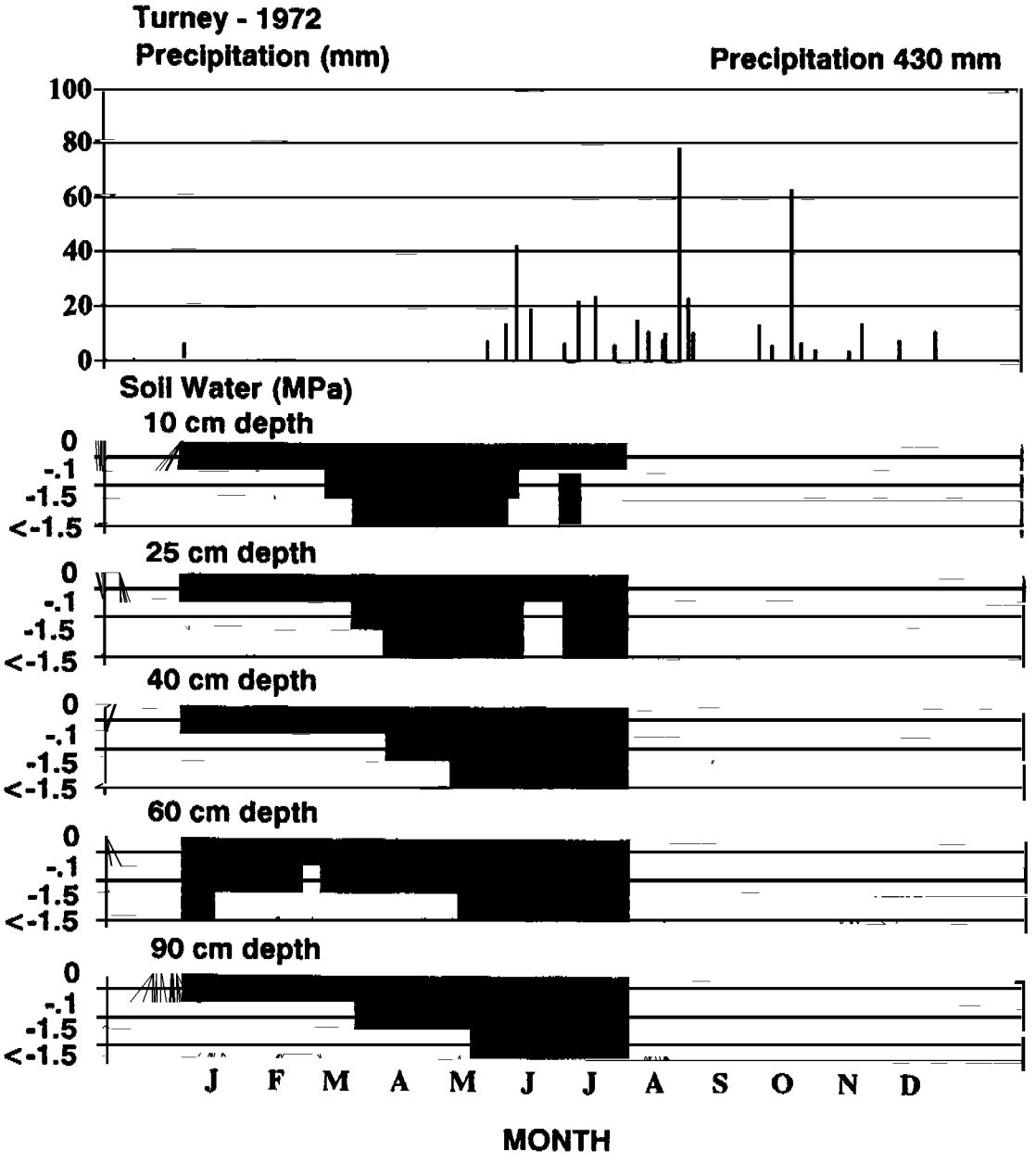


Figure 219. Annual (430 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm for January 1-August 1, 1972 at the Turney site.

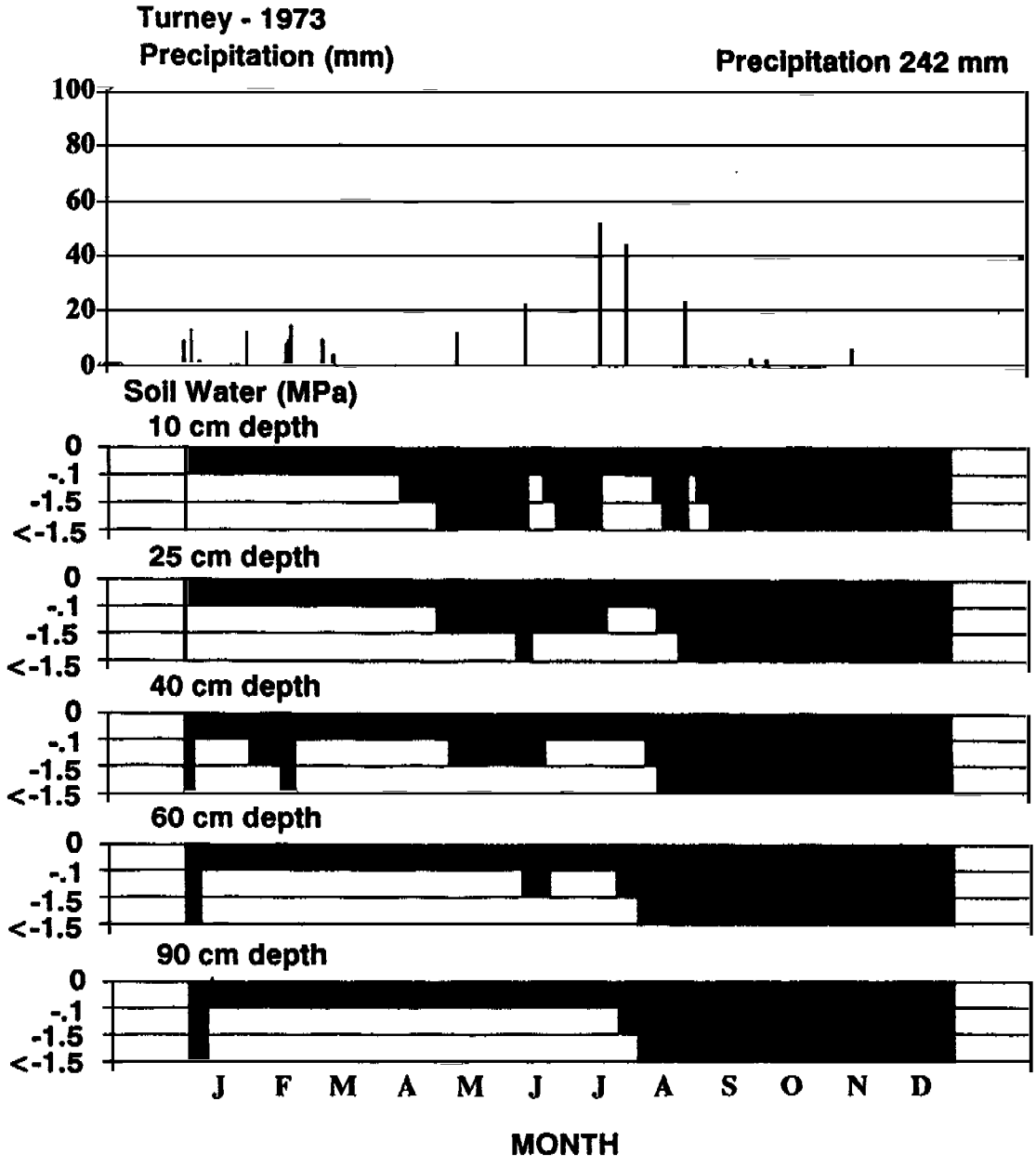


Figure 220. Annual precipitation (242 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1973.

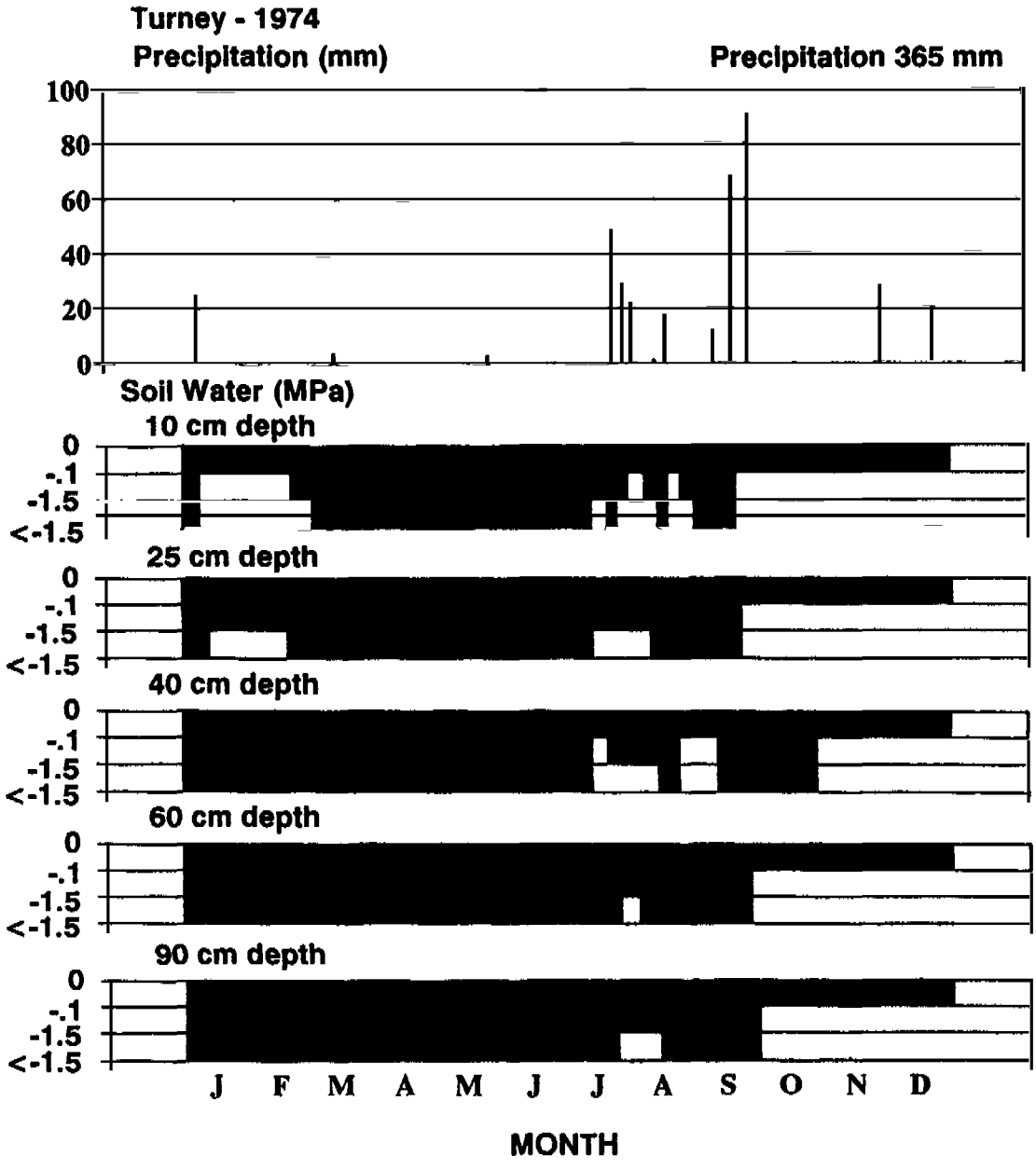


Figure 221. Annual precipitation (365 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1974.

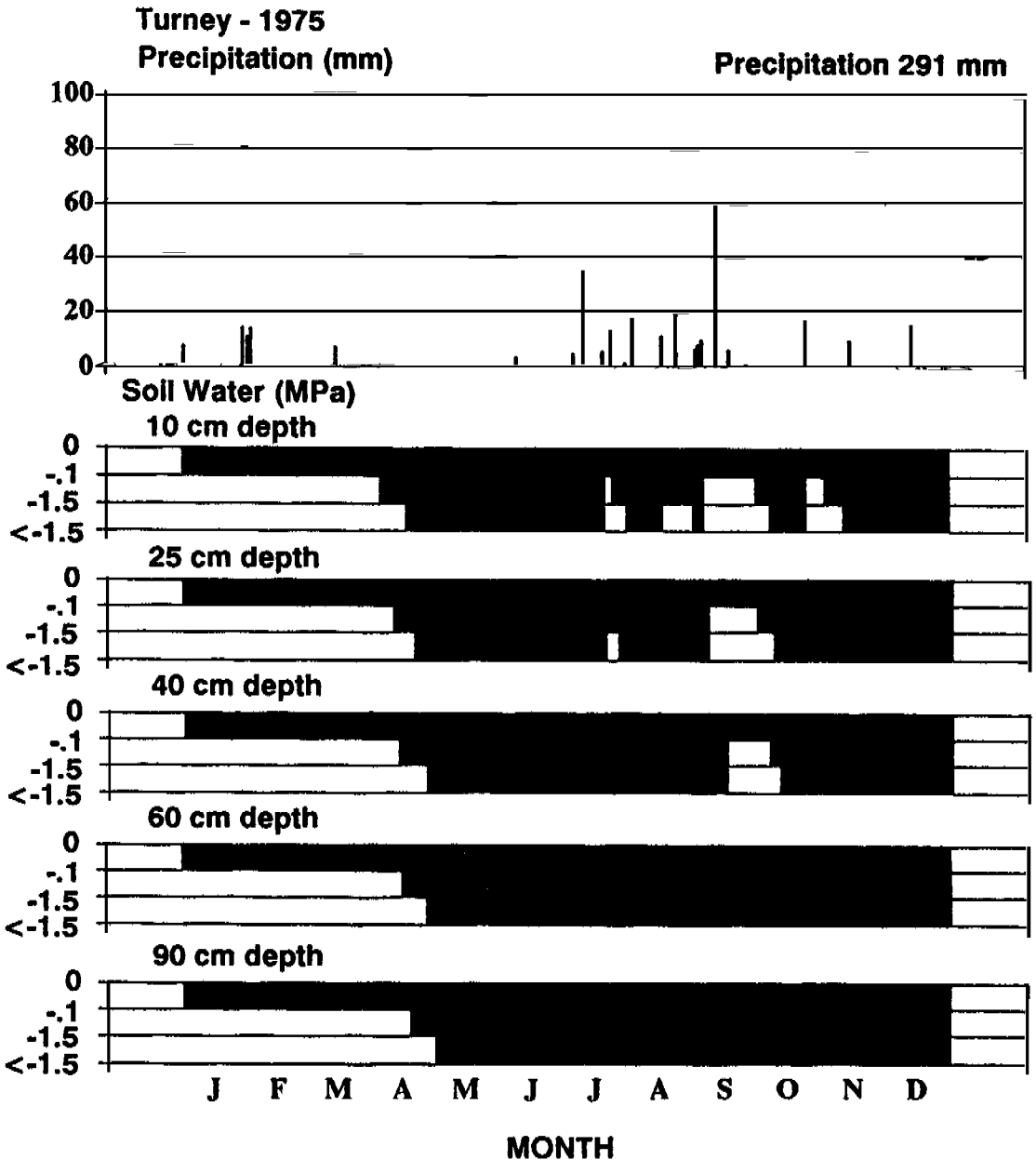


Figure 222. Annual precipitation (291 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1975.

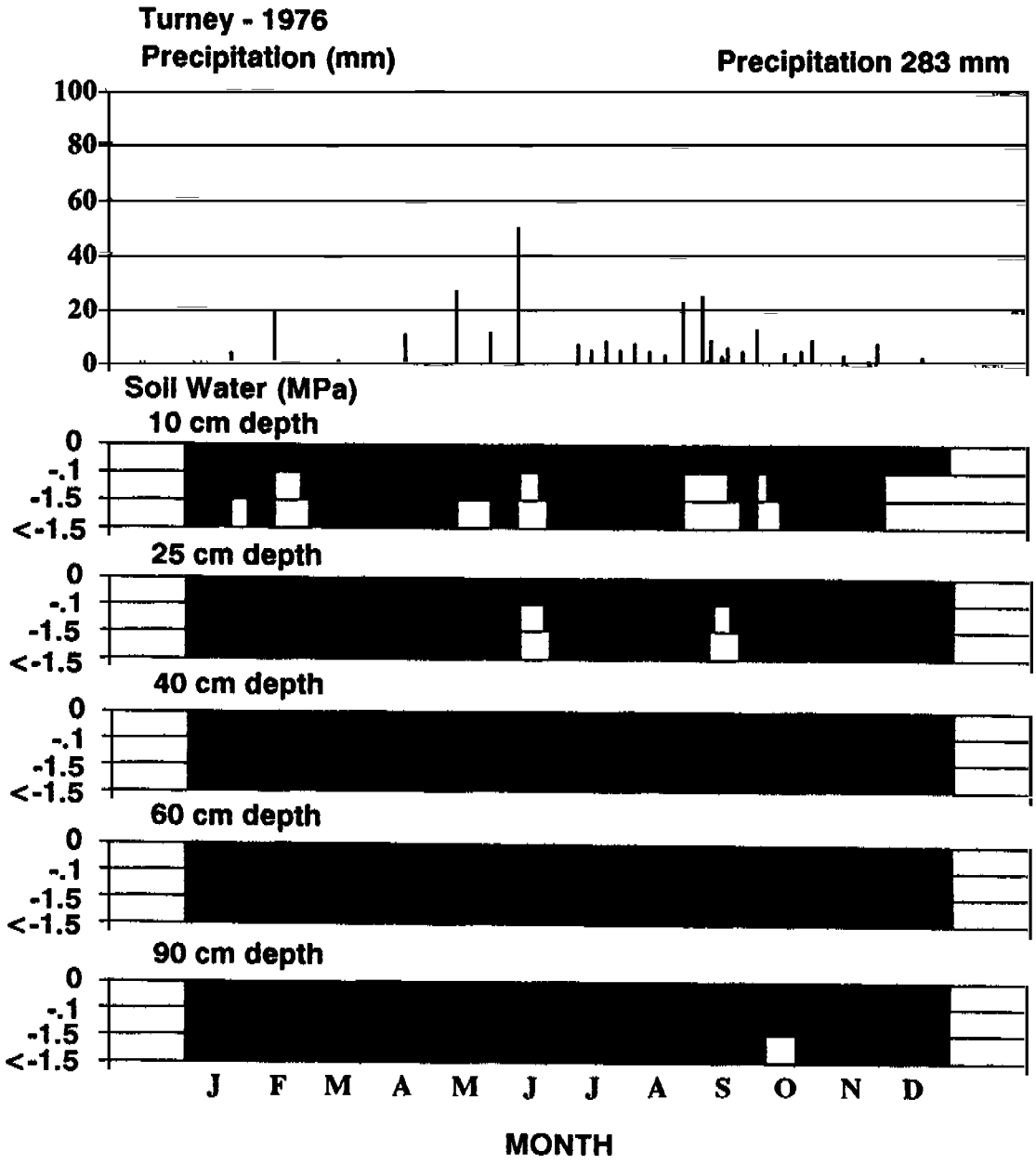


Figure 223. Annual precipitation (283 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Turney site for 1976.

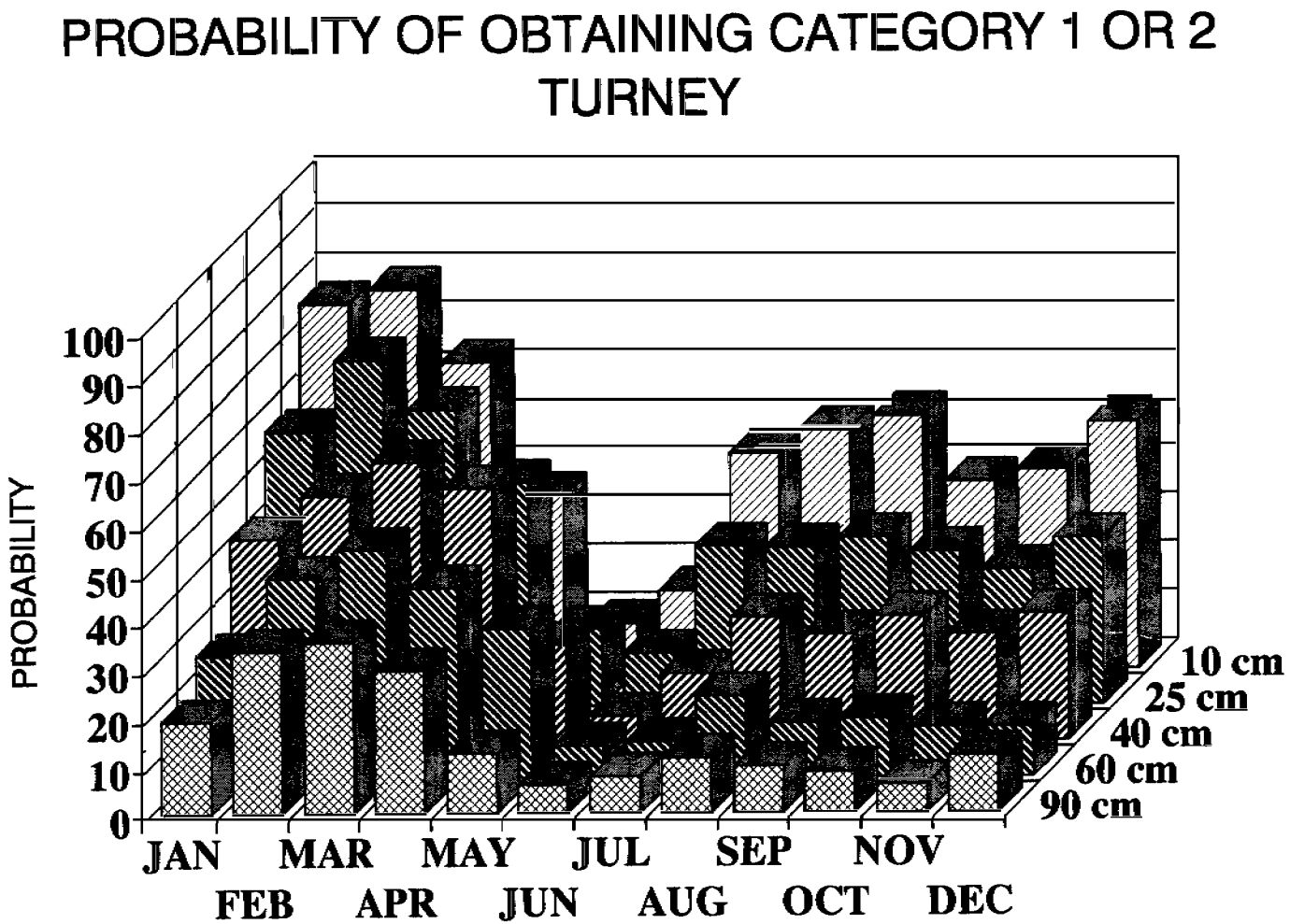


Figure 224. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, and 90 cm at the Turney site.

the four months after June 21, five of 18 years when the soil water data were complete for the entire year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was observed in both years and the 30-day criterion was met in 1957.

Narrow Basin Floor, with Run-in, and an Adjacent Fan-Piedmont

All of the soil water sites in this group occur in the D sert Soil-Geomorphology Project (fig. 1), where the soil-geomorphic relations have been worked out in more detail than in that part of the Range that is north of the Project. Figure 225 locates the study sites and shows the general stratigraphy at sites H and S2; figure 226 shows topography and elevations of sites H, S1, S2, VS3, and R.

Site Herbel (H)

Site H (figs. 227-228, table 10) is in the Doña Ana exclosure on the Jornada Experimental Range. The studied pedon is about 7 m southwest of the southwest corner of the small exclosure with the nonrecording range gauge (fig. 228). Vegetation records (1858 and 1915) indicate that this site was dominated by black grama (Buffington and Herbel, 1965). Vegetation has changed greatly since 1915. The black grama has disappeared, and vegetation is now dominated by creosotebush, tarbush, bush muhly (which commonly occurs at the base of shrubs), mesa dropseed, fluffgrass, broom snakeweed, and a few soaptree yucca. With this shift in vegetation, there has been some erosion in the general area, and scattered small drainageways occur in the vicinity. The soil water blocks are located in a relatively stable area between the drainageways.

Soils. The soil water blocks are in the Typic Torriorthent Herbel (fig. 228, table 10). An ochric epipedon is the only diagnostic horizon. The soil has formed in fan-piedmont sediments derived from monzonite, andesite, and rhyolite, and is on the Organ surface of Holocene age (tables 1, 2). The studied pedon has formed in sediments of three ages (table 1): Organ, from 0 to 67 cm; Isaacks' Ranch, from 67 to 102 cm; and Jornada II, from 102 to 123 cm. Slope is 2% to the east.

Soil morphology suggests that horizons from 0-67 cm depth may be of Organ II age (table 1). A similar soil of Organ age (see study area 10, p. 144-149, Gile et al. 1981), is known to be less than 4,200 years old by radiocarbon dating of buried charcoal. The dated soil has a Bt horizon but clay increase from A to B is not enough for an argillic horizon. This is also the case for this Herbel soil, and the two are thought to be about the same age -- less than about 4,000 years old, and possibly within the Organ II age range of 1,100 to 2,100 years.

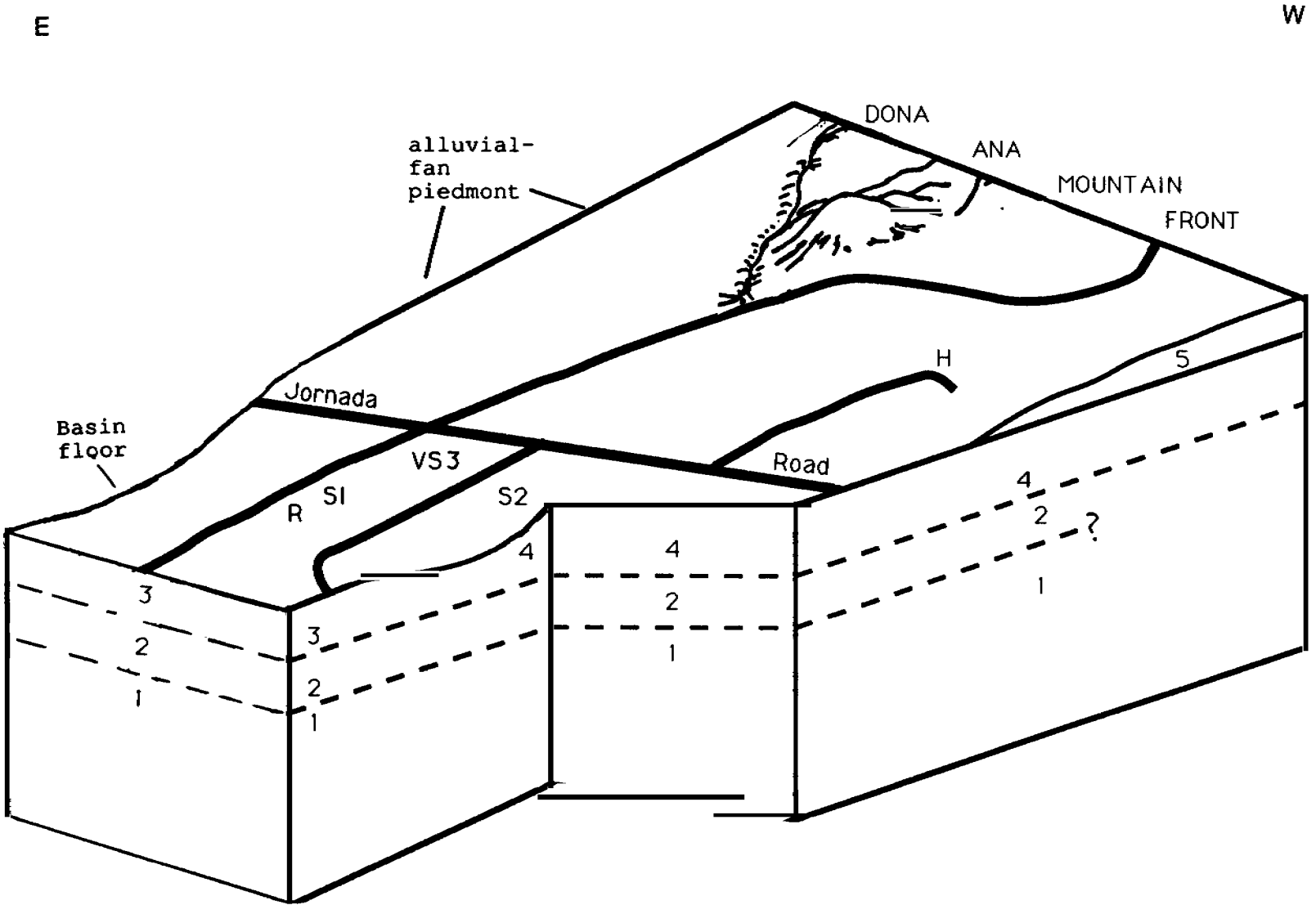


Figure 225. Diagram showing location of sites H, R, S1, S2, and V3 on the alluvial-fan piedmont and the basin floor, and the general stratigraphy of sites H and S2, east of the Dona Ana Mountains. Modified from a drawing by John Smith. 1=fluvial facies of the Upper Camp Rice Formation. 2=Jornada I alluvium. 3=Petts Tank sediments. 4=Jornada II alluvium (piedmont-slope analog of the basin-floor P tts Tank sediments). 5=Organ and Isaacks' Ranch.

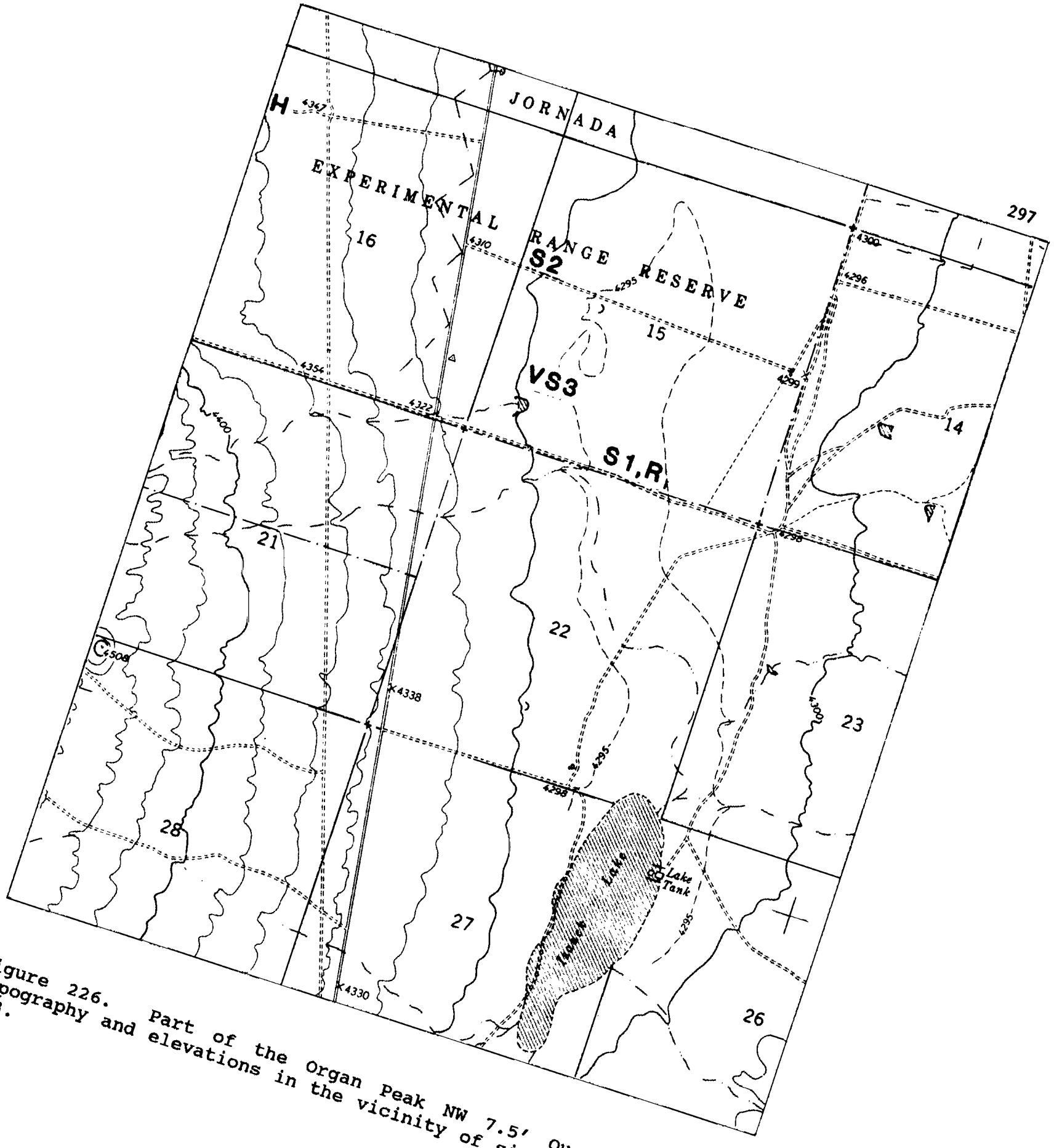


Figure 226. Part of the Organ Peak NW 7.5′ Quadrangle, showing topography and elevations in the vicinity of sites H, R, S1, S2, and VS3.

Table 10. Characteristics of the Typic Torriorthent, Herbel, at site H.

Alluvium	Horizon	Depth cm	Hue	Value/Chroma Dry	Value/Chroma Moist	Structure	Consistence Dry	Consistence Moist	Eff. with HCl	Textural class
Organ	E	0-4	7.5YR	6/3	4/3	lfpl	s	vfr	nc	fsl
	Bt	4-20	7.5YR	5.5/4	4/4	m	sh	fr	e, nc	gsl
	Ck1	20-33	7.5YR	6/4	4.5/4	m	s	vfr	es	vgsl
	Ck2	33-52	7.5YR	6/4	4.5/4	lmsbk	sh	fr	es	gsl
	Ck3	52-67	7.5YR	6/4	4.5/4	m	s	vfr	es	gsl
Isaacks'	Btkb	67-80	5YR	5/4	4/4	lm, fsbk	sh	fr	es, e	gscl
Ranch	K&Cb	80-102	7.5YR	8/2	8/4	m	sh, h	fr, fi	es	gsl
			7.5YR	6/4	5/4					
Jornada II	Btkb2	102-123	5YR	5/4	4/4	lm, fsbk	h	fr	es, e, nc	gscl

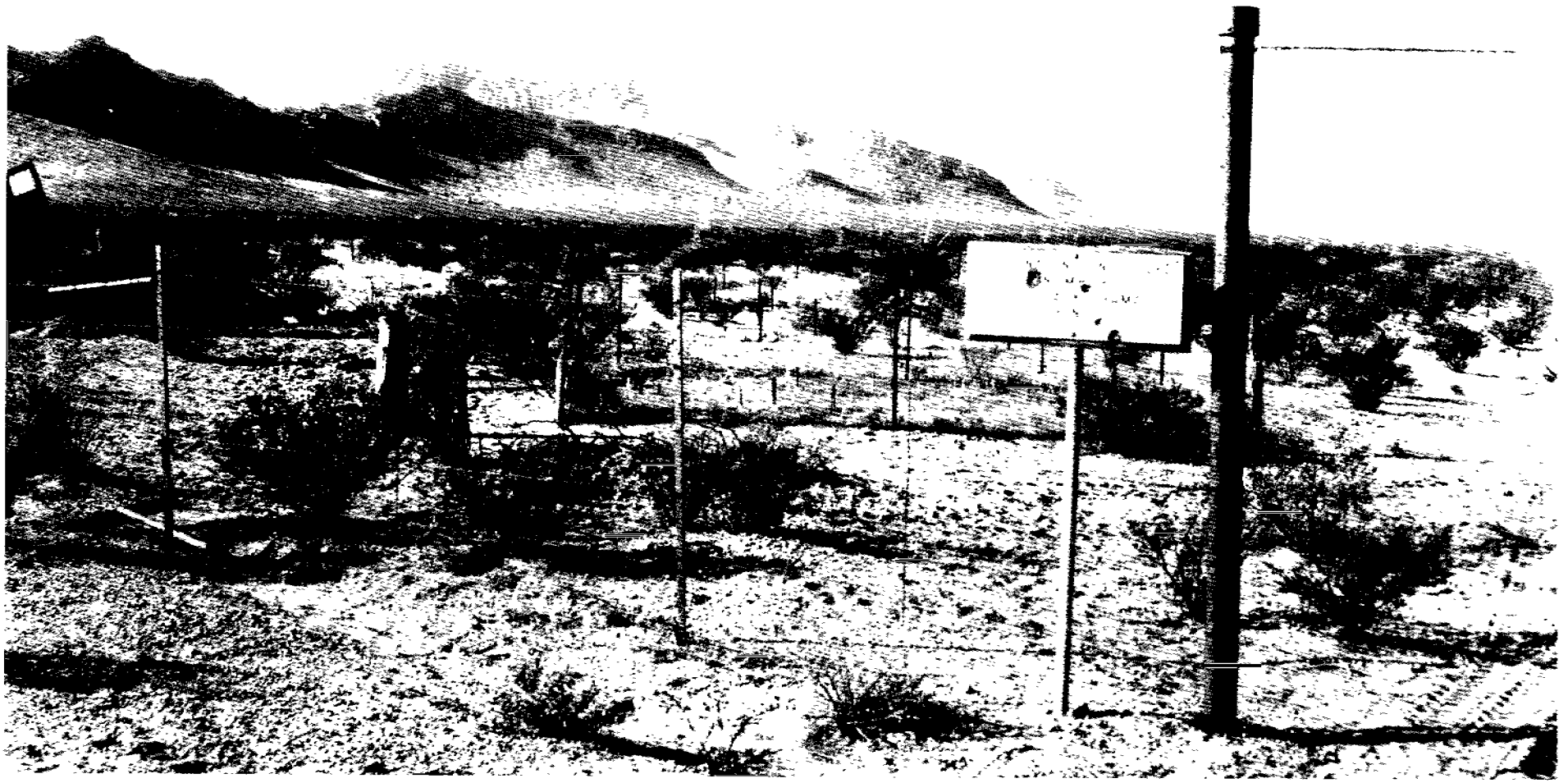


Figure 227. Landscape at Site H (fig. 226) and the Typic Torriorthent Herbel, in the Dona Ana exclosure in the Jornada Experimental Range. The nonrecording rain gauge and the study trench are at left. The stakes and the wires to the soil blocks are in a smaller exclosure to the right (north) of the nonrecording rain gauge. The Dona Ana Mountains are on the skyline. Photographed December 1970.

Figure 228. Profile of the Typic Torriorthent Herbel. The nonrecording rain gauge is at left, and the San Andres Mountains are on the skyline. Scale is in feet.

The foregoing evidence indicates that horizons from 0-67 cm depth must have formed in a climate very similar to the present one. The soil water data (figs. 231-249) show that the noncalcareous upper horizons are wetted most frequently, and that the Ck1 horizon is wetted somewhat less frequently. The soil water data, soil morphology, and soil age indicate that silicate clay is slowly accumulating in the Bt horizon, and carbonate in the Ck1 horizon.

Soil Water and Precipitation. The gypsum resistance blocks were installed at 10-, 25-, and 40-cm depths on July 11, 1958; and at the 60- and 90-cm depths on July 29, 1959 within a livestock exclosure placed inside of a larger rodent exclosure at the Doña Ana Rain Gauge. The rain gauge at this location was established in 1926. The annual precipitation in 1958 was 358 mm (fig. 231). The matric potential of the soil water at 10 cm was >-1.5 MPa July 29-August 9, August 21-30, September 11-19, and September 28-November 27, 1958. The moisture control section, 25-cm depth, had soil water >-1.5 MPa July 28-29, September 29-October 12, and October 17-December 17, 1958. There was soil water >-1.5 MPa at 40 cm October 17-December 3, 1958 (fig. 231).

The 1959 precipitation was 234 mm but 149 mm occurred in August (fig. 232). The winter-spring of 1958-59 was very droughty. The 25-cm depth had soil water >-1.5 MPa July 29-September 14, 1959 (fig. 232).

The precipitation in 1960 was below average and the largest daily amount was 31 mm on December 11 (fig. 233). Soil water at the 60- and 90-cm depths remained <-1.5 MPa throughout the year. Soil water at 25 cm was >-1.5 MPa January 23-May 11 and December 13, 1960-May 18, 1961 (figs. 233, 234). Precipitation in 1961 was above average and besides the wet conditions early in the year, the soil water at 25 cm was >-1.5 MPa July 18-30; August 18-September 27; and November 11, 1961-May 24, 1962 (figs. 234, 235).

Precipitation was 233 mm in 1962 (fig. 235). Besides wet conditions in the winter and spring, soil water at 25 cm was >-1.5 MPa July 21-27; September 9-13; September 27-October 28; and December 6, 1962-April 13, 1963 (fig. 235, 236).

Both 1963 and 1964 had below average precipitation. Besides the soil water in the early part of 1963, the soil water at the 25-cm depth was between -0.1 and -1.5 MPa July 13-20, 1963 and September 12-26, 1964 (figs. 236, 237).

Precipitation in 1965 was 229 mm (fig. 238). Soil water was <-1.5 MPa at the 40-, 60-, and 90-cm depths in 1964 and 1965 (figs. 237, 238). At the 25-cm depth, soil water was >-1.5 MPa February 10-April 11, 1965; September 9-28; and December 13, 1965-April 14, 1966 (figs. 238, 239).

Annual precipitation for 1966 was 188 mm (fig. 239). Besides soil water >-1.5 MPa in the early part of 1966, the soil water at 25 cm was between -0.1 and -1.5 MPa briefly September 6-8.

Even though the precipitation in 1967 was 337 mm, the only soil water >-1.5 MPa recorded at the 25-cm depth was December 22-31 (fig. 240). This level of soil water continued through April 25, 1968 (fig. 241). The annual precipitation was above average for

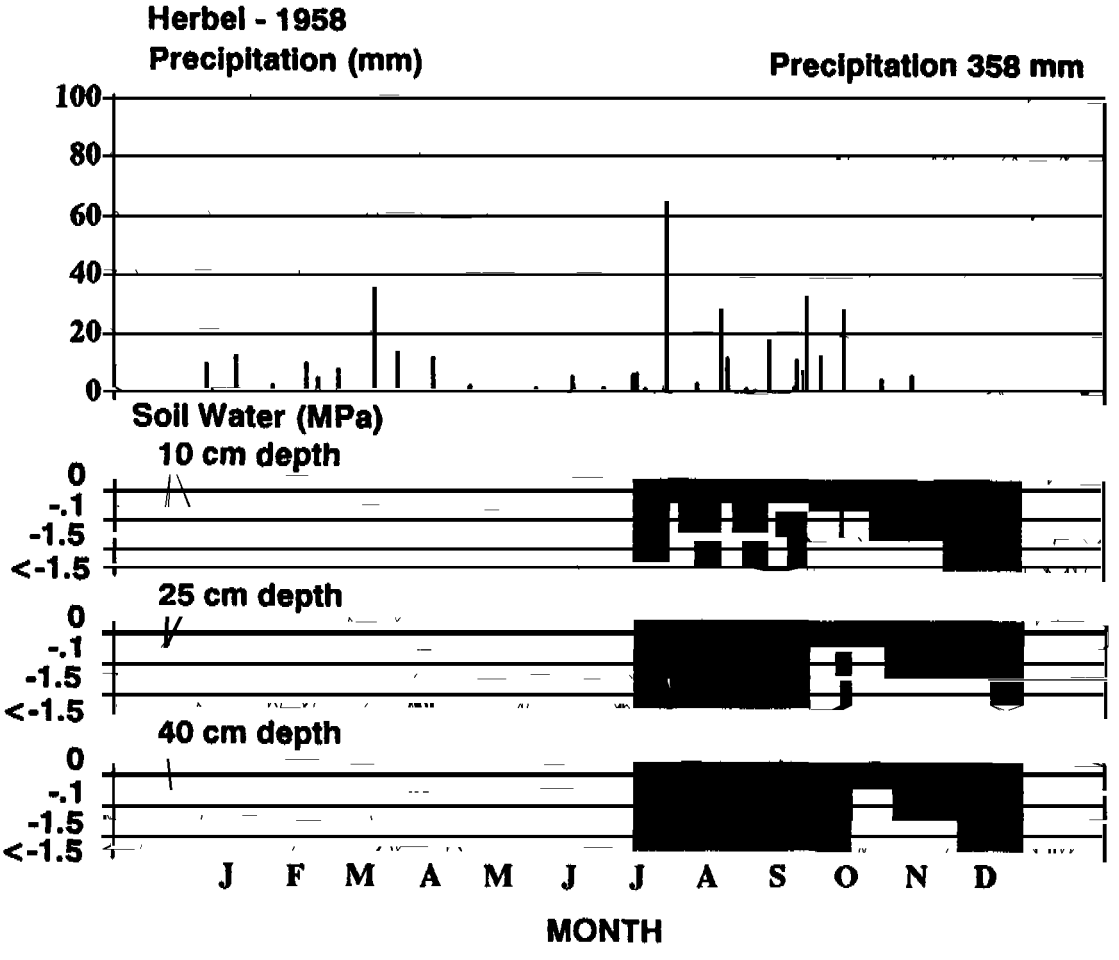


Figure 231. Annual (358 mm) and daily (mm) precipitation for 1958, and matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for July 11-December 31, 1958 at the Herbel site.

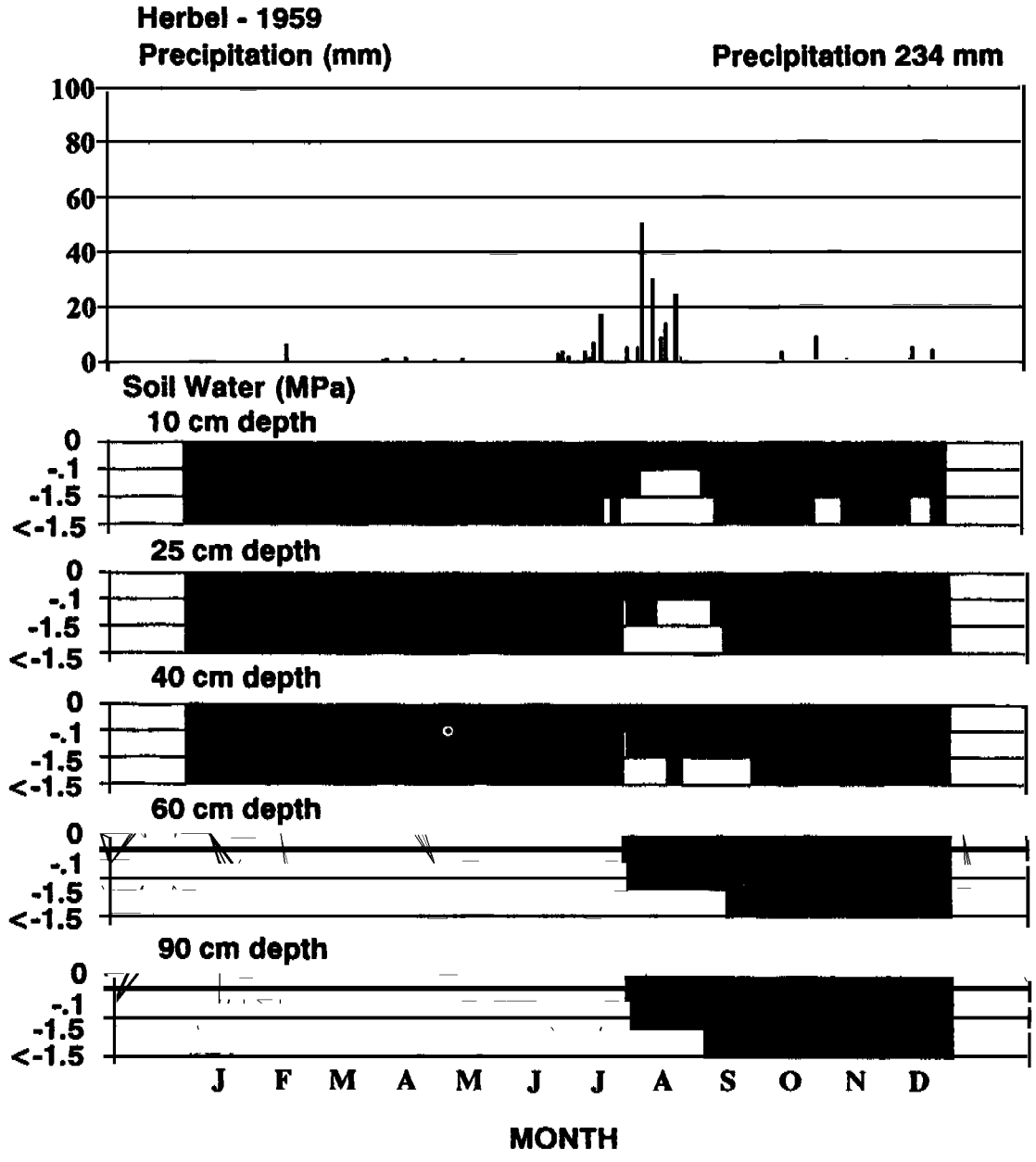


Figure 232. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Herbel site for 1959. Also shown is the soil water at depths of 60 and 90 cm July 29-December 31, 1959.

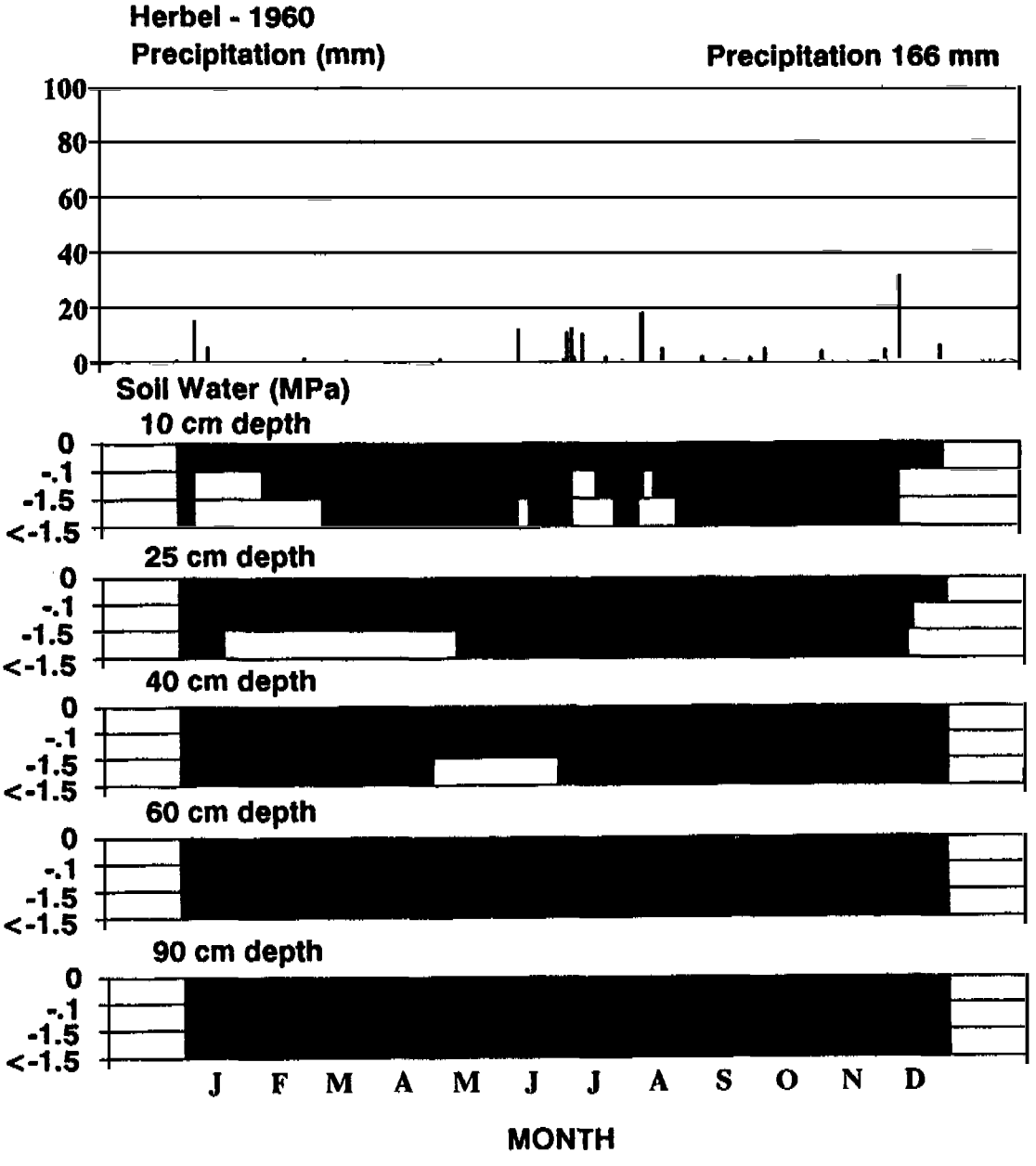


Figure 233. Annual precipitation (166 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1960.

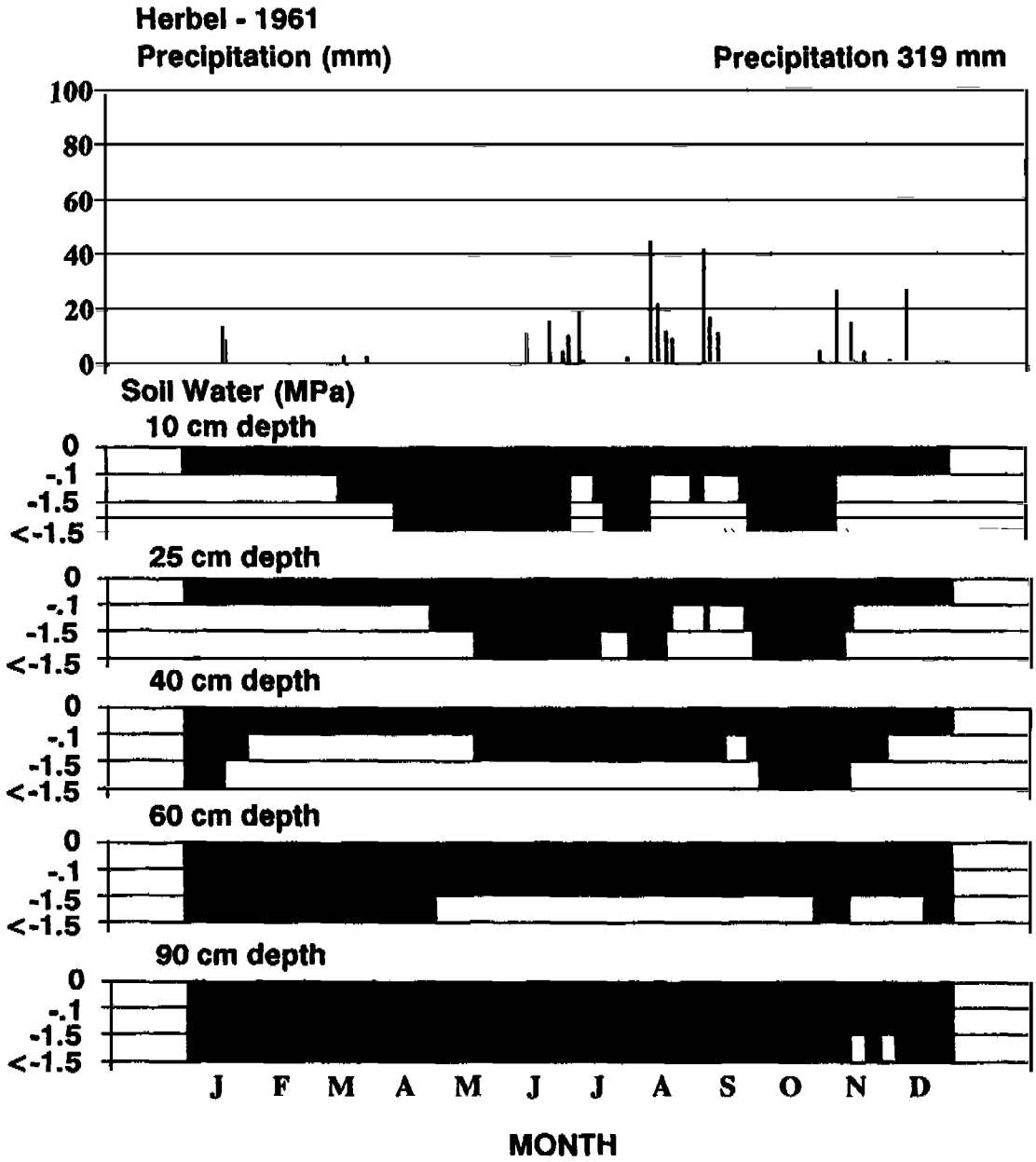


Figure 234. Annual precipitation (319 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1961.

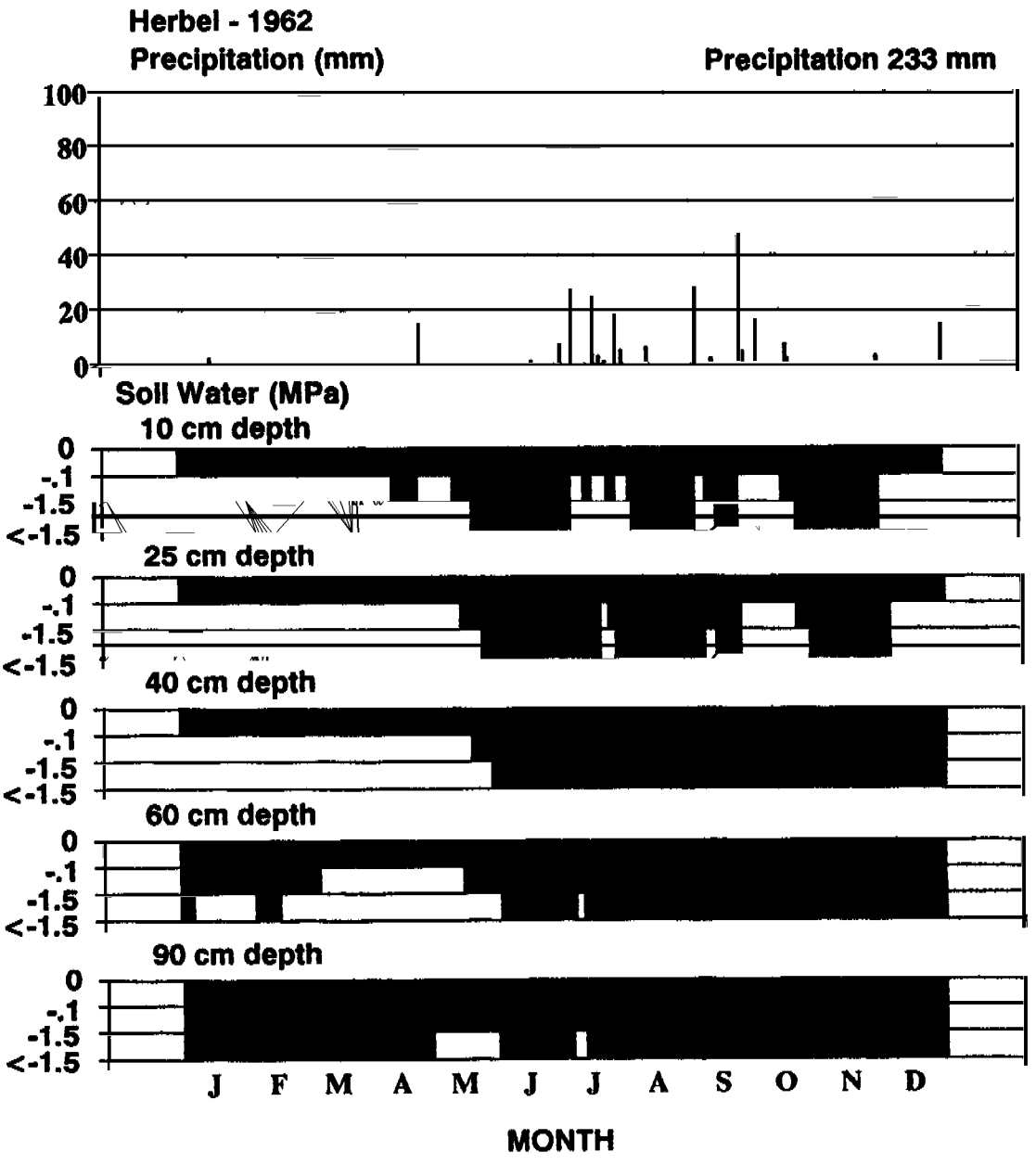


Figure 235. Annual precipitation (233 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1962.

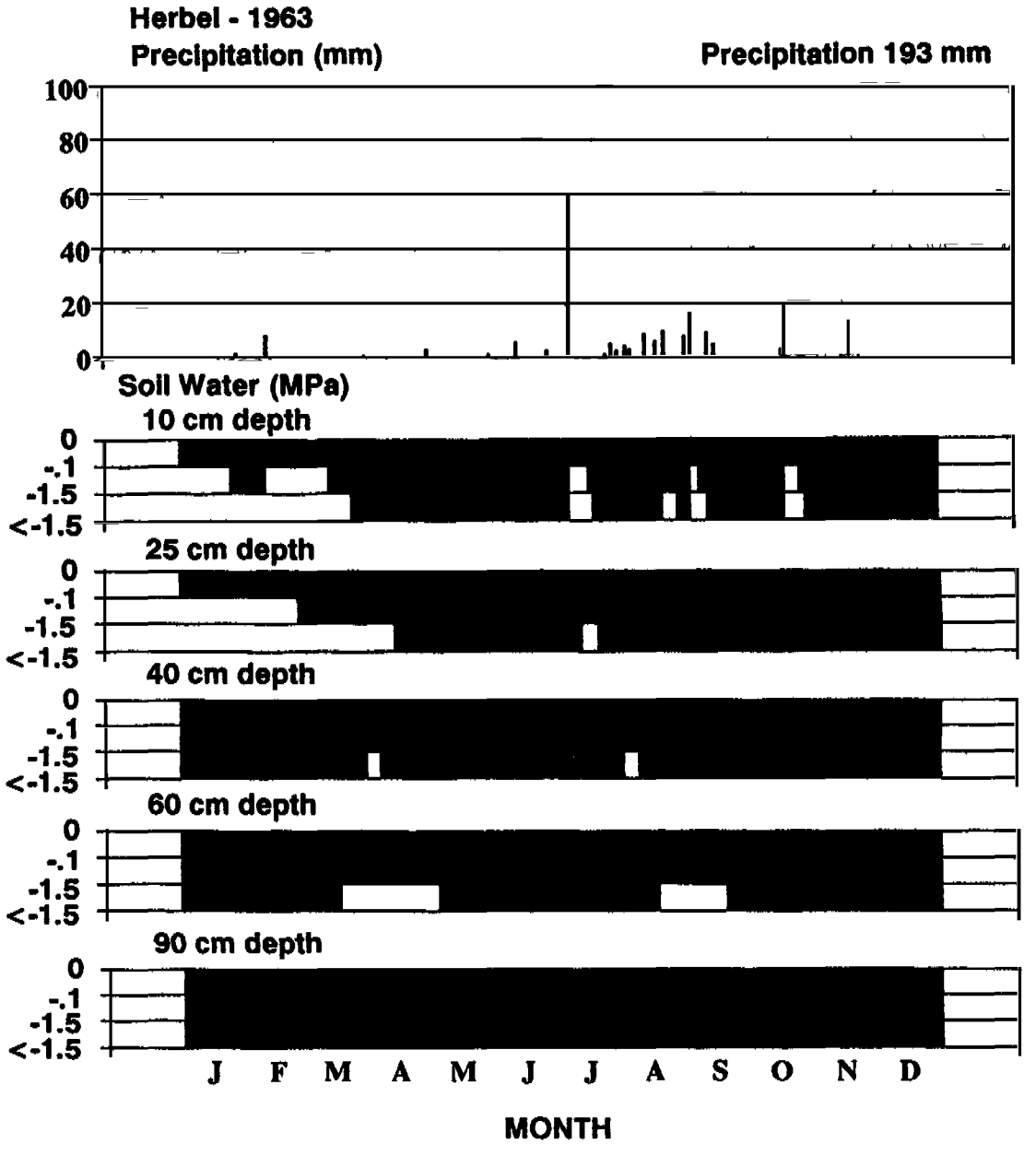


Figure 236. Annual precipitation (193 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1963.

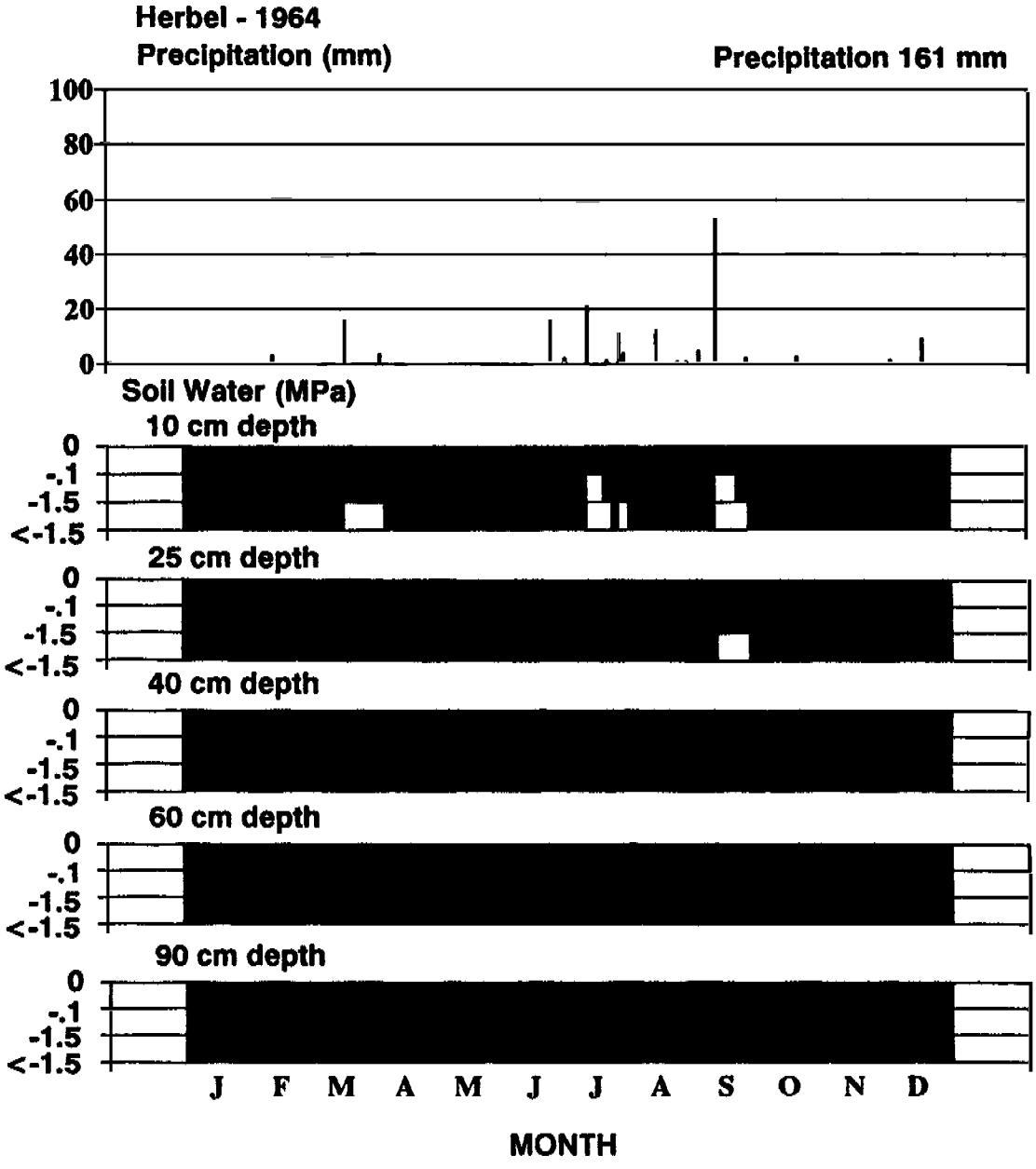


Figure 237. Annual precipitaion (161 mm), daily precipitaion (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1964.

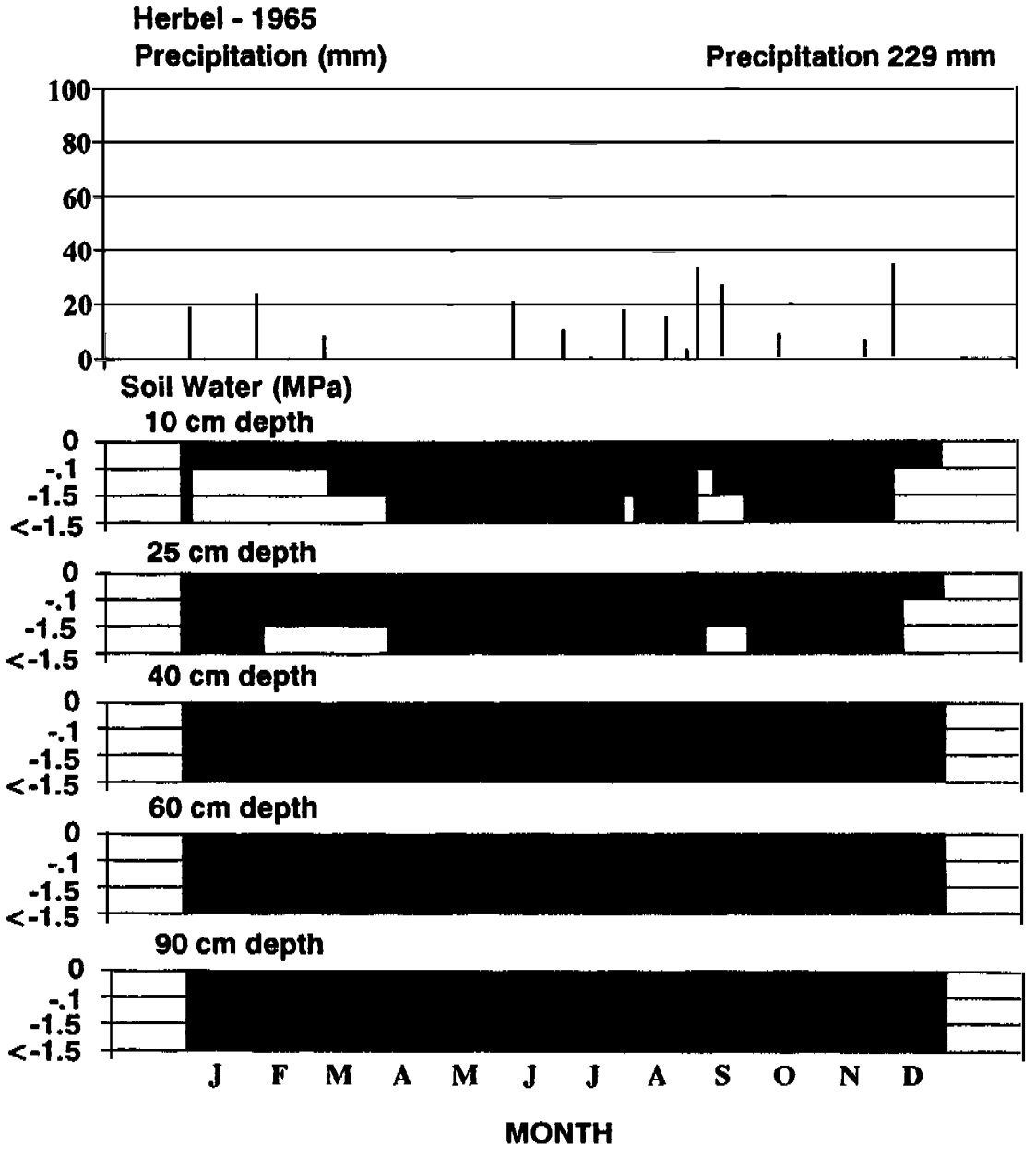


Figure 238. Annual precipitation (229 mm), daily precipitaion (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1965.

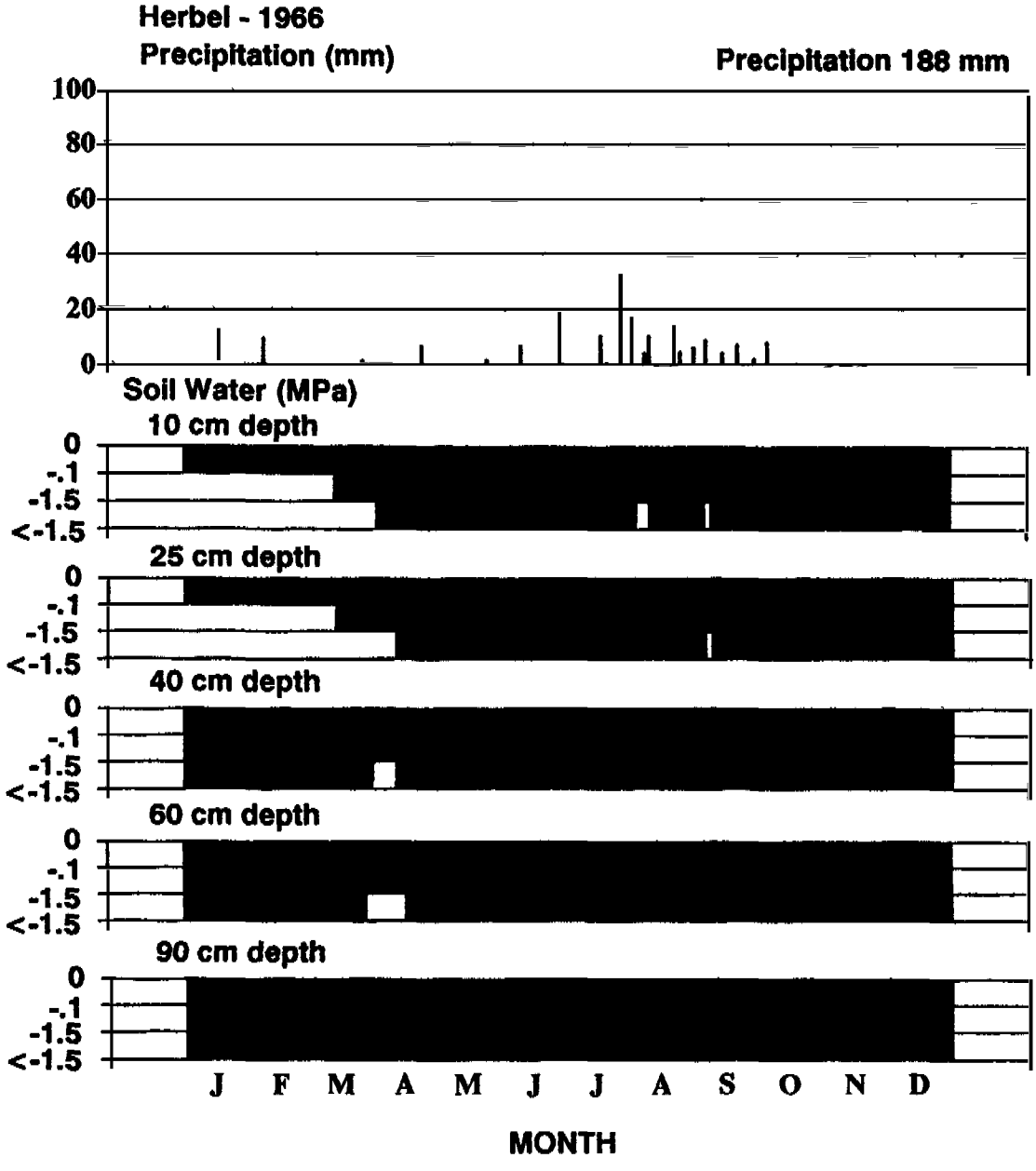


Figure 239. Annual precipitation (188 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1966.

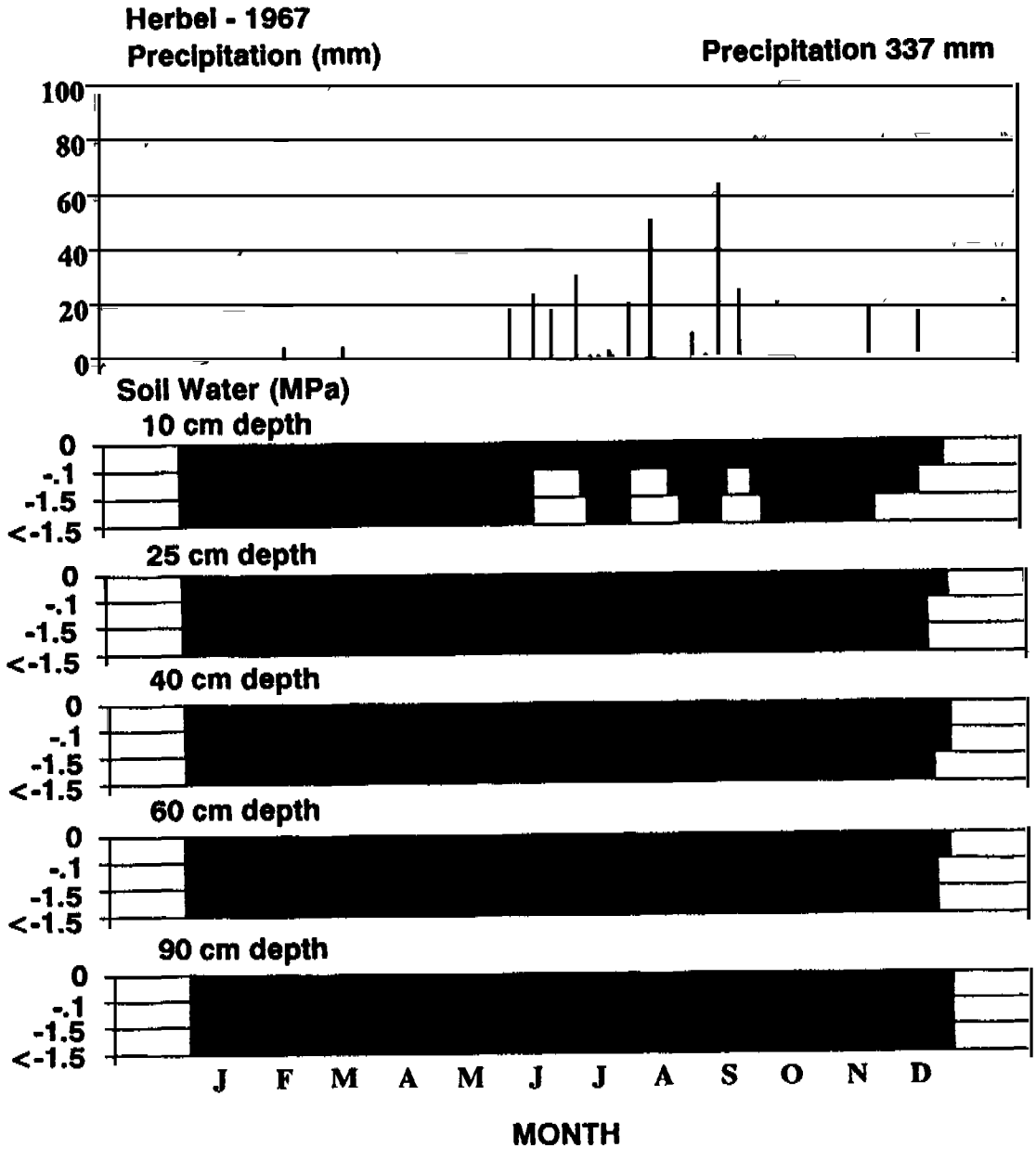


Figure 240. Annual precipitation (337 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1967.

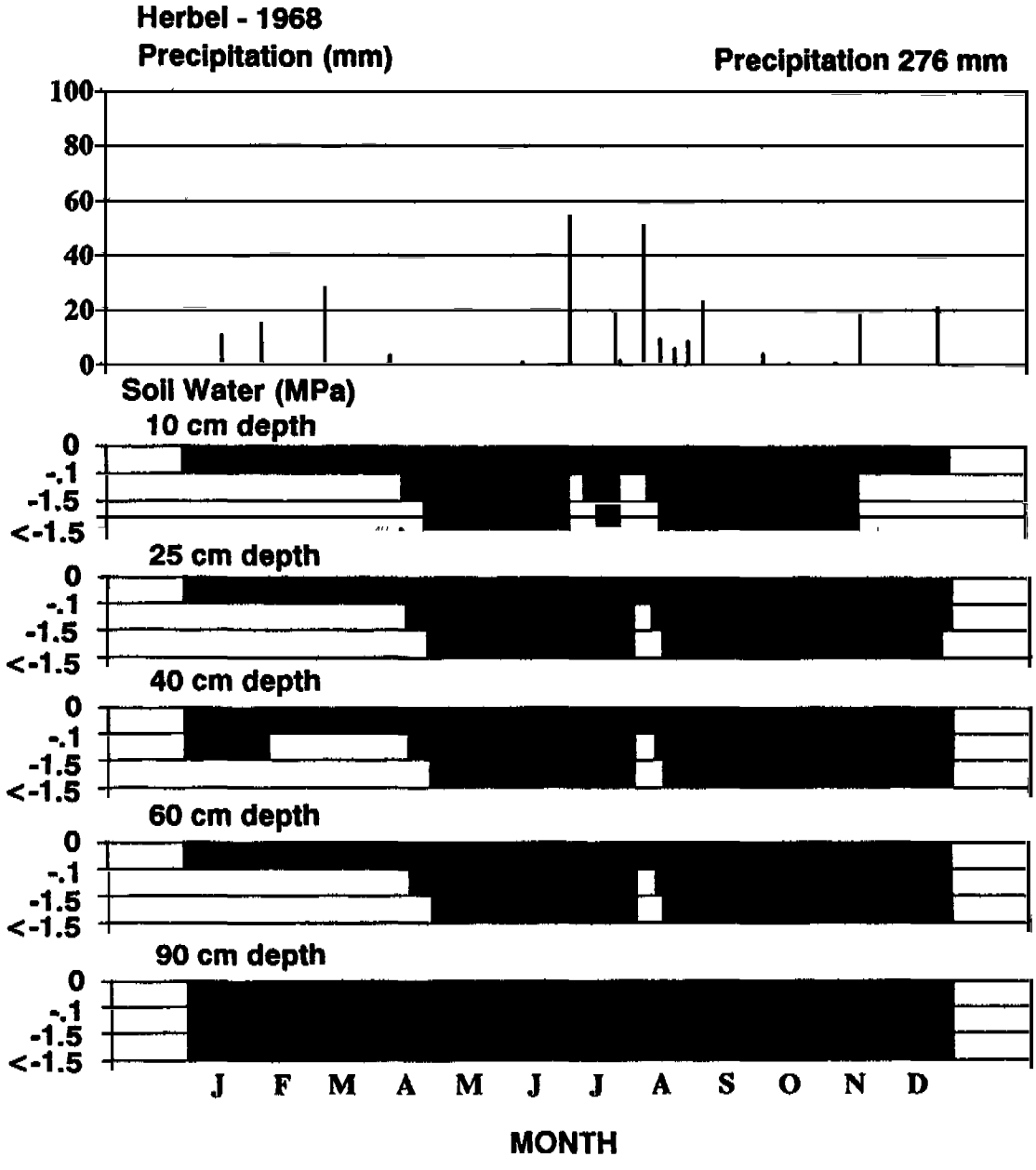


Figure 241. Annual precipitation (276 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1968.

1968 and about average for 1969. Besides that mentioned previously, soil water >-1.5 MPa at 25 cm occurred August 3-15 (fig. 241); December 27, 1968-March 23, 1969 (figs. 241, 242); July 10-29; September 5-13; and December 9, 1969-February 17, 1970 (figs. 242, 243).

Precipitation for 1970 was quite low. Besides the soil water >-1.5 MPa in the winter, the only other soil water >-1.5 MPa at 25 cm occurred July 28-August 13 (fig. 243).

Annual precipitation was about average in 1971 and above average in 1972. However, the ohmmeter was inoperative the latter part of 1972 so consequently no soil water estimates were available August 13-December 31, 1972. The matric potential of the soil water at 25 cm was >-1.5 MPa August 30-September 8, 1971 (fig. 244); October 26, 1971-March 10, 1972 (figs. 244, 245); and June 8-26, 1972.

Precipitation for 1973 was 226 mm (fig. 246). The 25-cm soil depth only had water >-1.5 MPa in the winter and early spring.

Annual precipitation was above average 1974-76. Soil water >-1.5 MPa at 25 cm occurred January 15-February 15, 1974 (fig. 247); July 15-25; July 31-September 11; September 24, 1974-April 25 1975 (figs. 247, 248); July 21-31; September 1-October 5; October 26, 1975-February 21, 1976 (figs. 248, 249); June 9-22; July 17-22; September 10-15; November 16-22; November 27-December 2; and December 28-31, 1976 (fig. 249).

Annual precipitation for 1958-76 was above average for seven years, about average for three years, and below average for nine years. The probability of the matric potential of the water >-1.5 MPa at the 25-cm depth averaged 53.9% for December-April, 7.9% for May-June, 20.3% for July-September, and 22.0% for October-November (fig. 250).

Test of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, 13 of 19 years had soil water <-1.5 MPa more than half the time at 10 cm; 15 of 19 years at 25 cm; 18 of 19 years at 40 cm; 17 of 18 years at 60 cm; and 18 of 18 years at a depth of 90 cm. Eleven of 19 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 10 of 19 years at 25 cm; 14 of 19 years at 40 cm; 13 of 18 years at 60 cm; and 16 of 18 years at a soil depth of 90 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 12 of 17 years and >30 consecutive days in the four months after June 21, four of 17 years when the soil water data were complete for the ntire year. Soil water data were incomplete in 1958 and 1972 but the 60-day criterion was met in both years.

Site Stellar #1 (S1)

Site S1 (figs. 226, 251-253, table 11) is in the exclosure at the south boundary of the Jornada Experimental Range. The study trench is about 4 m north of the exclosure. Vegetation is tobosa, but a somewhat sparser stand than at site VS3, discussed later.

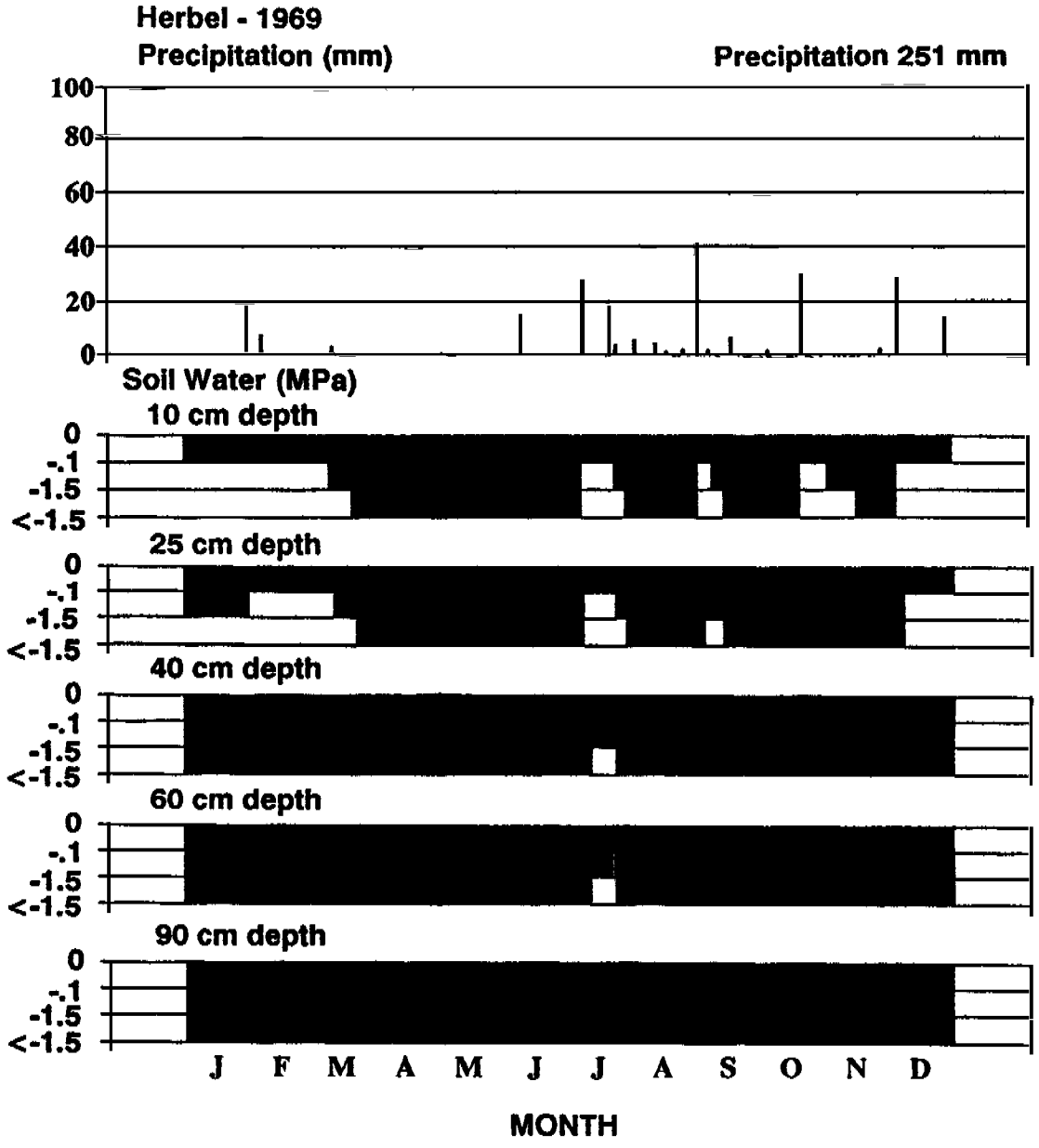


Figure 242. Annual precipitation (251 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1969.

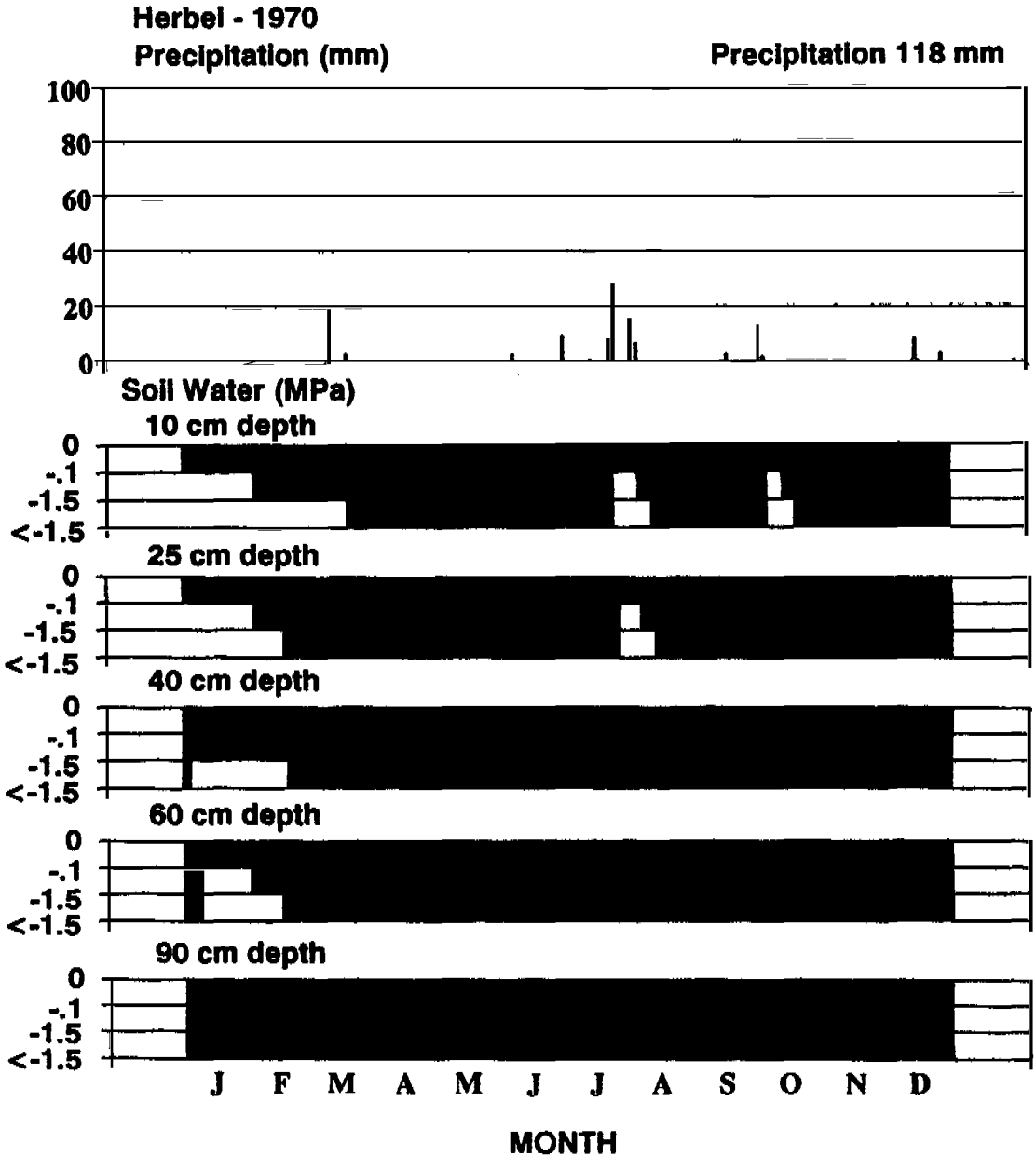


Figure 243. Annual precipitation (118 mm), daily precipitaion (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1970.

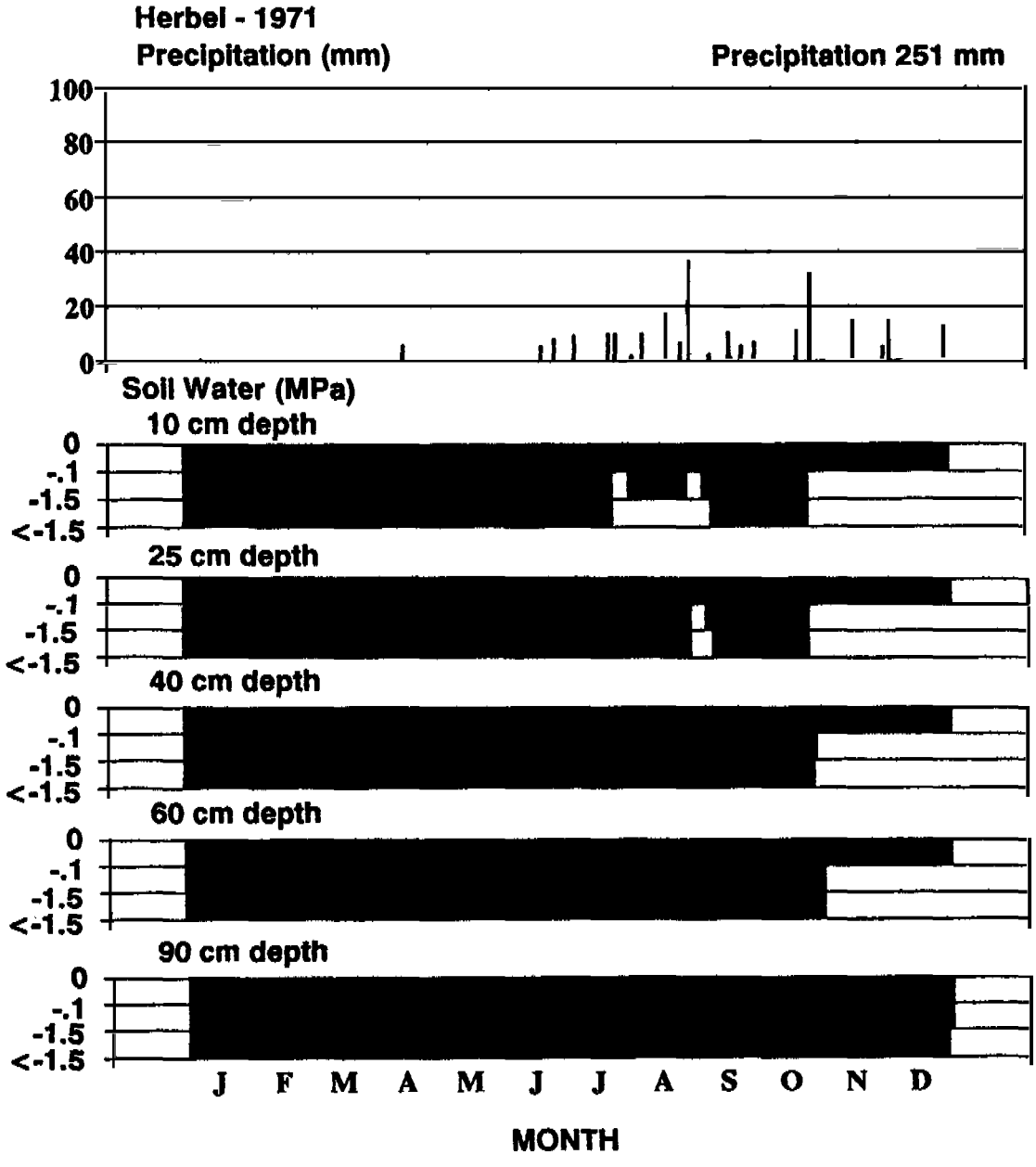


Figure 244. Annual precipitation (251 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1971.

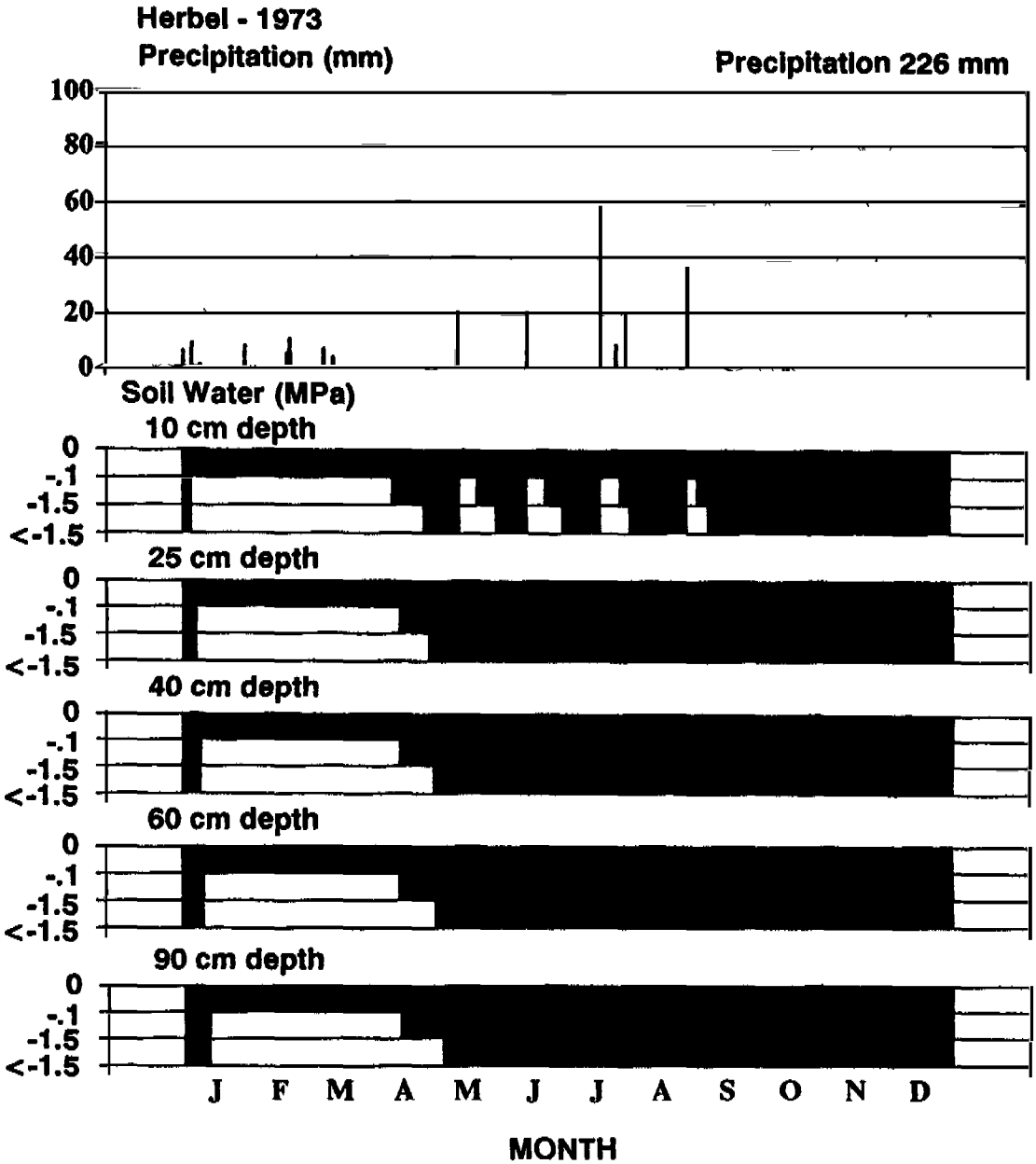


Figure 246. Annual precipitation (226 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1973.

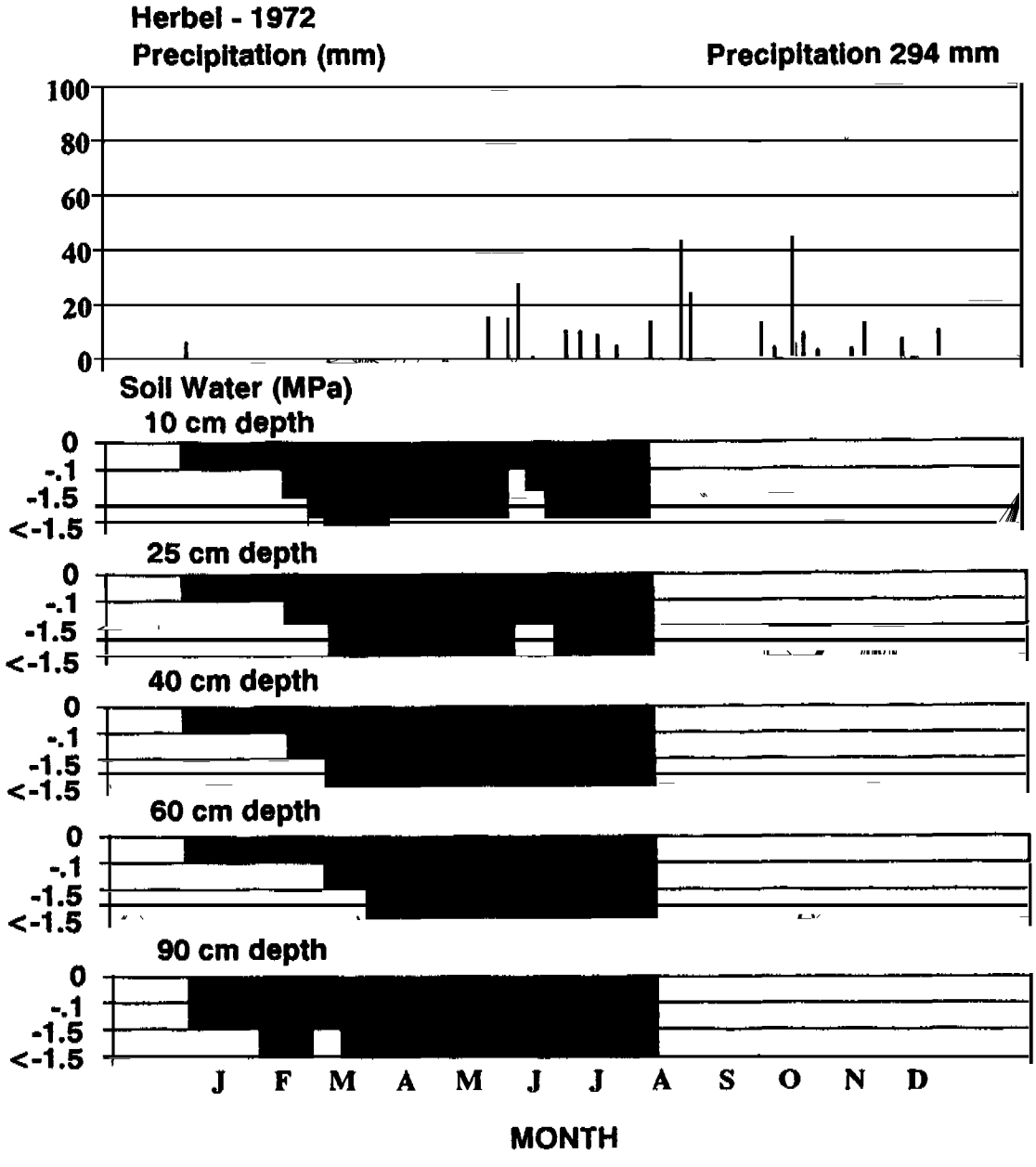


Figure 245. Annual precipitation (294 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm for January 1-August 12, 1972 at the Herbel site.

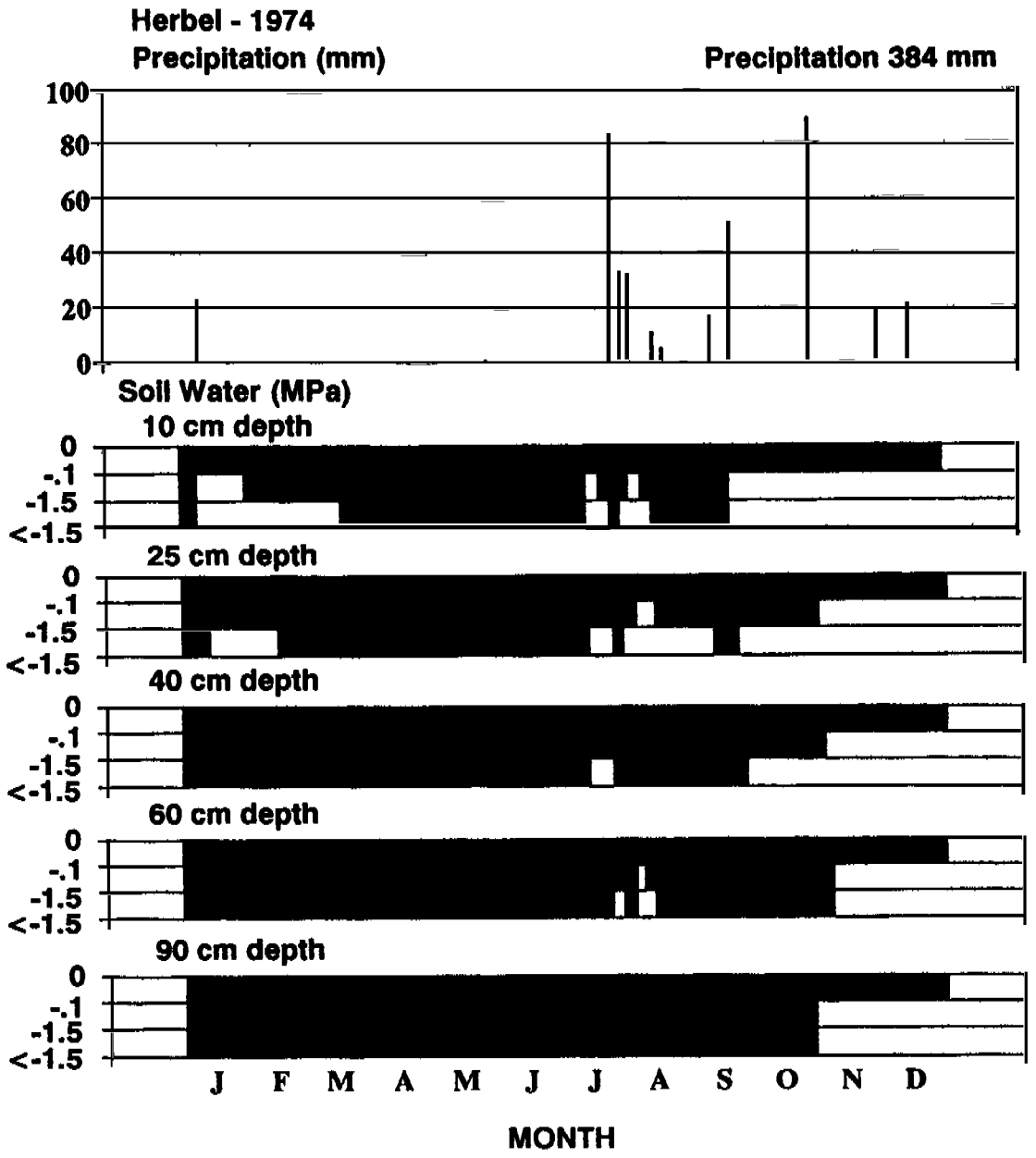


Figure 247. Annual precipitation (384 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1974.

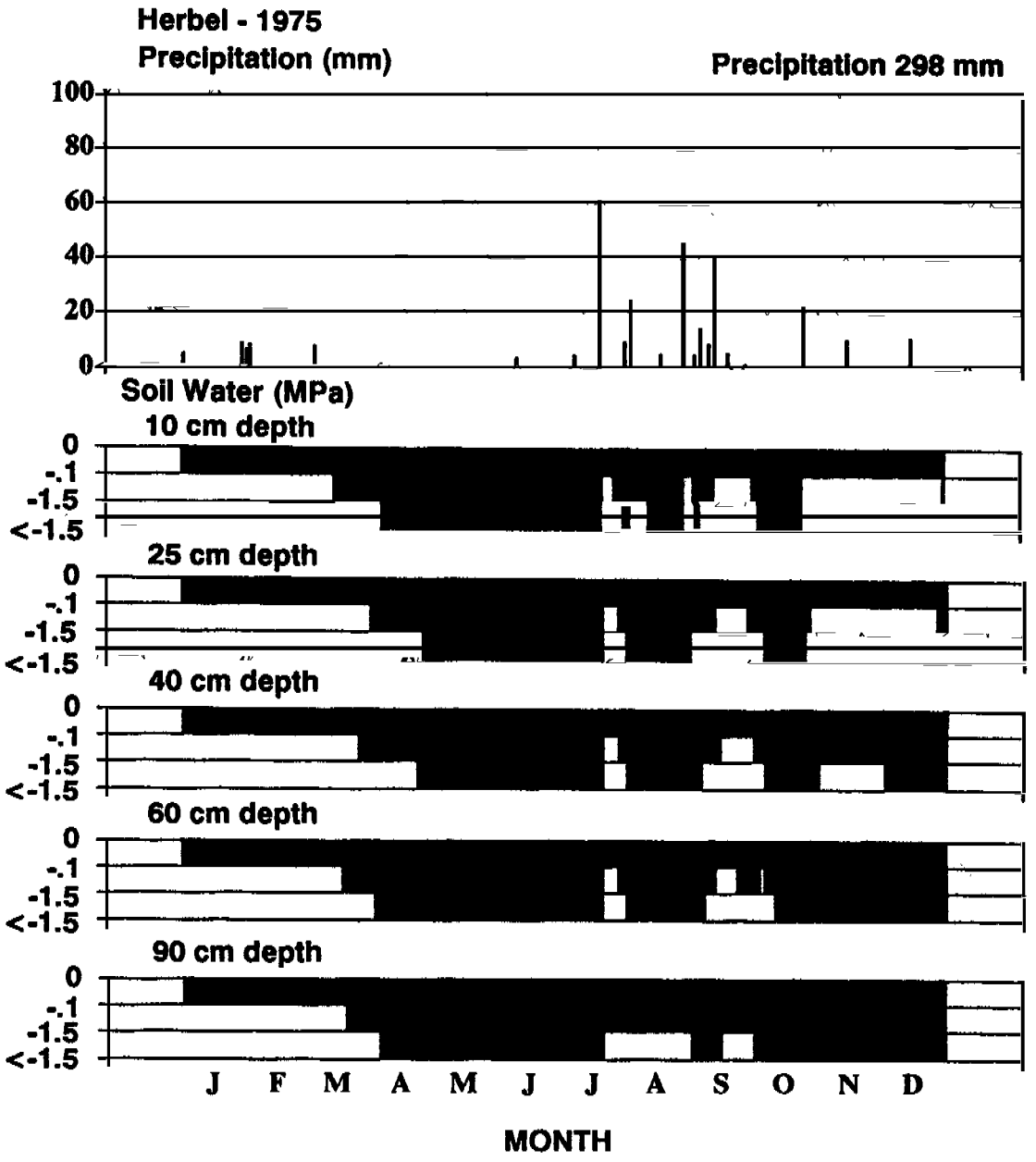


Figure 248. Annual precipitation (298 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1975.

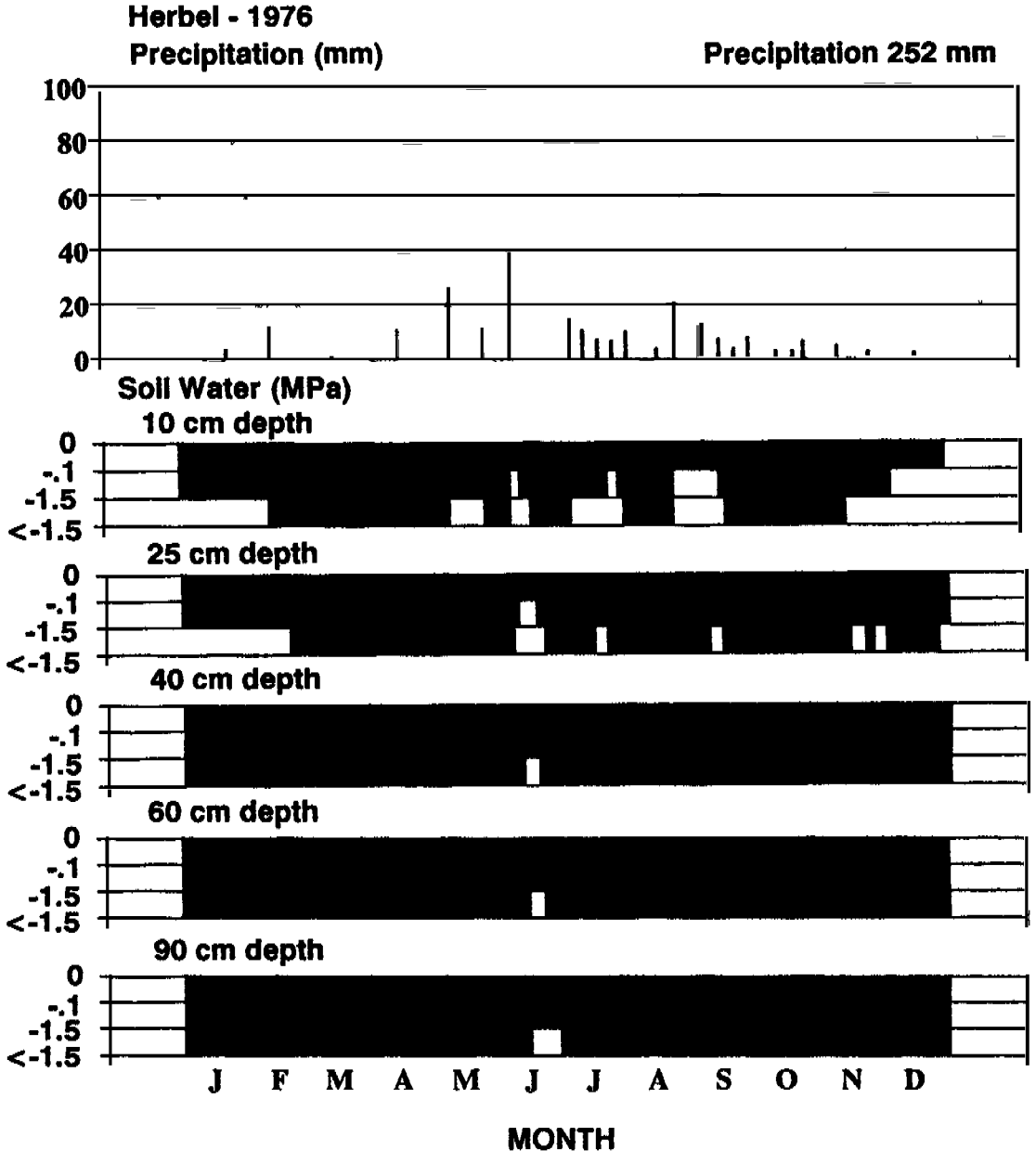


Figure 249. Annual precipitation (252 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site for 1976.

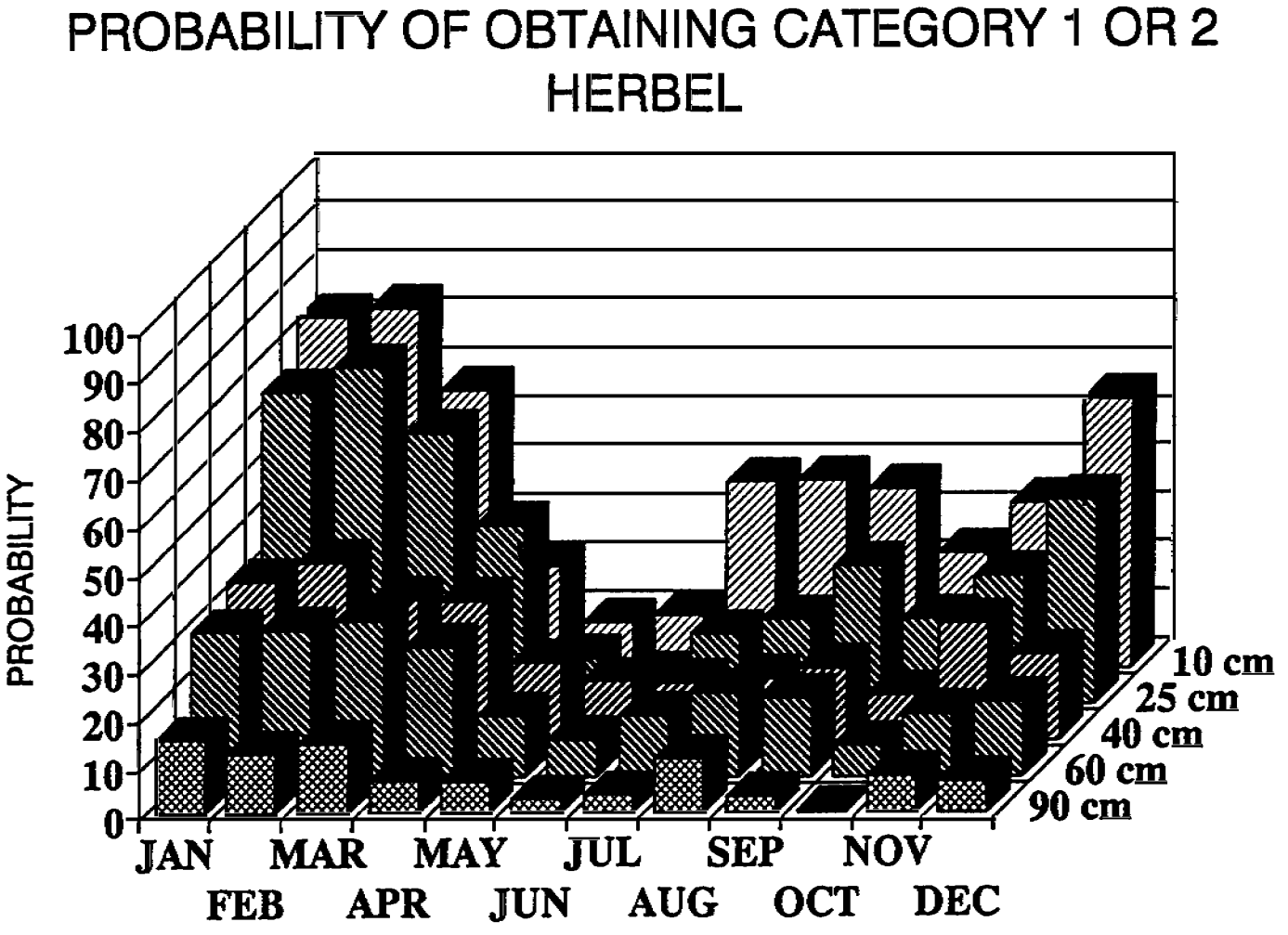


Figure 250. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 (MPa) at depths of 10, 25, 40, 60, and 90 cm at the Herbel site.

Table 11. Characteristics of the Calciorthid and Haplargid at sites S1 and R.

Alluvium	Horizon	Depth cm	Hue	Value/Chroma Dry	Value/Chroma Moist	Structure	Consistence Dry	Consistence Moist	Eff. with HCl	Textural class
				Ustollic Haplargid, Stellar, at Site S1						
Jornada I	E	0-5	10YR	7/2	4/3	lfpl,lmpl	sh	fr	es	cl
	EB	5-9	7.5YR	6/3	4/3	lfsbk	h	fr	nc, e	cl
	Bt1	9-23	6YR	5/4	4/4	lmpr-lmsbk, lfsbk	vh	fi	nc	c
	Bt2	23-44	6YR	5/4	4/4	lcpr,lm,sbk	vh	fi	es	cl
	Btk1	44-67	5YR	5/4	4/4	lcpr-lm,csbk	vh	fi	es	c
	Btk2	67-87	5YR	5/4	4/4	lcpr-lm,csbk	vh	fi	es	c
	K1	87-118	7.5YR	8/2	7/4	lmsbk	h	fi	es	cl
			7.5YR	6/4	5/4					
			5YR	5/4	4/4					
	K2l	118-134	7.5YR	8/2	7/4	lm,cpl	h	fi	es	cl
			7.5YR	7/4	6/4					
			5YR	8/4						
			5YR	5/4						
				Ustollic Calciorthid, Reagan, at Site R						
Petts Tank	A	0-4	10YR	6.5/2	4.5/3	lf,mpl	sh		es	cl
	AB	4-10	10YR	6.5/2	4/3	lcsbk	vh	fi	es	cl
	BA	10-26	7.5YR	6/4	5/4	lf,msbk	sh,h	fr	es	cl
	Bk1	26-53	7.5YR	6/4	4.5/4	lmpr-lf,msbk	h	fr	es	cl
	Bk2	53-79	7YR	5.5/4	4/4	2mpr-lmsbk	h	fr	es	cl
	K&B	79-95	7.5YR	7/4	5/4	lm,fsbk	sh,h	fr	es	cl
			10YR	9/3-7/3						
Jornada I	Btkb	95-122	5YR	5/5	4/5	lmpr-lf,				
			5YR	5/4	4/4	msbk	h	fr	e,es	cl
			7.5YR	6/4						

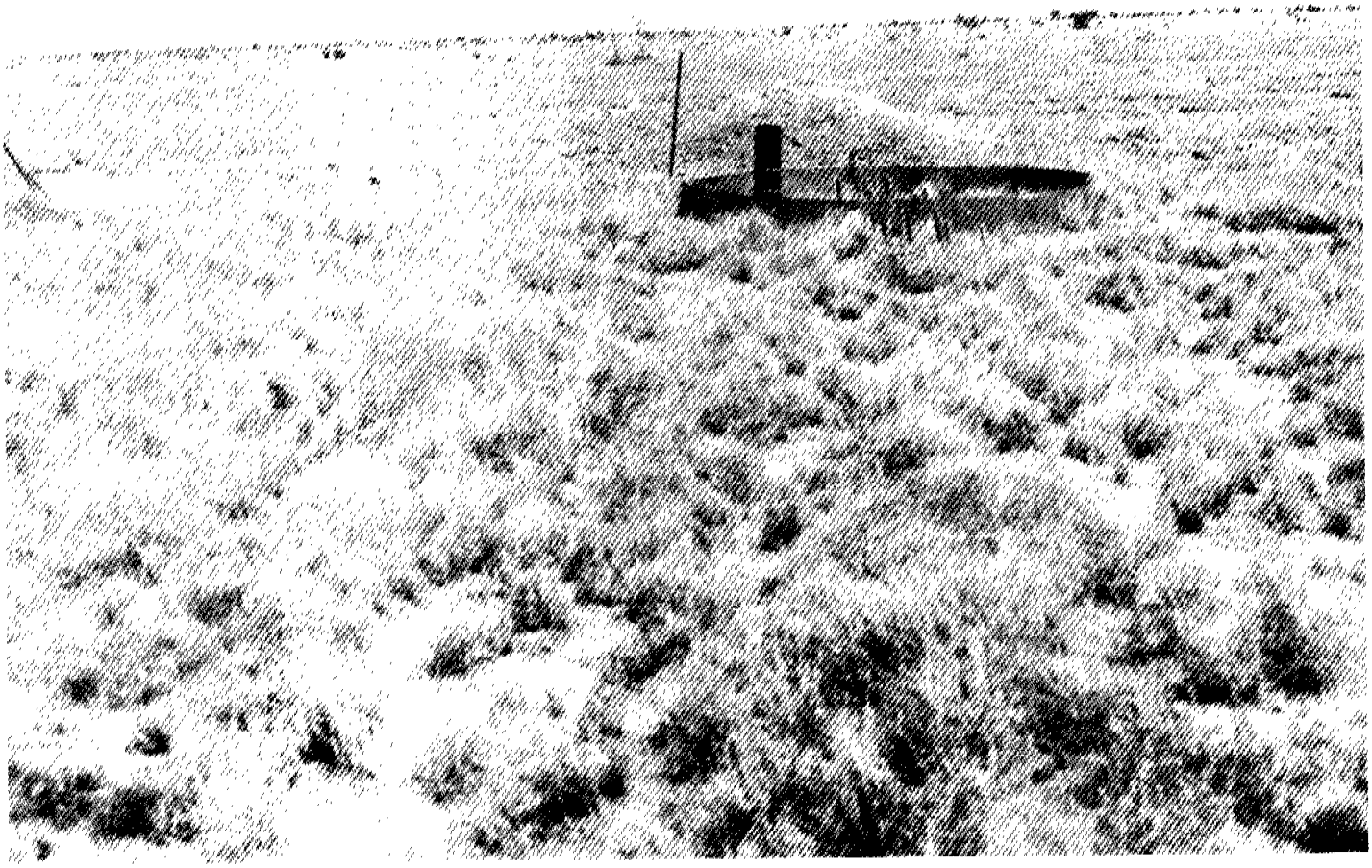


Figure 251. Landscape of the basin floor at Site S1 (fig. 226) and the Ustollic Haplargid Stellar #1, at the Hmu exclosure at the Jornada Experimental Range. Stakes and wires to the soil water blocks are both inside and outside the large metal cylinders; the nonrecording rain gauge is inside the metal cylinder. The study trench is beyond the cylinder. Photographed May 1971.

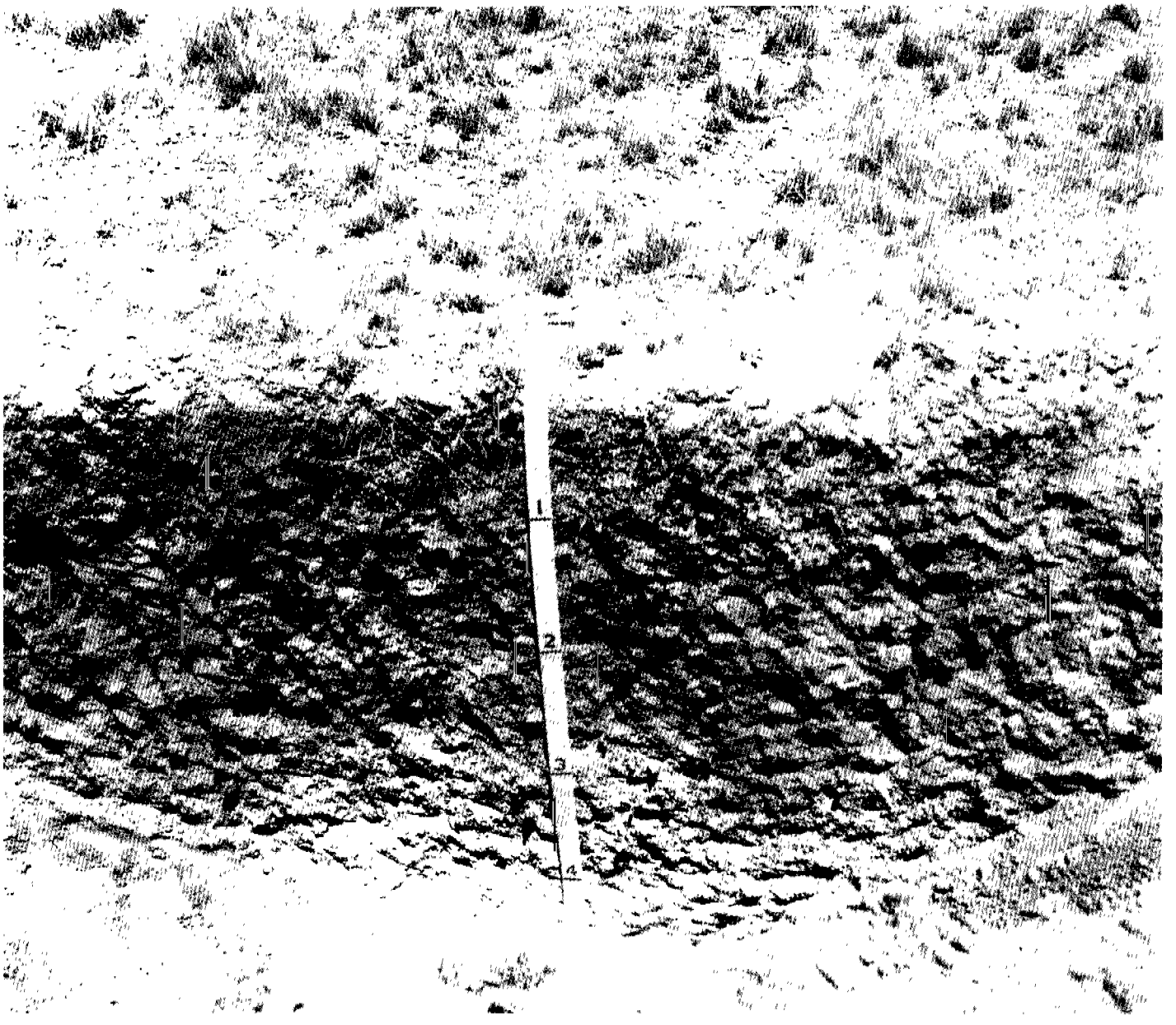


Figure 252. Profile of the Ustollic Haplargid Stellar #1. Scale is in feet.

Average annual production for 1960-70 was 1,055 kg/ha; during 1960-66 it was 755 kg/ha. The latter was only 32% of the production obtained at site VS3 for the same period.

This site and site R, discussed in the next section, occur on the basin floor (fig. 253). Although the basin floor is very nearly level, run-in water from the adjacent slopes does not stand on the area but drains slowly to a playa about 2 km south of these sites.

Soils. The soil water blocks are in the Ustollic Haplargid Stellar #1 (fig. 252, table 11). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a calcic horizon. The soil has formed in basin-floor sediments derived from monzonite, rhyolite, andesite, and latite, and is on the Jornada I surface of late mid-Pleistocene age. Stellar #1 differs from the Stellar at site VS3 in having formed almost wholly in Jornada I sediments (fig. 253, tables 1, 2; a thin deposit of Jornada II alluvium may be present at the surface). Stellar #1 is very similar to Stellar 60-21, only a few meters south (See Gile and Grossman, 1979, p. 838-839, for laboratory data and description).

The effect of run-in is substantial (figs. 254-293). At the 25-cm depth, the days per year when soil moisture is at 0 to -1.5 MPa with run-in is more than twice that without run-in. This extra moisture may be critically important in keeping most of the E and Bt1 horizons noncalcareous. However, available soil moisture at all depths, both with and without run-in, is less frequent than for the Paleargids discussed previously. This is attributed to the finer texture of Stellar, and to the considerably greater percentage of clay and silt associated with the smooth-topped plates in the E horizon. Such horizons have a tendency to "seal" when wetted (Gile et al., 1981).

Soil Water, Precipitation, and Yields. The gypsum resistance blocks were installed in two replications at depths of 10, 25, and 40 cm on August 16, 1957 and at soil depths of 60, 90, and 120 cm on July 29, 1959 within a livestock exclosure at the south boundary. Also on July 29, 1959 two replications of blocks were installed at depths of 10, 25, 40, 60, 90, and 120 cm within a sheet metal cylinder that excluded run-in water from adjacent slopes. The exclosure was 0.8 ha and extended from an area dominated by tobosa to one dominated by burrograss (Reagan soils). This section discusses the area dominated by tobosa. The rain gauge at this location was established July 15, 1958. Daily precipitation between August 16, 1957 and July 15, 1958 can be obtained from Stellar #2 which is 1.1 km from Stellar #1.

Precipitation at Stellar #2 August 16-December 31, 1957 totaled 195 mm. The matric potential of the soil water at 10 cm was >-1.5 MPa August 16-26, 1957 (fig. 254); August 30-September 7; and October 5-April 26, 1958 (figs. 254, 255). The moisture control section, 25-cm soil depth, had water >-1.5 MPa August 15-September 12 and October 14, 1957-May 2, 1958 (figs. 254, 255). There was soil water >-1.5 MPa at 40 cm August 16-September 9 and October 15, 1957-May 3, 1958 (figs. 254, 255). The tobosa on 25, 30.5-cm x 1.5-m quadrats was clipped to ground level each fall.

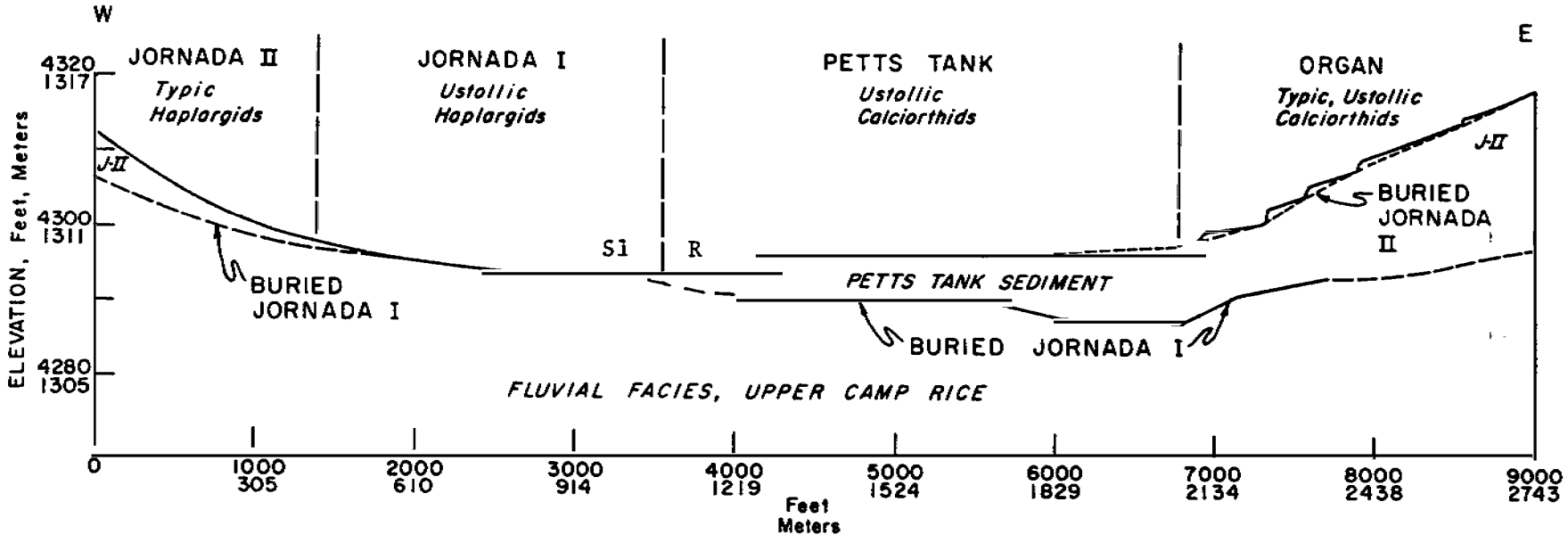


Figure 253. Cross section of the basin floor and adjacent piedmont slope at sites S1 and R, showing the geomorphic surfaces, subgroups, stratigraphy and elevations. Modified from fig. 195 in Gile and Grossman (1979).

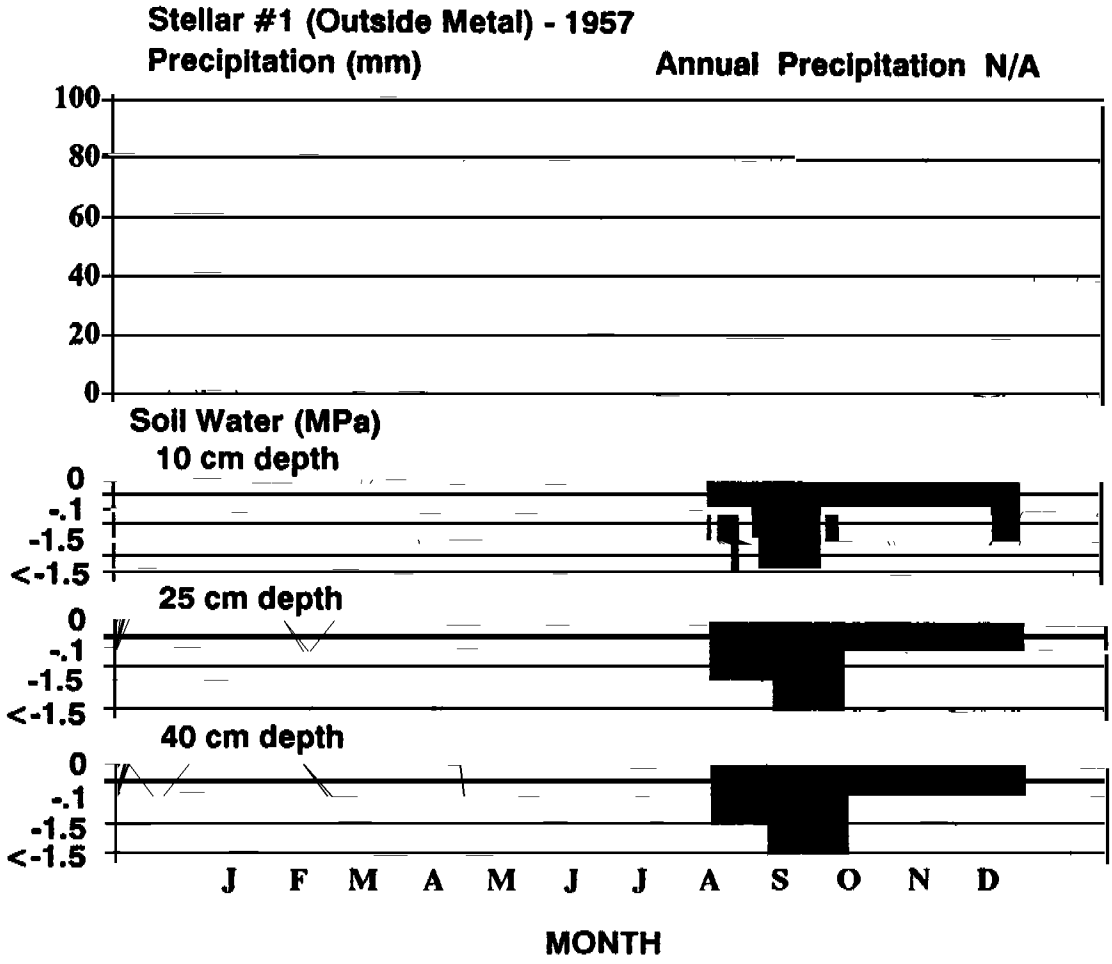


Figure 254. The matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 16-December 31, 1957 outside a sheet metal cylinder at the Stellar #1 site.

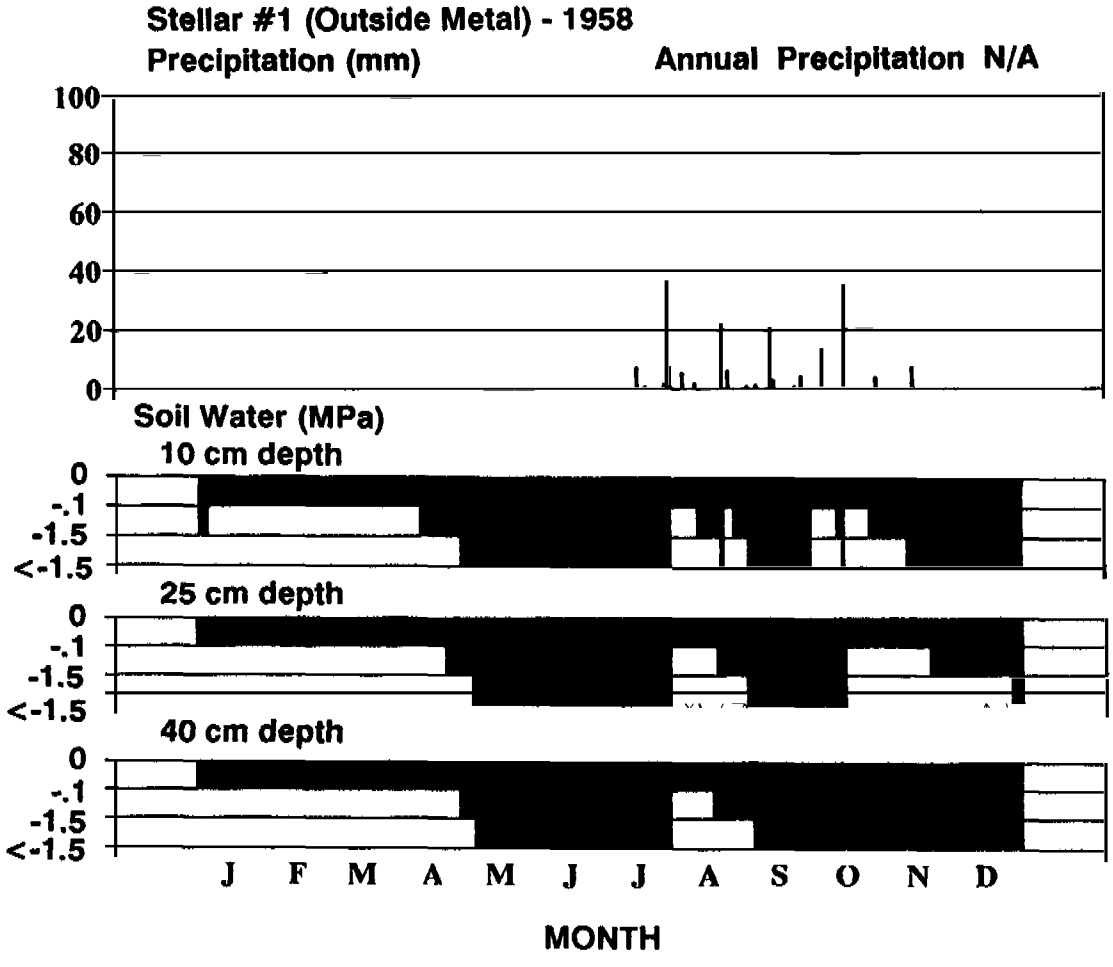


Figure 255. Daily precipitation (mm) for July 15-December 31, 1958 and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for 1958 outside a sheet metal cylinder at the Stellar #1 site.

The average production of tobosa in 1957 was 1880 kg/ha (s.e.=189 kg/ha).

The precipitation at Stellar #2 January 1-July 14, 1958 was 94 mm. The precipitation at this location for the remainder of 1958 was 178 mm. Besides the soil water during the winter and early spring, the 25-cm soil depth had water >-1.5 MPa July 30-August 31 and October 15-December 26, 1958 (fig. 255). Tobosa yielded 1523 kg/ha (s.e.=261 kg/ha).

The 1959 precipitation at this location was 239 mm (fig. 256). The 25-cm soil depth outside the metal cylinder had water >-1.5 MPa July 29-October 11 and October 14-21, 1959 (fig. 256). The 25-cm depth inside the cylinder had soil water >-1.5 MPa July 29-October 7 (fig. 257) indicating that run-in contributed 12 extra days of soil water >-1.5 MPa to the 25-cm depth in October 1959. Estimates of tobosa production in fall 1959 were 1846 kg/ha (s.e.=164 kg/ha).

The annual precipitation for 1960 was 162 mm (figs. 258, 259). Except for soil water >-1.5 MPa at 90 and 120 cm in the winter and early spring, only the 10-cm depth had soil water >-1.5 MPa during the growing season (figs. 258, 259). Tobosa production was estimated at 390 kg/ha (s.e.=45 kg/ha).

Annual precipitation was 288 mm in 1961 (figs. 260, 261) and 269 mm in 1962 (figs. 262, 263). Outside the metal cylinder, there was soil water >-1.5 MPa February 1, 1961-April 12 (fig. 260); September 7-October 13; November 15, 1961-May 2, 1962 (figs. 260, 262); July 18-August 12; and September 25-November 4, 1962. Soil water inside the metal at 25 cm was >-1.5 MPa January 26-March 10, 1961 and November 25-29, 1961 (fig. 261). There were considerably more days of soil water >-1.5 MPa at the 25-cm depth outside the metal cylinder in both years (figs. 260-263). Tobosa yielded 978 kg/ha (s.e.=61 kg/ha) in 1961 and 1285 kg/ha (s.e.=72 kg/ha) in 1962.

The 1963 precipitation was 234 mm (figs. 264, 265). Outside the metal cylinder at the 25 cm depth, the soil water was >-1.5 MPa July 8-August 15 and August 23-September 21 (fig. 264) whereas inside the metal at 25 cm the soil water was >-1.5 MPa July 8-August 4 (fig. 265). Tobosa production in 1963 was 1666 kg/ha (s.e.=99 kg/ha).

Annual precipitation was below average for the next 3 years, 1964-1966 (figs. 266-271). The matric potential of the soil water at 25 cm was <-1.5 MPa inside the metal (figs. 267, 269, 271) while outside the metal at the same depth it was >-1.5 MPa September 12-October 11, 1964 (fig. 266) and August 3-28, 1966 (fig. 270). Annual yields of tobosa averaged 165 kg/ha (s.e.=19 kg/ha) in 1964, 14 kg/ha (s.e.=6 kg/ha) in 1965, and 782 kg/ha (s.e.=162 kg/ha) in 1966.

The 1967 and 1968 precipitation were similar (figs. 272-275). Outside the metal cylinder at the 25-cm depth, water was >-1.5 MPa June 30, 1967-July 28 (fig. 272); August 6, 1967-May 21, 1968 (figs. 272, 274); and July 28-August 28 (fig. 274). The soil water inside the metal at 25 cm was >-1.5 MPa August 5, 1967-May 8, 1968 (figs. 273, 275) and August 5-31, 1968 (fig. 275). There were 28

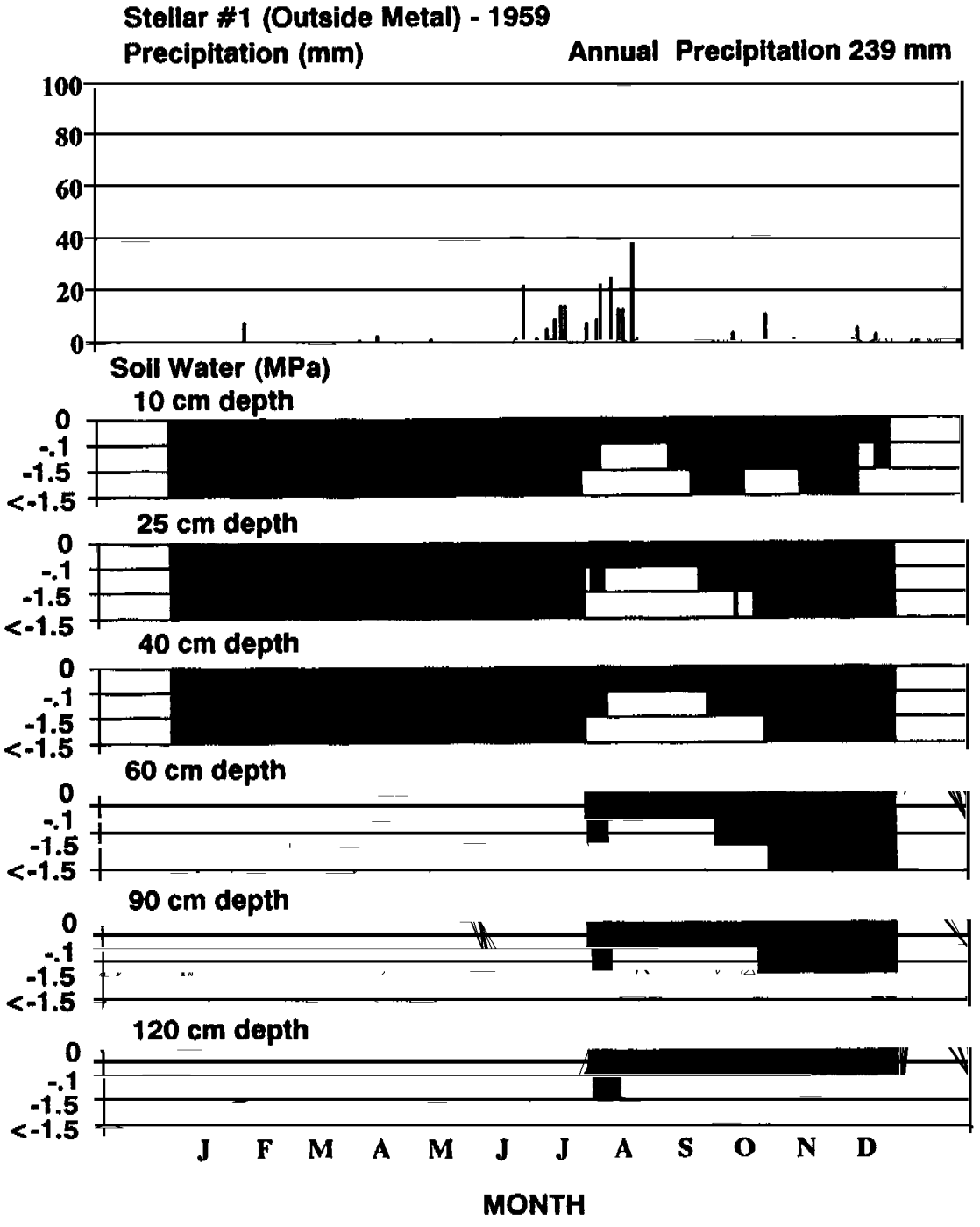


Figure 256. Annual precipitation (239 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm outside a sheet metal cylinder at the Stellar #1 site for 1959. Also shown is the soil water at depths of 60, 90, and 120 cm July 29-December 31, 1959.

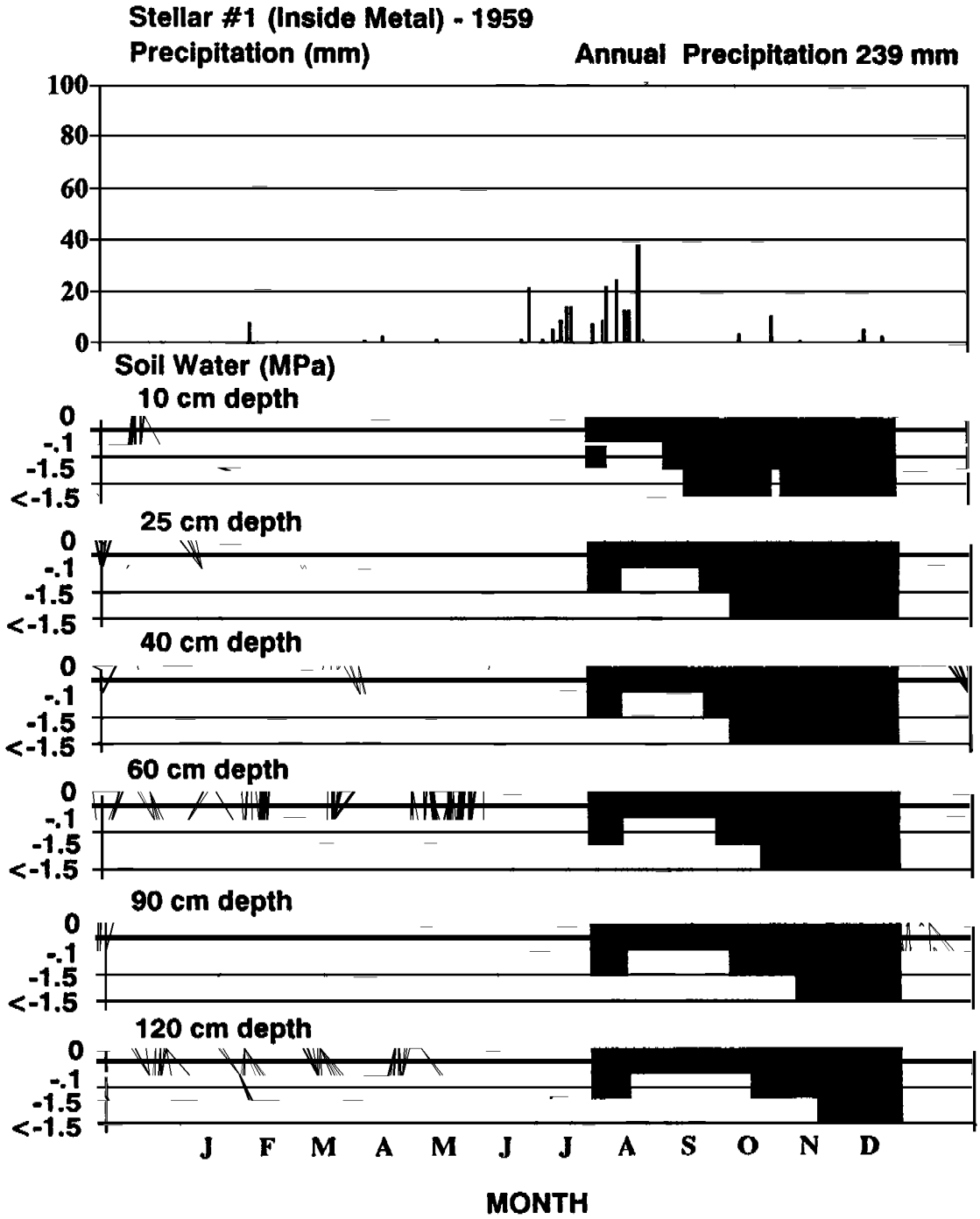


Figure 257. Annual (239 mm) and daily (mm) precipitation for 1959, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm July 29-December 31, 1959 inside a sheet metal cylinder at the Stellar #1 sit .

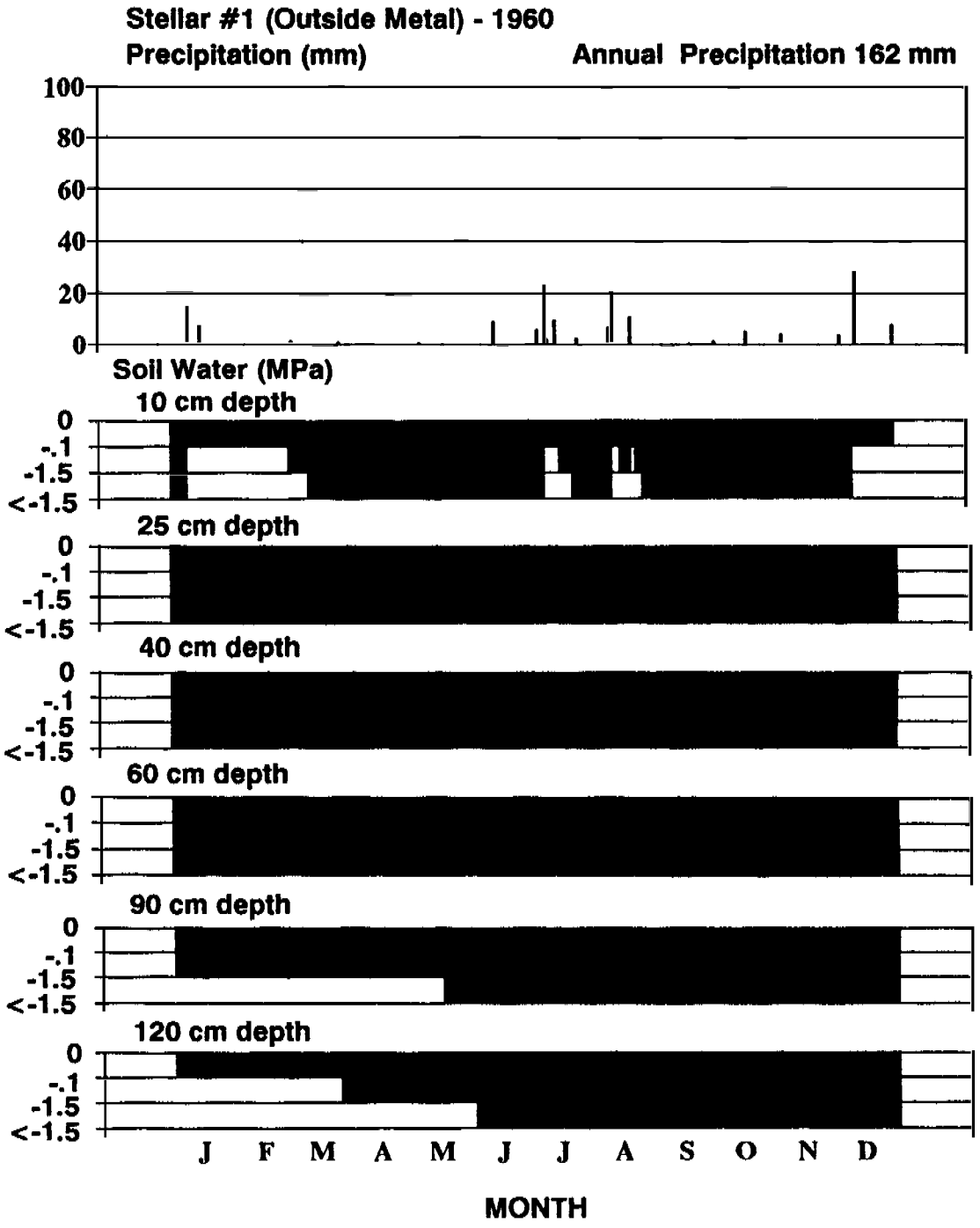


Figure 258. Annual precipitation (162 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1960.

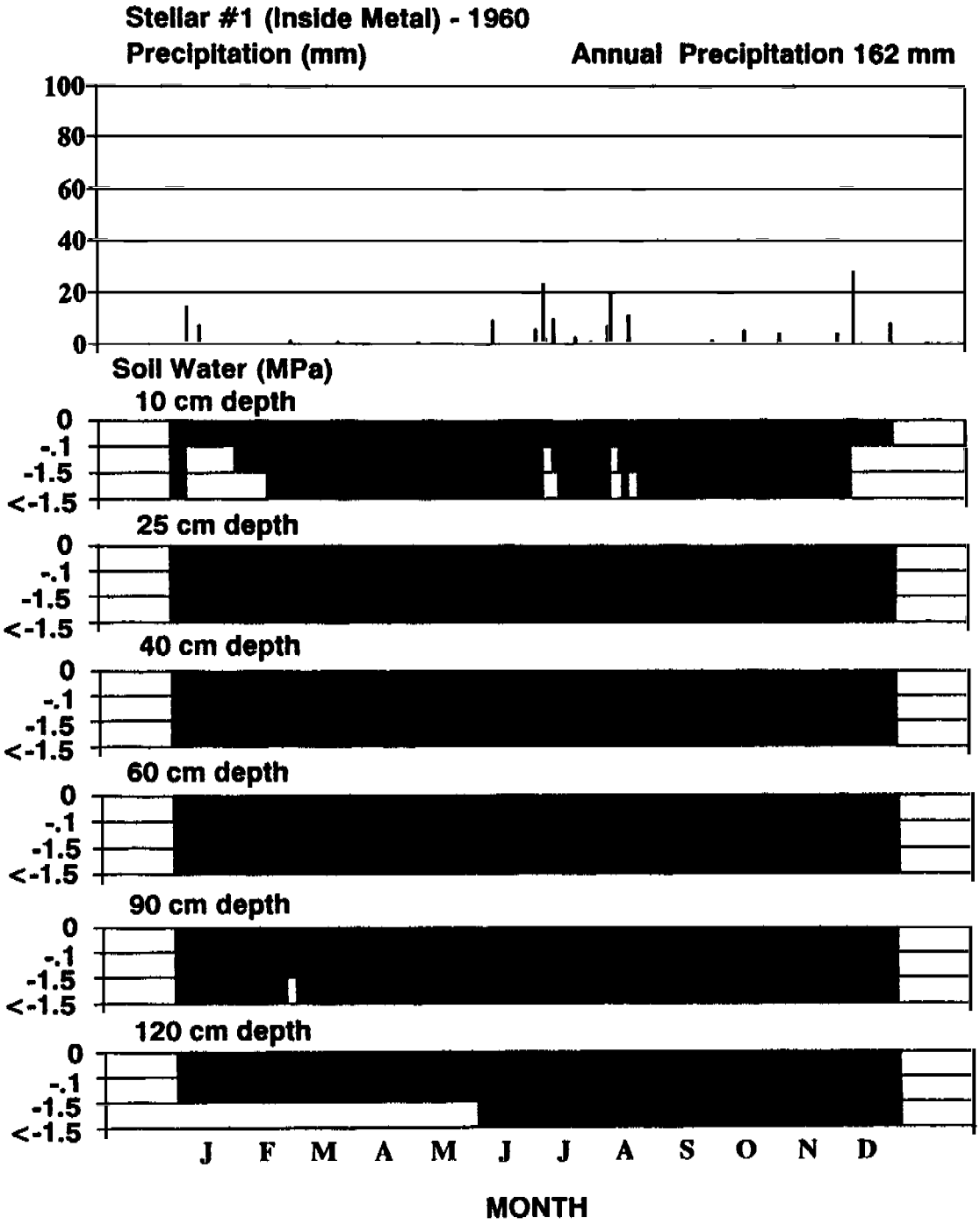


Figure 259. Annual precipitation (162 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1960.

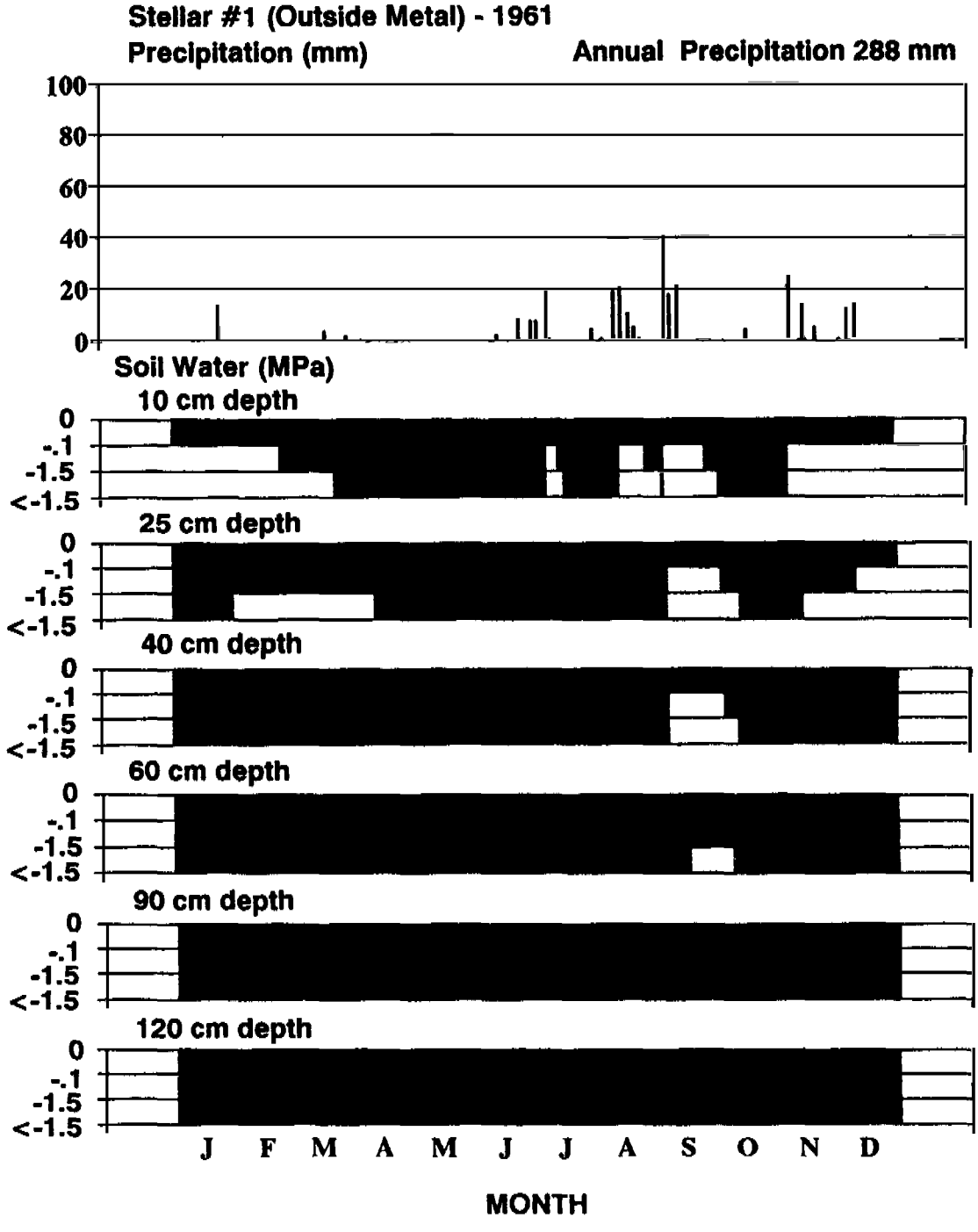


Figure 260. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1961.

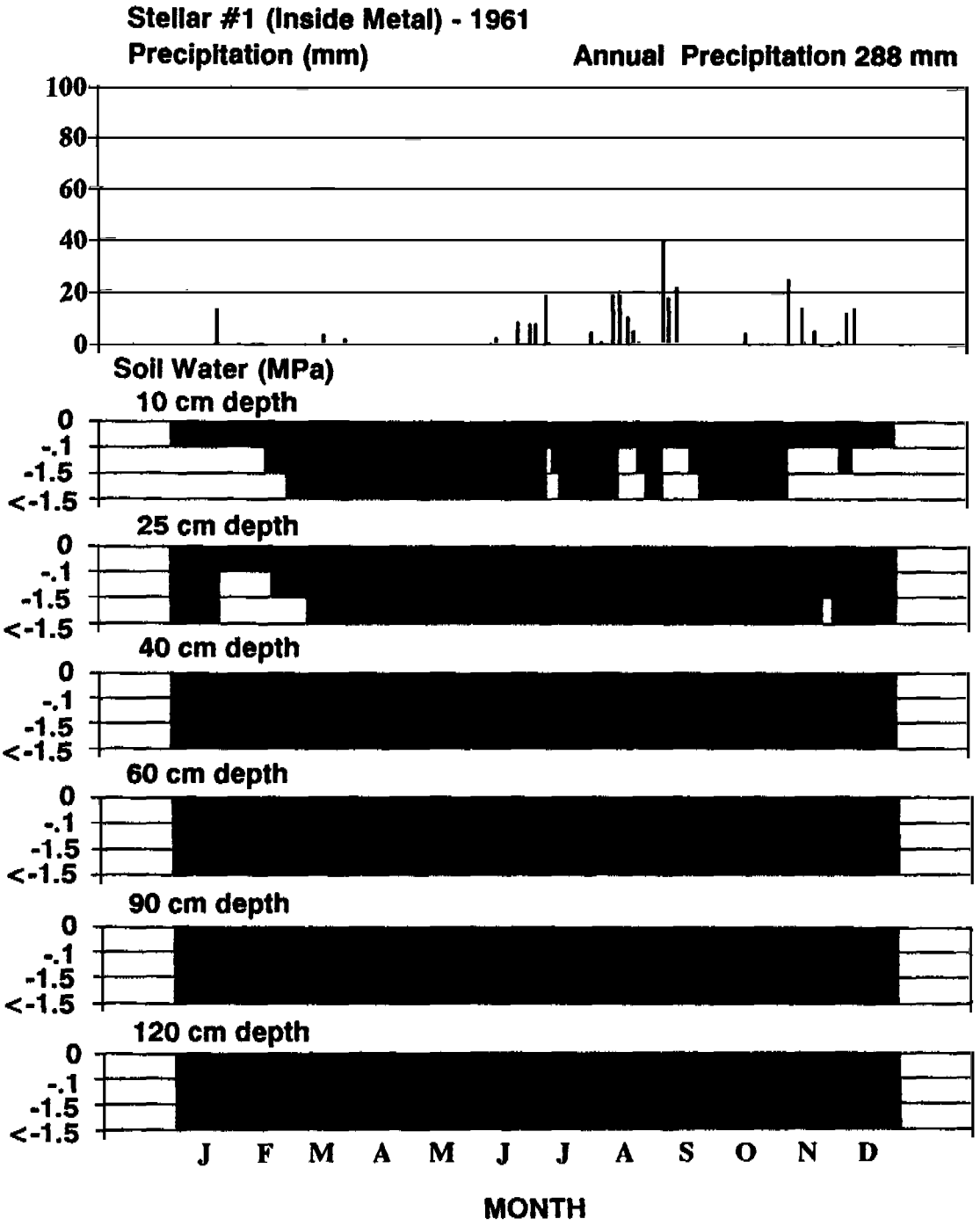


Figure 261. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1961.

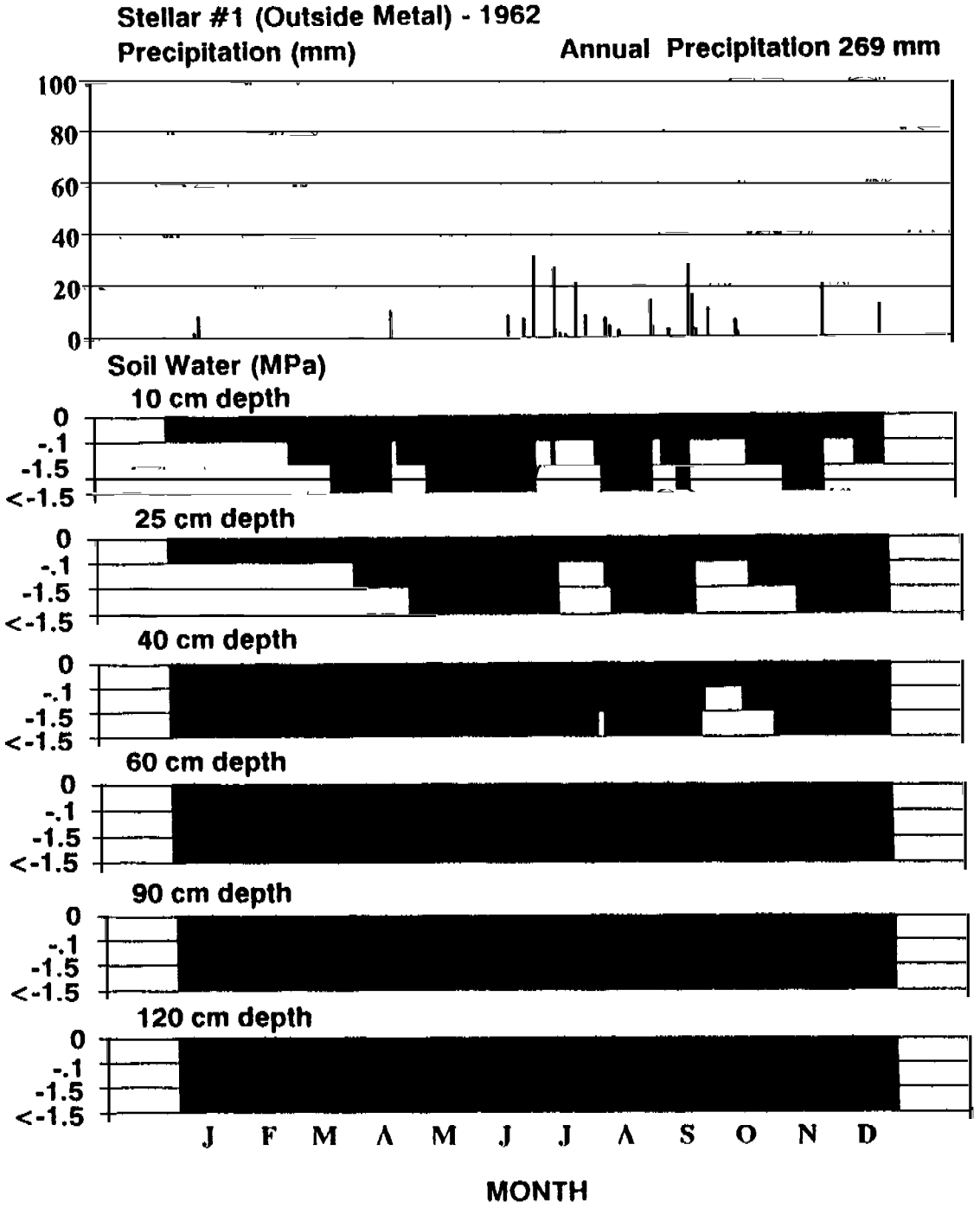


Figure 262. Annual precipitation (269 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1962.

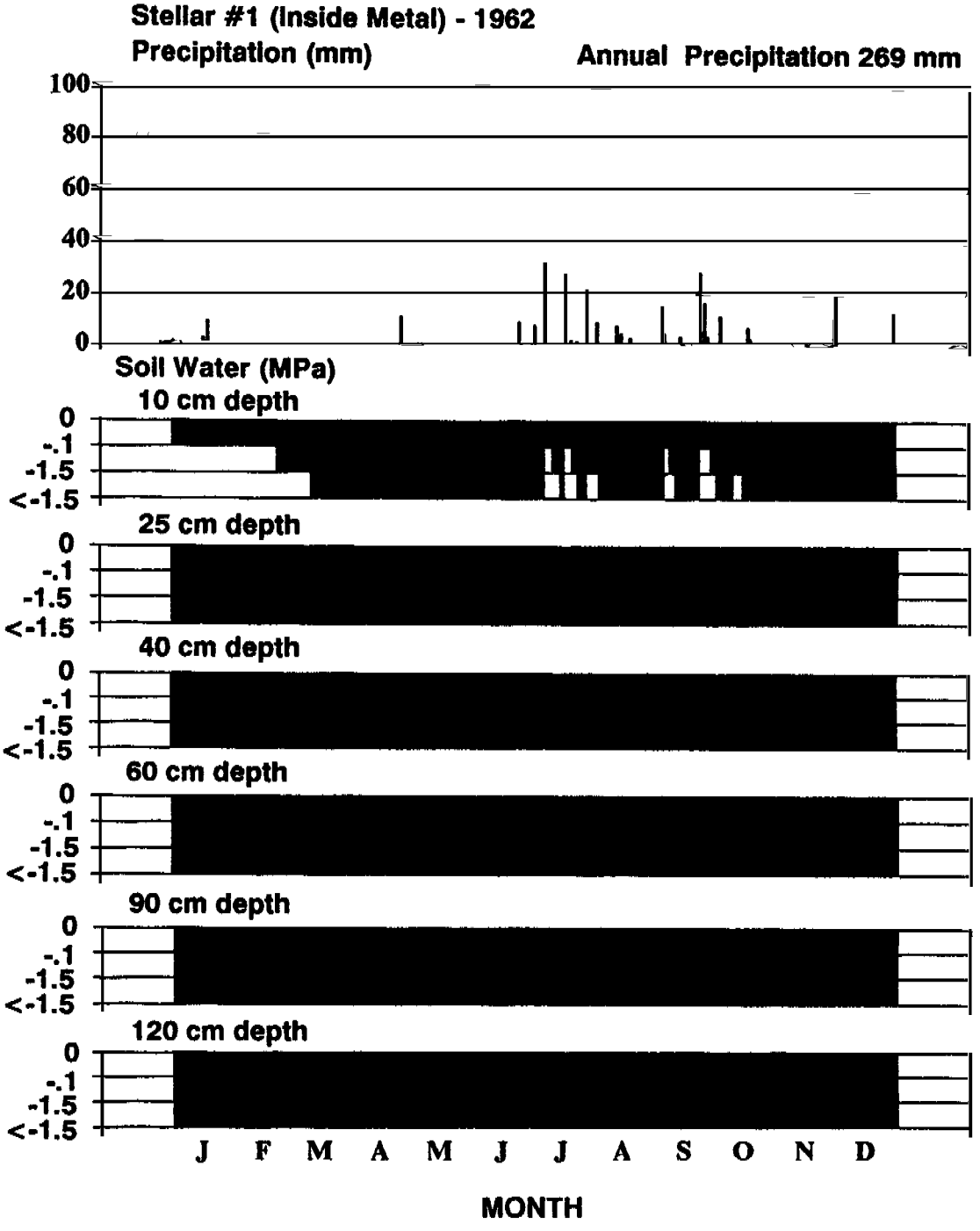


Figure 263. Annual precipitation (269 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1962.

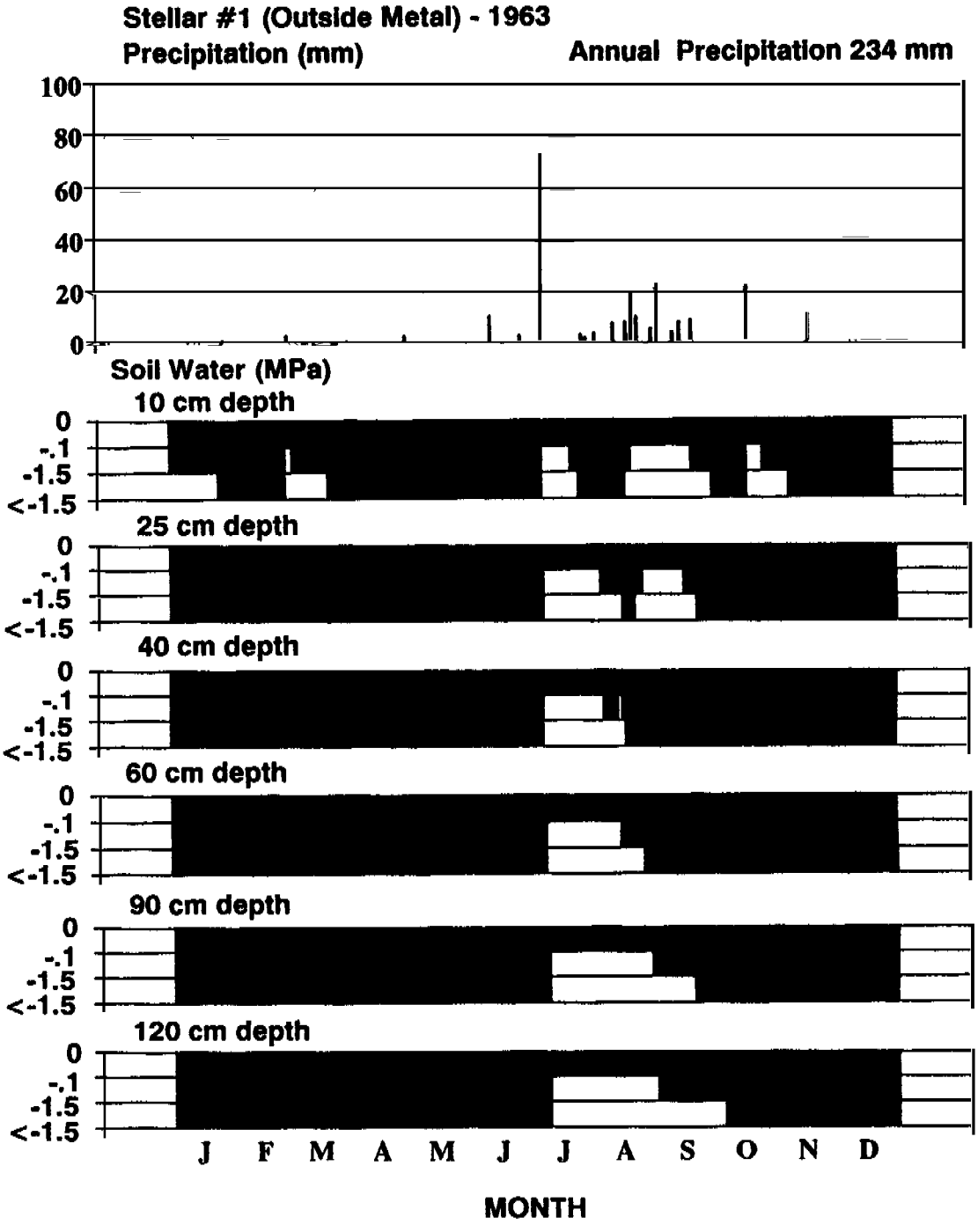


Figure 264. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1963.

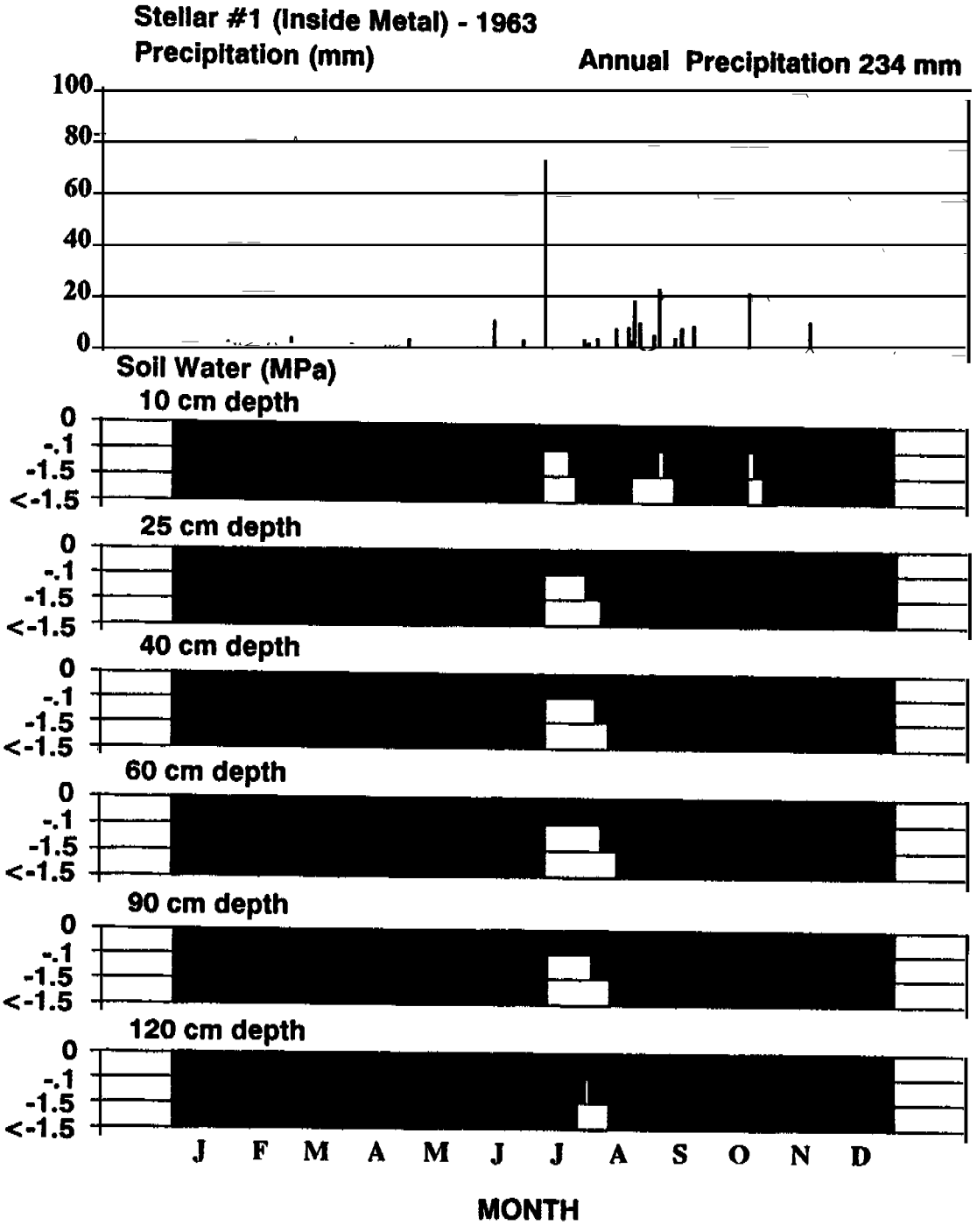


Figure 265. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1963.

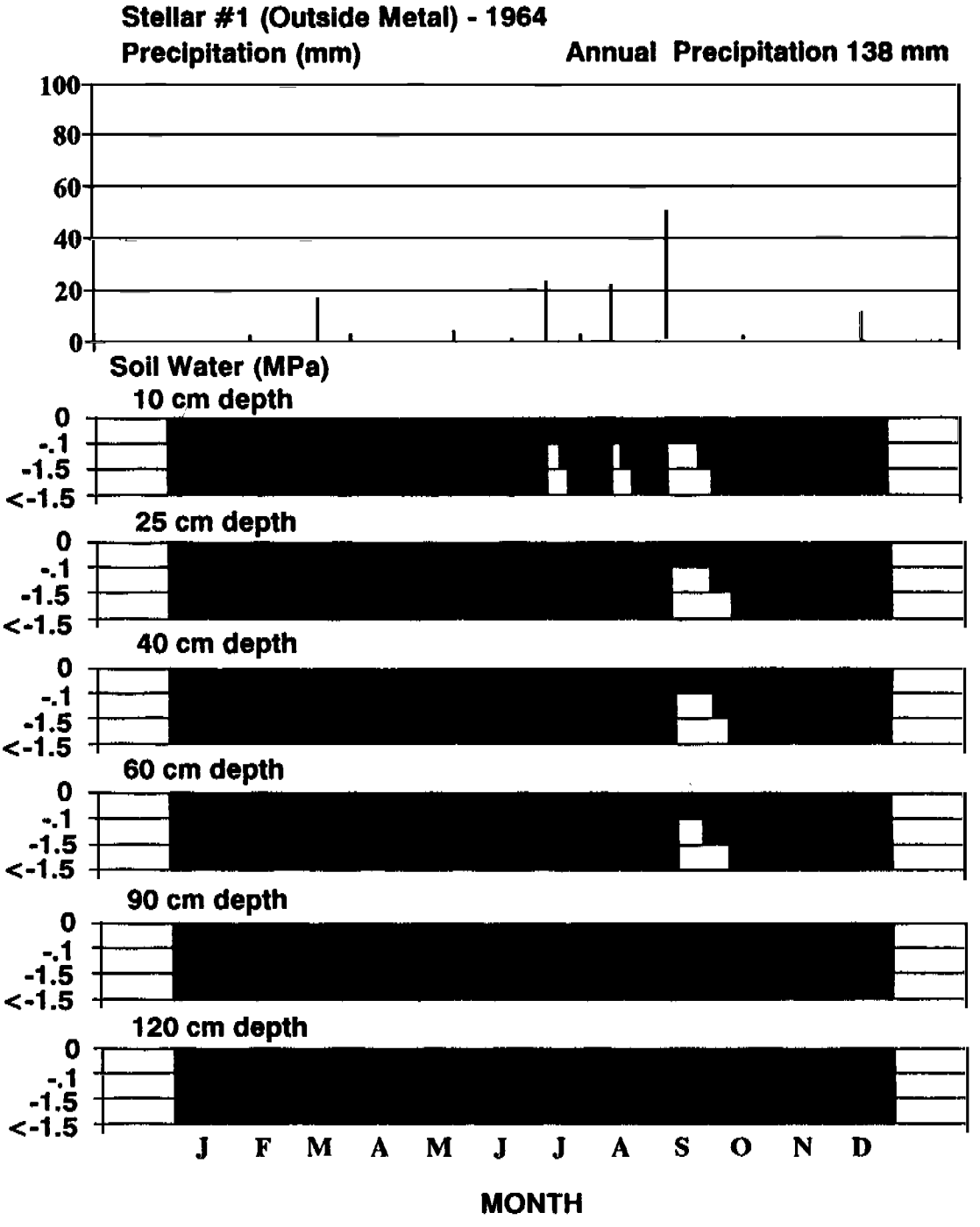


Figure 266. Annual precipitation (138 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1964.

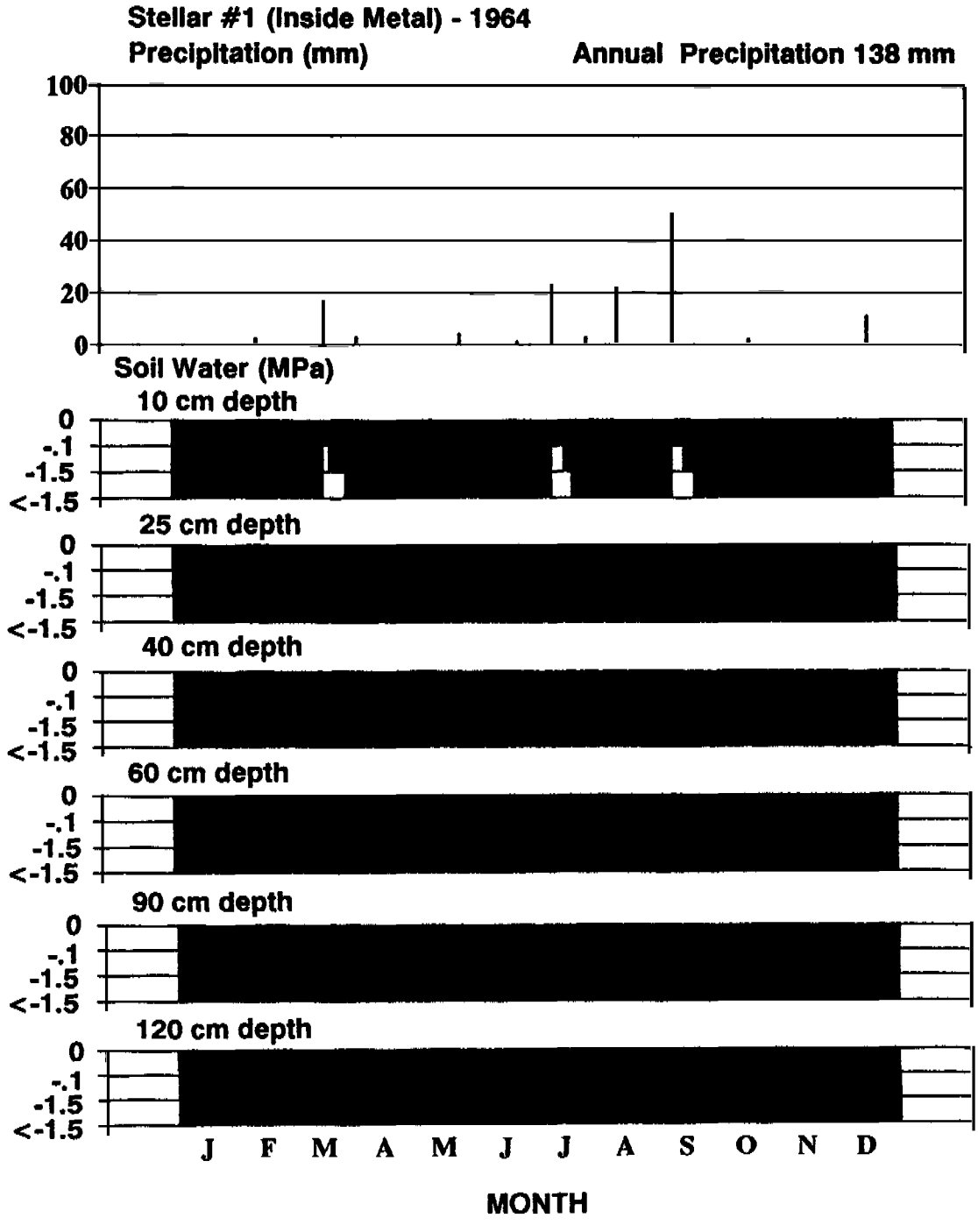


Figure 267. Annual precipitation (138 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1964.

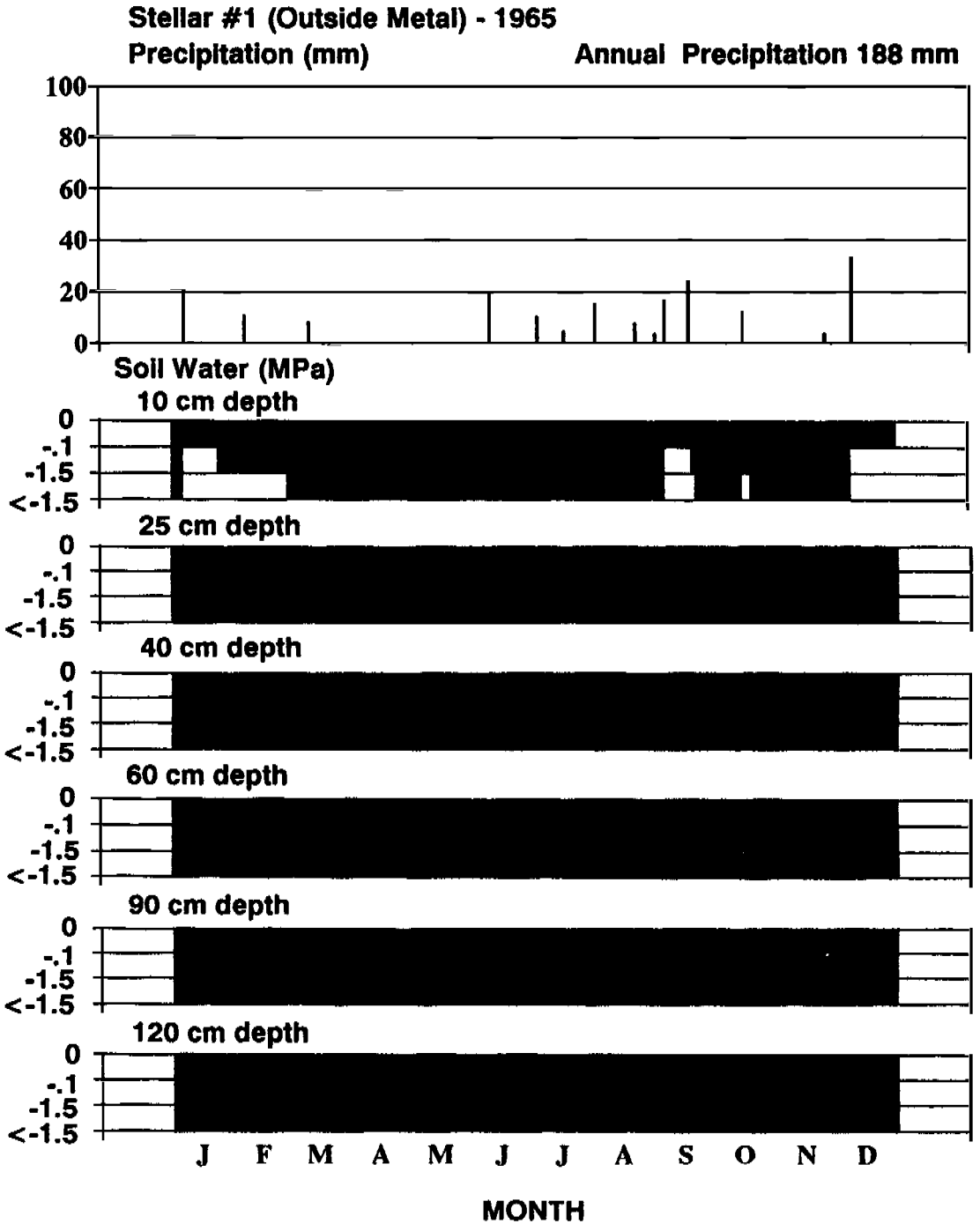


Figure 268. Annual precipitation (188 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1965.

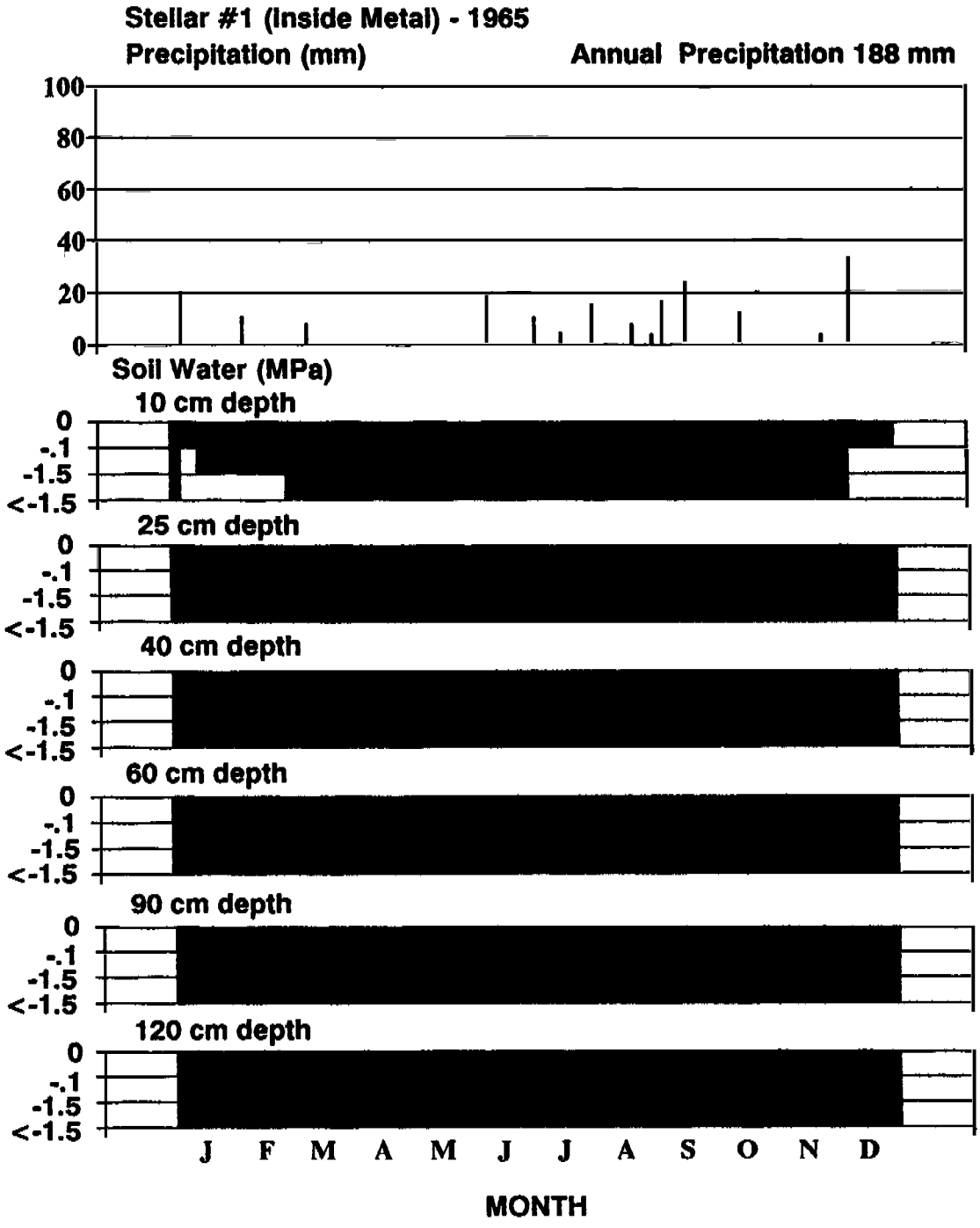


Figure 269. Annual precipitation (188 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1965.

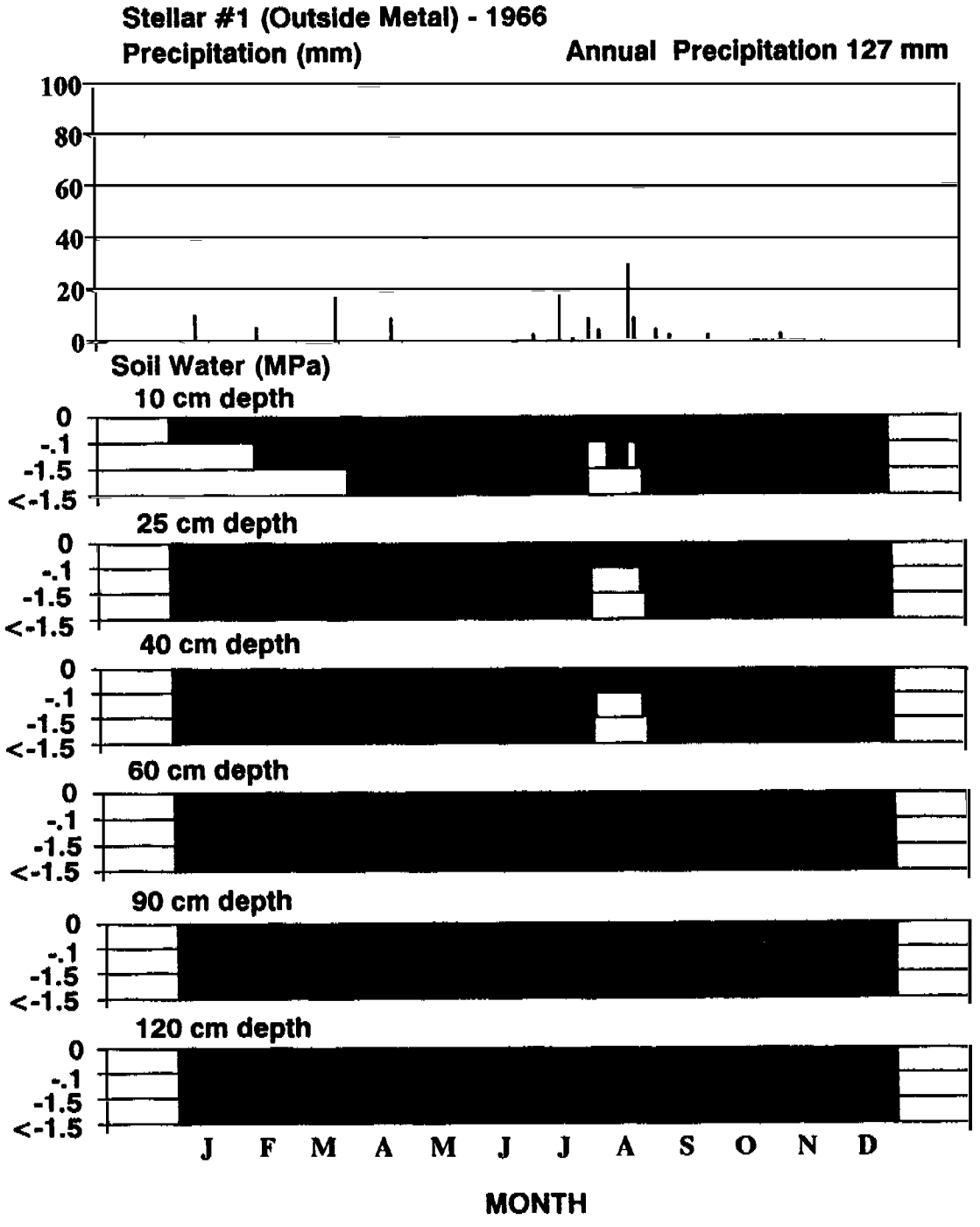


Figure 270. Annual precipitation (127 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1966.

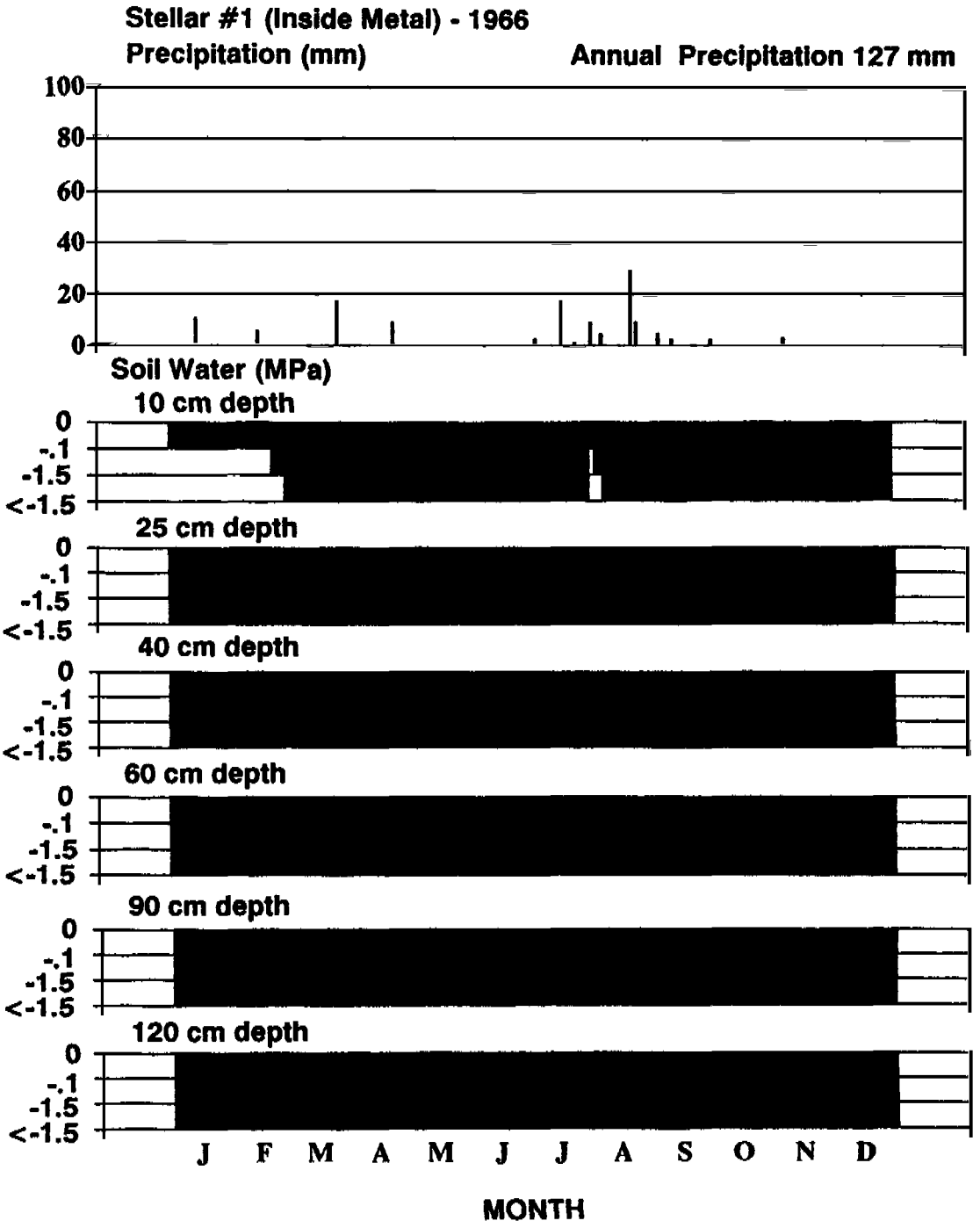


Figure 271. Annual precipitation (127 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1966.

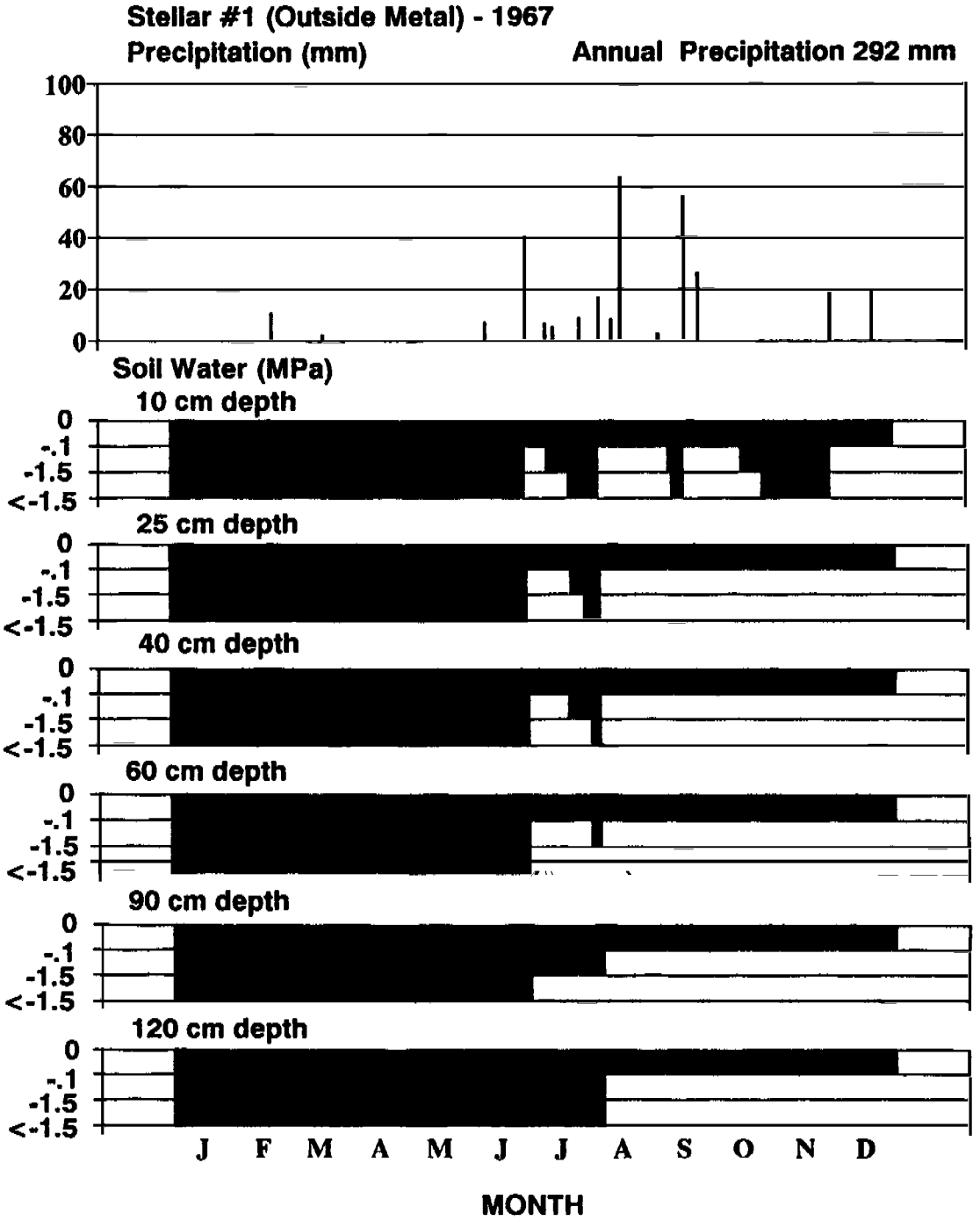


Figure 272. Annual precipitation (292 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1967.

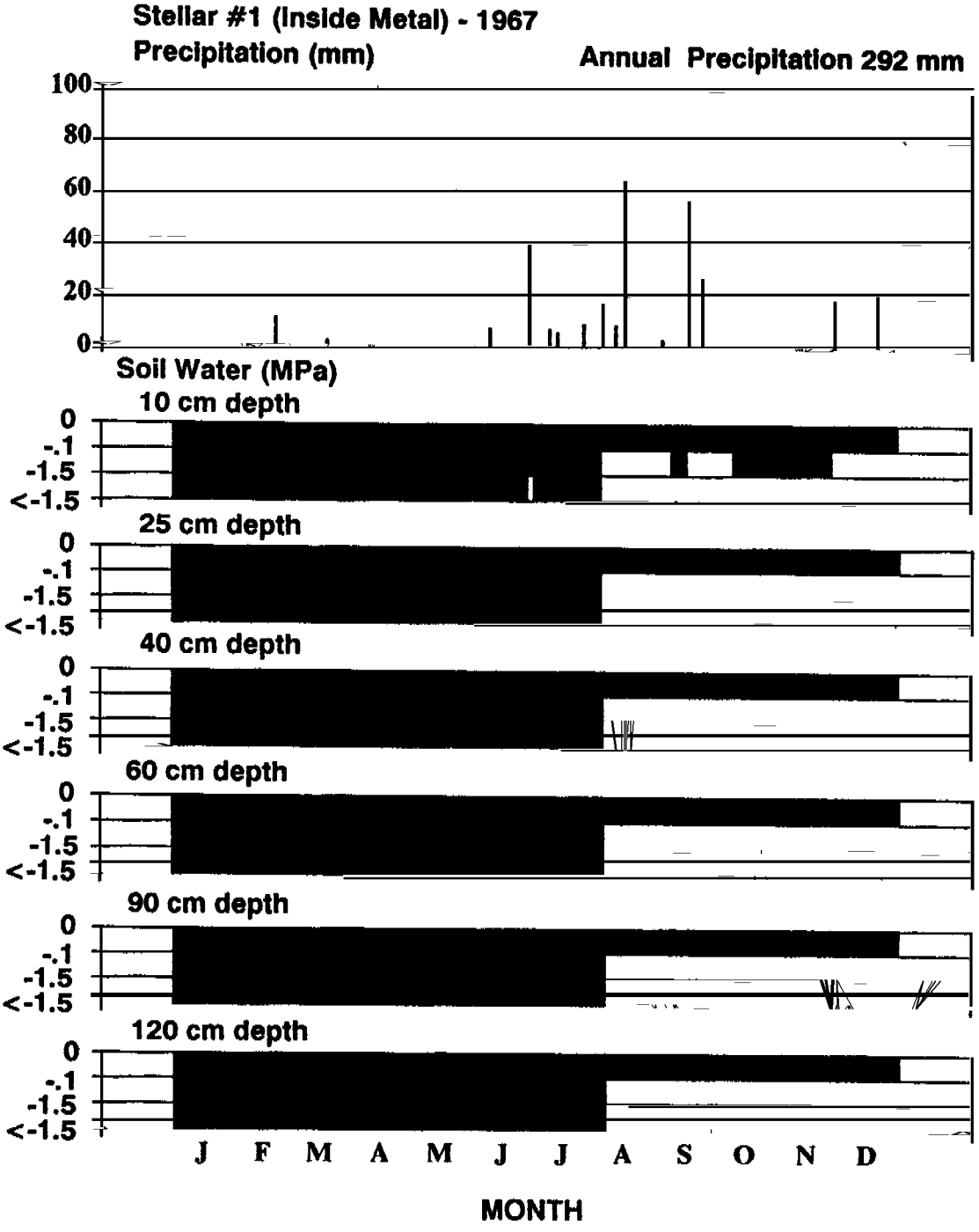


Figure 273. Annual precipitation (292 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1967.

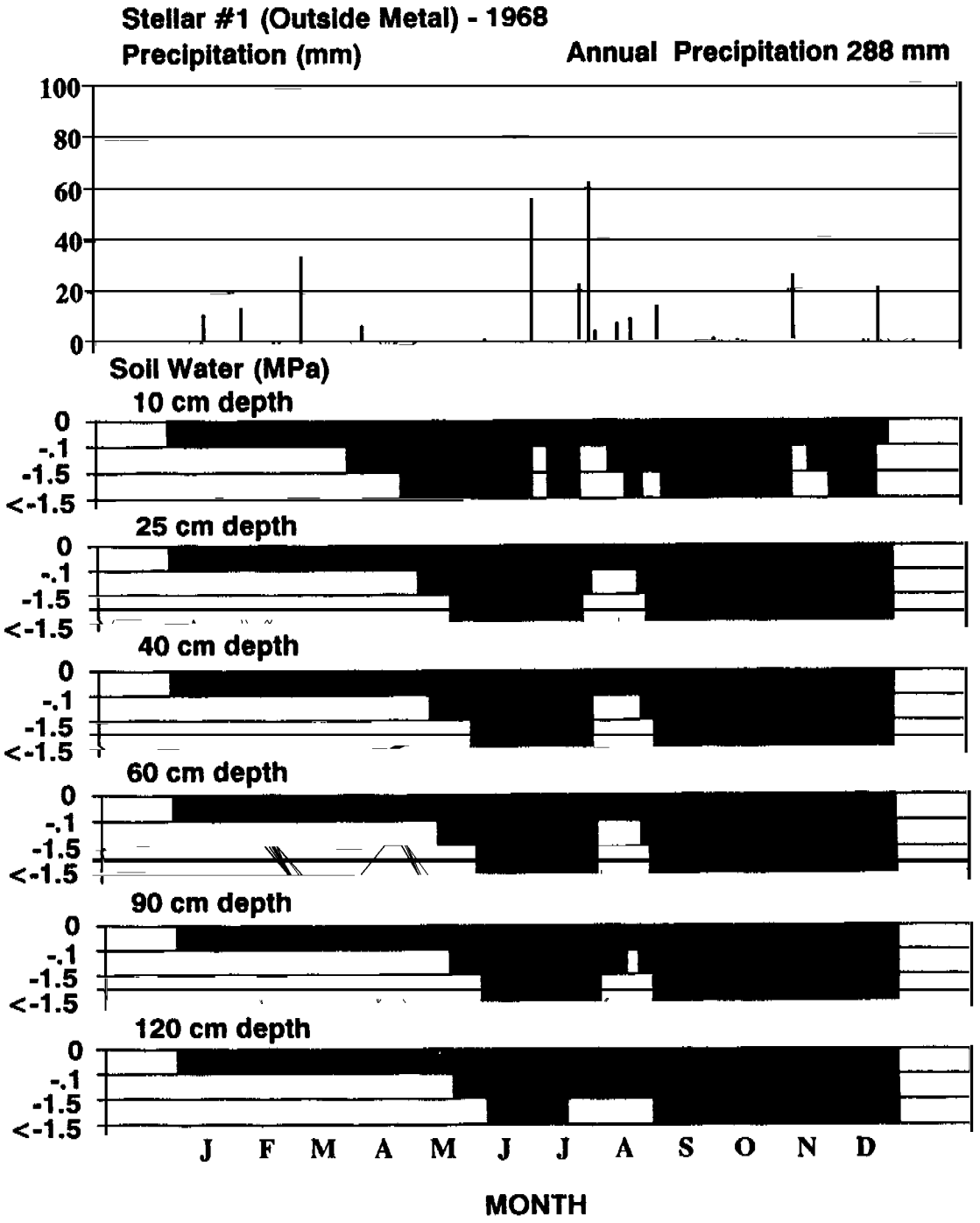


Figure 274. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1968.

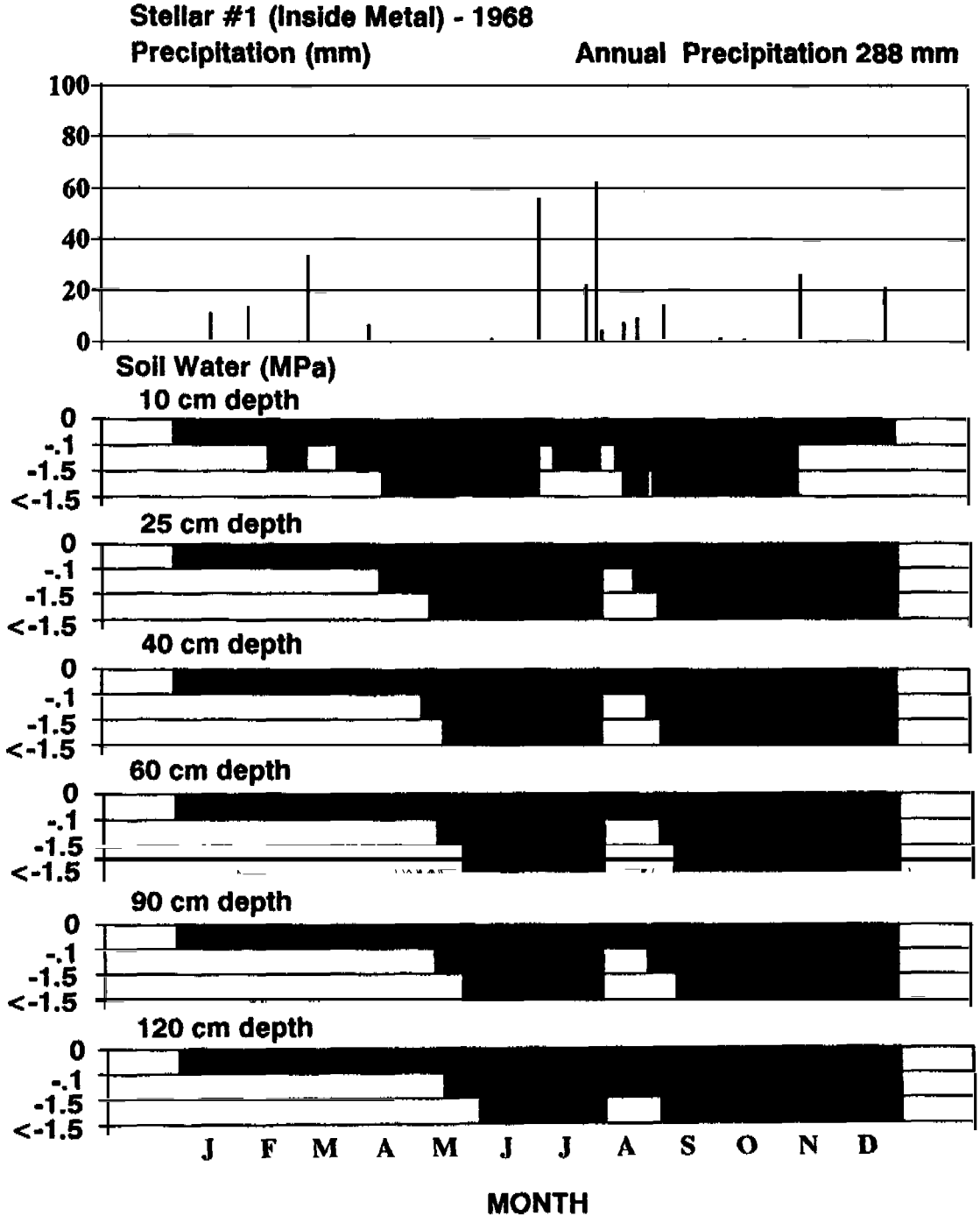


Figure 275. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1968.

additional days of soil water >-1.5 MPa outside the metal cylinder at 25-cm depth in 1967 (figs. 272, 273) and 18 additional days in 1968 (figs. 274, 275). Production of tobosa was 2207 kg/ha (s.e.=122 kg/ha) in 1967 and 1495 kg/ha (s.e.=186 kg/ha) in 1968.

The annual precipitation in 1969 was about average (figs. 276, 277). At the 25-cm depth, the soil water was <-1.5 MPa the entire year both inside and outside the metal cylinder (figs. 276, 277) except for 25 days in December outside the cylinder (fig. 276). Tobosa production was 2061 kg/ha (s.e.=158 kg/ha).

Tobosa produced 461 kg/ha (s.e.=39 kg/ha) in 1970. Annual precipitation was 153 mm (figs. 278, 279). Soil water at 25 cm outside the metal was >-1.5 MPa January 1-17 (fig. 278); August 1-17; and October 3, 1970-February 2, 1971 (figs. 278, 280). Soil water inside the metal cylinder at 25 cm was <-1.5 MPa the entire year of 1970 (fig. 279).

The annual precipitation for the next 6 years was >245 mm (figs. 280-291). Estimated tobosa yields were 2206 kg/ha (s.e.=91 kg/ha) in 1971, 3718 kg/ha (s.e.=207 kg/ha) in 1972, 1855 kg/ha (s.e.=137 kg/ha) in 1973, 2258 kg/ha (s.e.=182 kg/ha) in 1974, 2291 kg/ha (s.e.=110 kg/ha) in 1975, and 1030 kg/ha (s.e.=101 kg/ha) in 1976. Inside the cylinder at 25 cm soil water was >-1.5 MPa October 27-November 11, 1971 (fig. 281); January 6, 1973-April 13 (fig. 285); July 19-August 5; August 29-September 7, 1973 (fig. 285); July 15, 1974-September 7 (fig. 287); September 22, 1974-March 26, 1975 (figs. 287, 289); July 8-9; and September 14-24, 1975 (fig. 289). Outside the metal cylinder the matric potential of the soil water at 25 cm was >-1.5 MPa August 19, 1971-April 9, 1972 (figs. 280, 282); January 7, 1973-April 24 (fig. 284); June 15-26; July 19-August 5; August 29-September 7, 1973 (fig. 284); July 15, 1974-September 2 (fig. 286); September 21, 1974-April 23, 1975 (figs. 286, 288); July 21-26; and September 13-November 8, 1975 (fig. 288). No soil water data were collected August 8-December 31, 1972.

The annual precipitation at this location for 1959-76 averaged 244 mm. Tobosa yields for 1957-76 averaged 1506 kg/ha, 163% of the burrograss yields on the adjacent Reagan site. The probability of the matric potential of the soil water >-1.5 MPa at the 25-cm depth inside the metal cylinder averaged 16.0% for December-April, 0.9% for May-June, 17.8% for July-September, and 14.5% for October-November (fig. 293). The annual probabilities inside the metal were 14% higher at the Stellar site than the nearby Reagan site at the 25-cm depth (figs. 293, 335). Outside the metal cylinder the probabilities at the same depth at this Stellar site averaged 36.1% for December-April, 3.4% for May-June, 33.5% for July-September, and 41.4% for October-November (fig. 292). Approximately 56% of the days when the soil water at 25 cm was >1.5 MPa was due to run-in (figs. 292, 293). The annual probabilities outside the cylinder w re 49% higher at the Stellar site than the adjacent Reagan site at the 25-cm depth, with much of the difference occurring October-April (figs. 292, 334). The lighter precipitation events of the cool season gave more days of soil water >-1.5 MPa at 25 cm than the heavier storms of summer at Stellar than at Reagan.

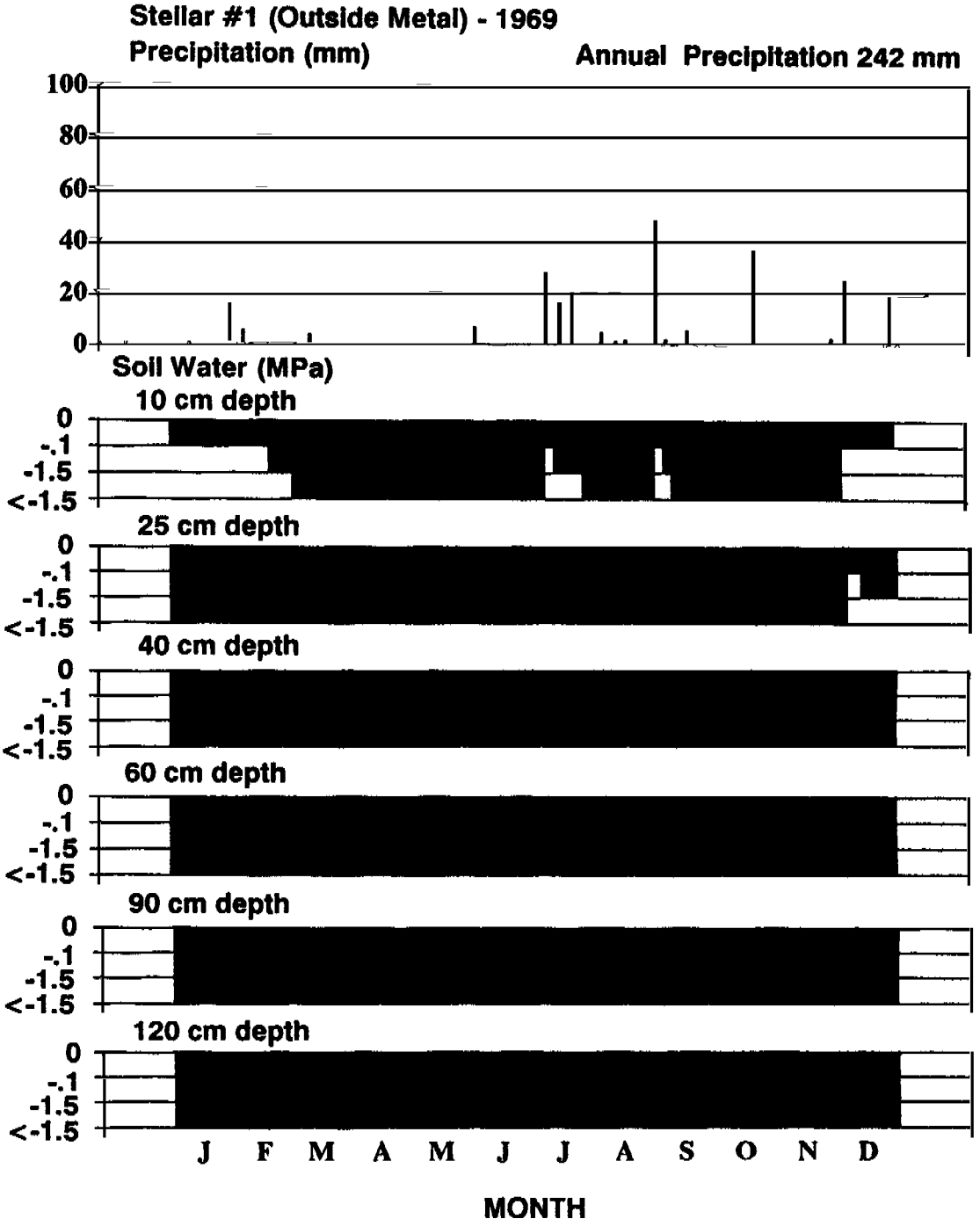


Figure 276. Annual precipitation (242 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1969.

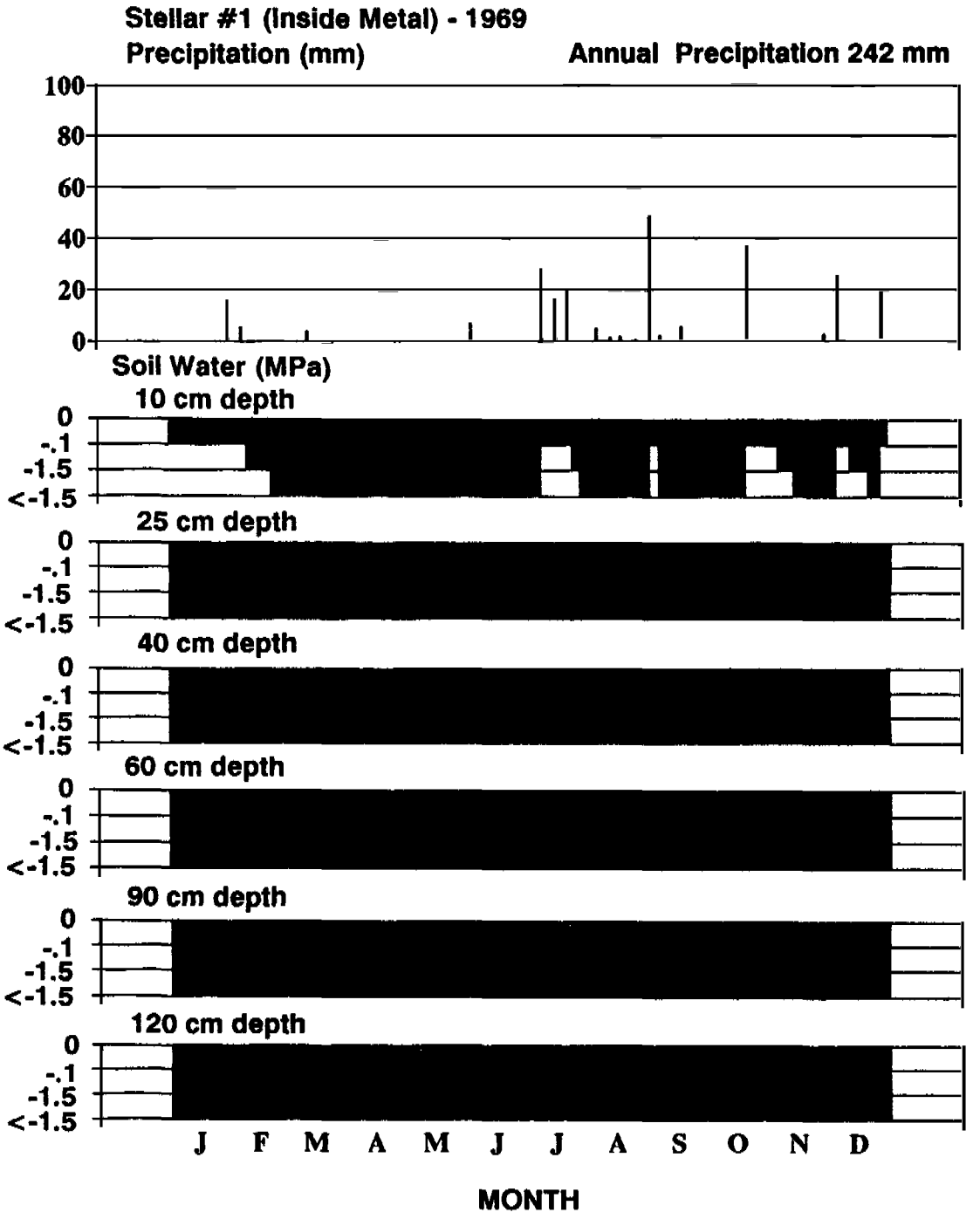


Figure 277. Annual precipitation (242 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 sit for 1969.

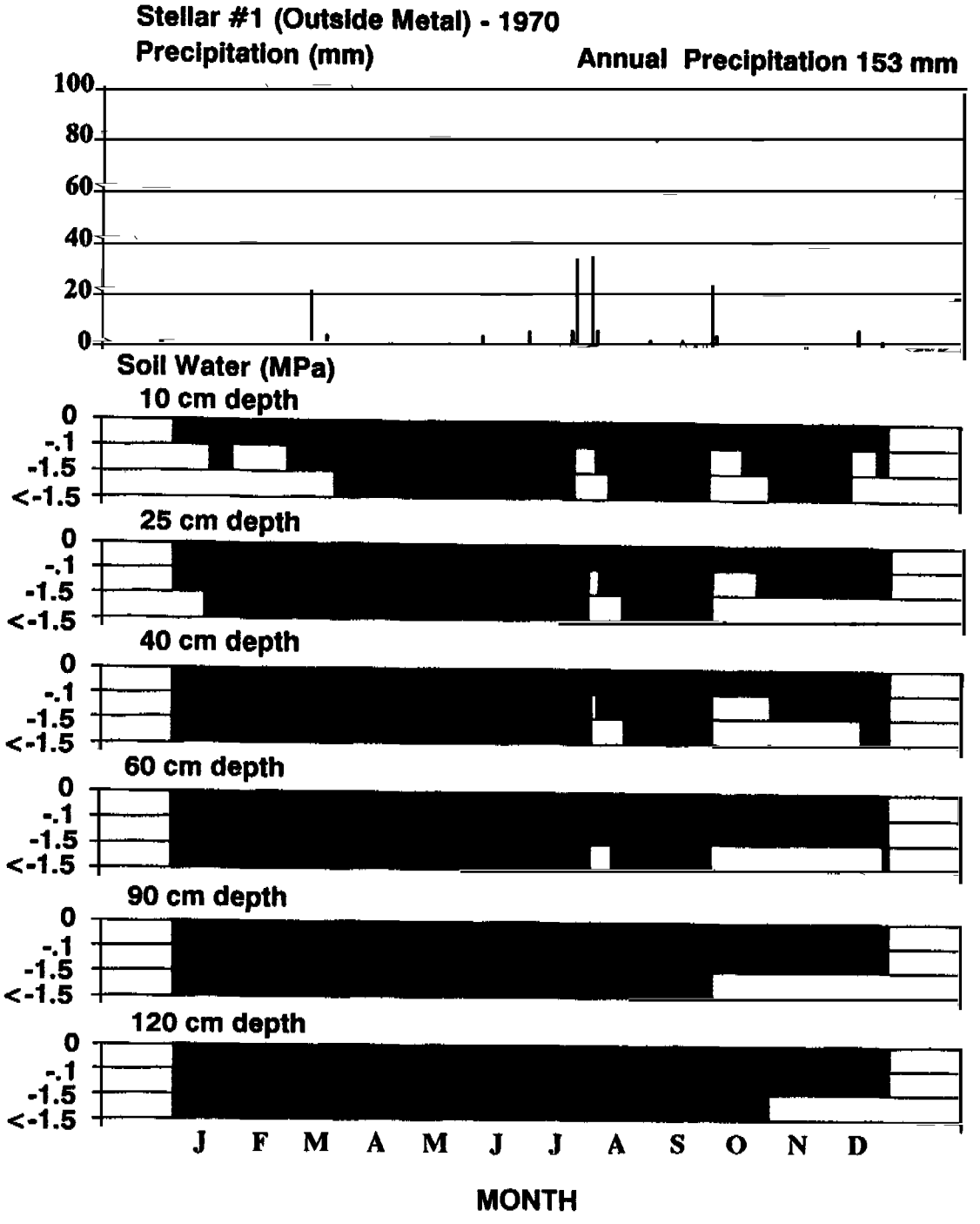


Figure 278. Annual precipitation (153 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1970.

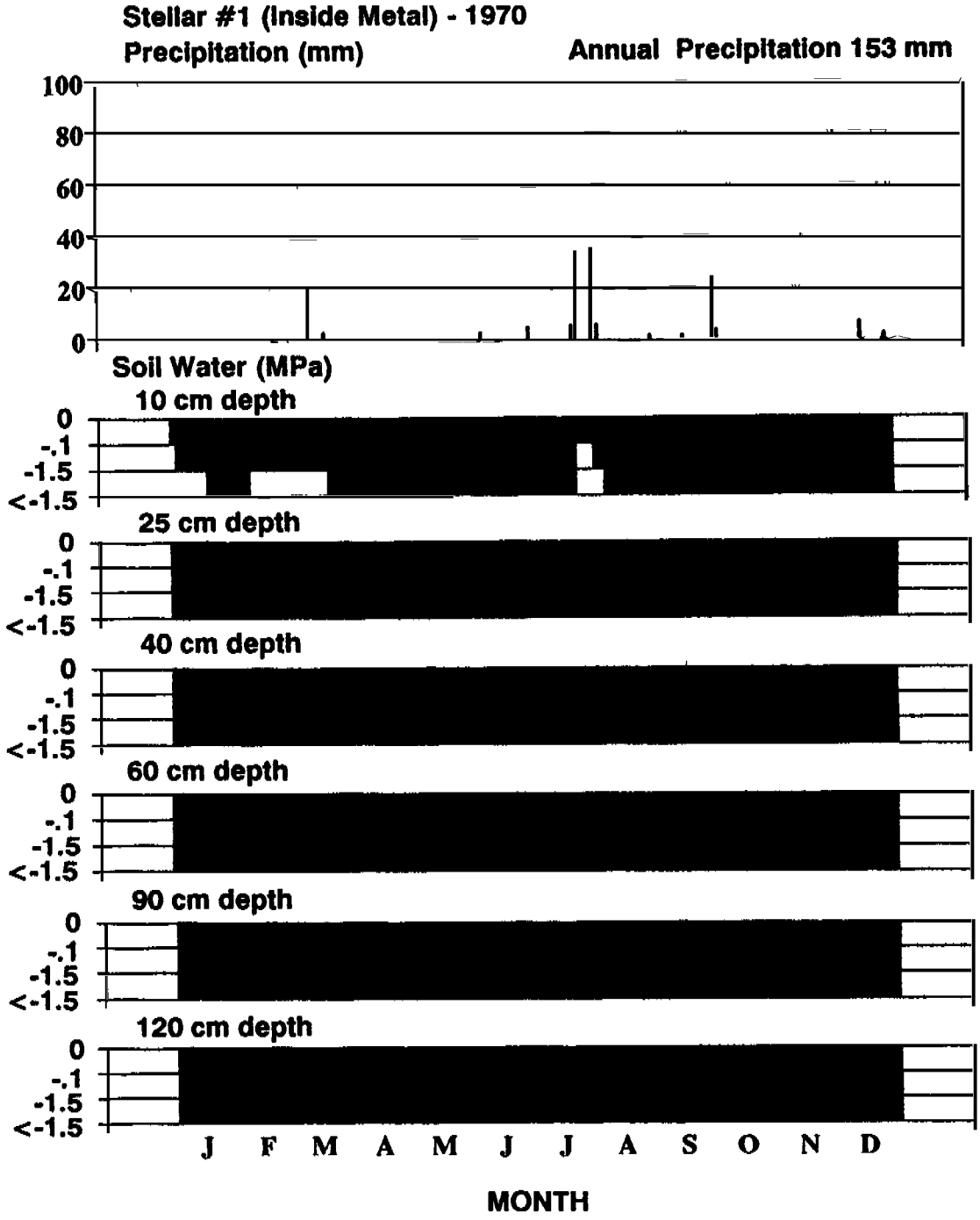


Figure 279. Annual precipitation (153 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1970.

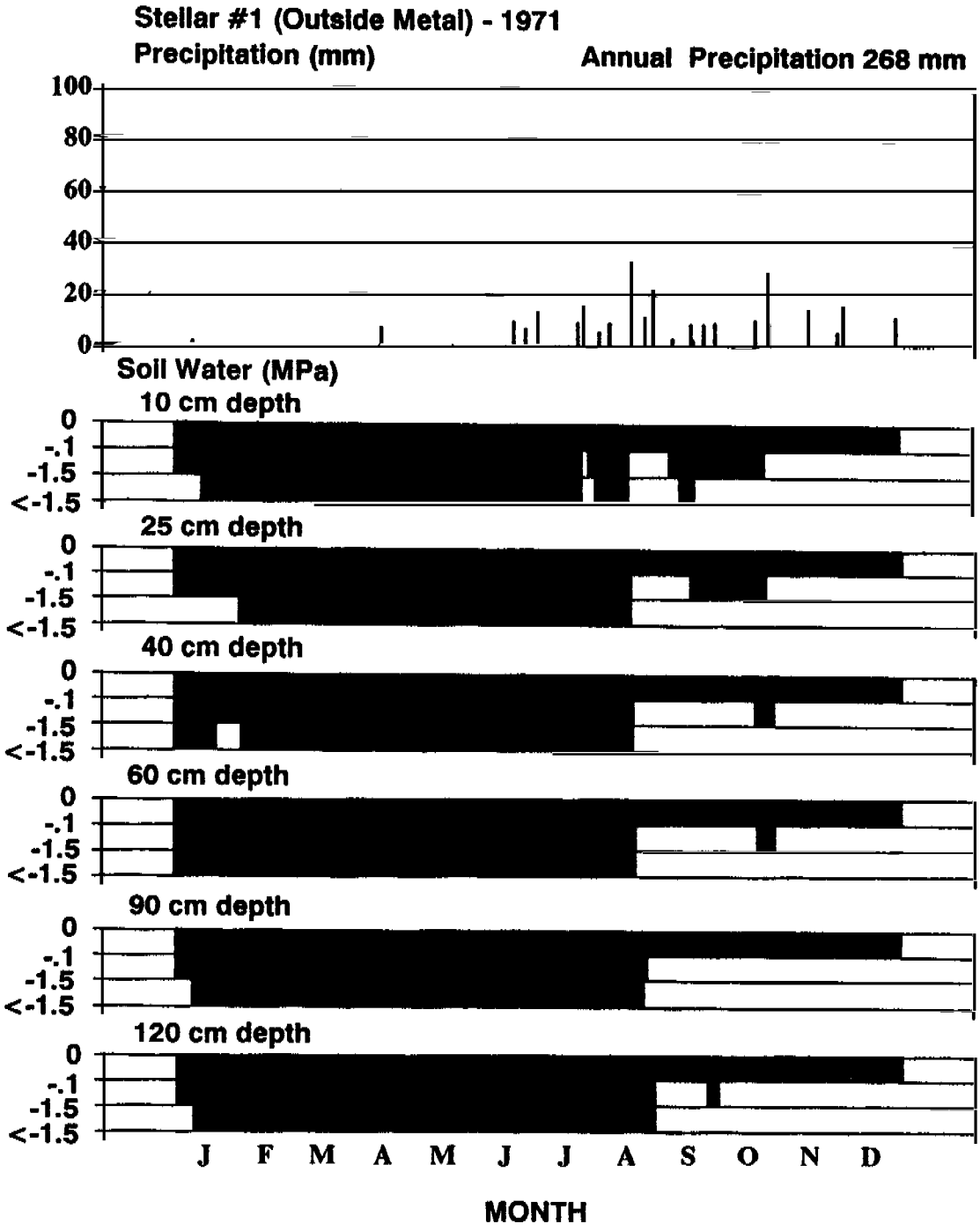


Figure 280. Annual precipitation (268 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1971.

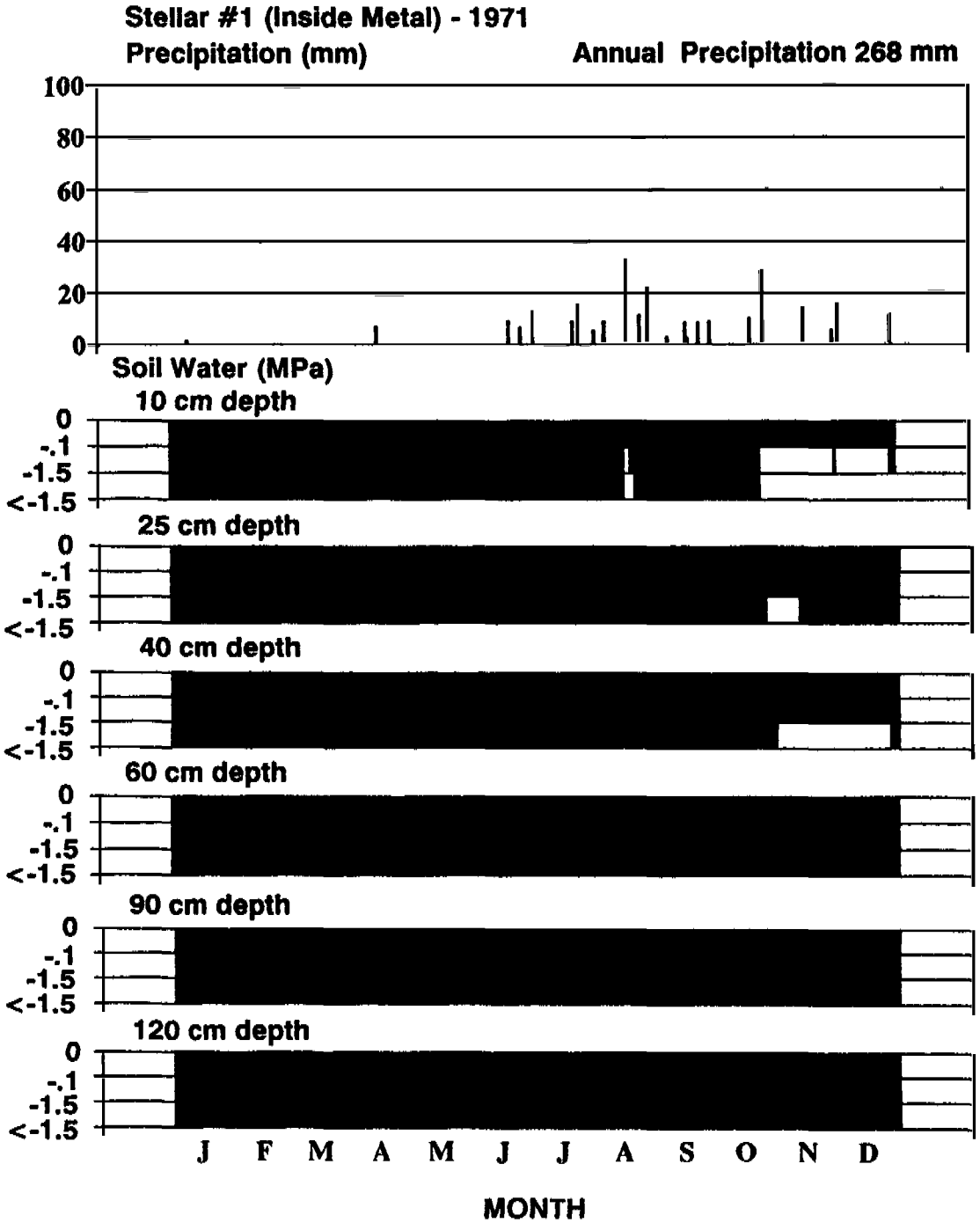


Figure 281. Annual precipitation (268 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1971.

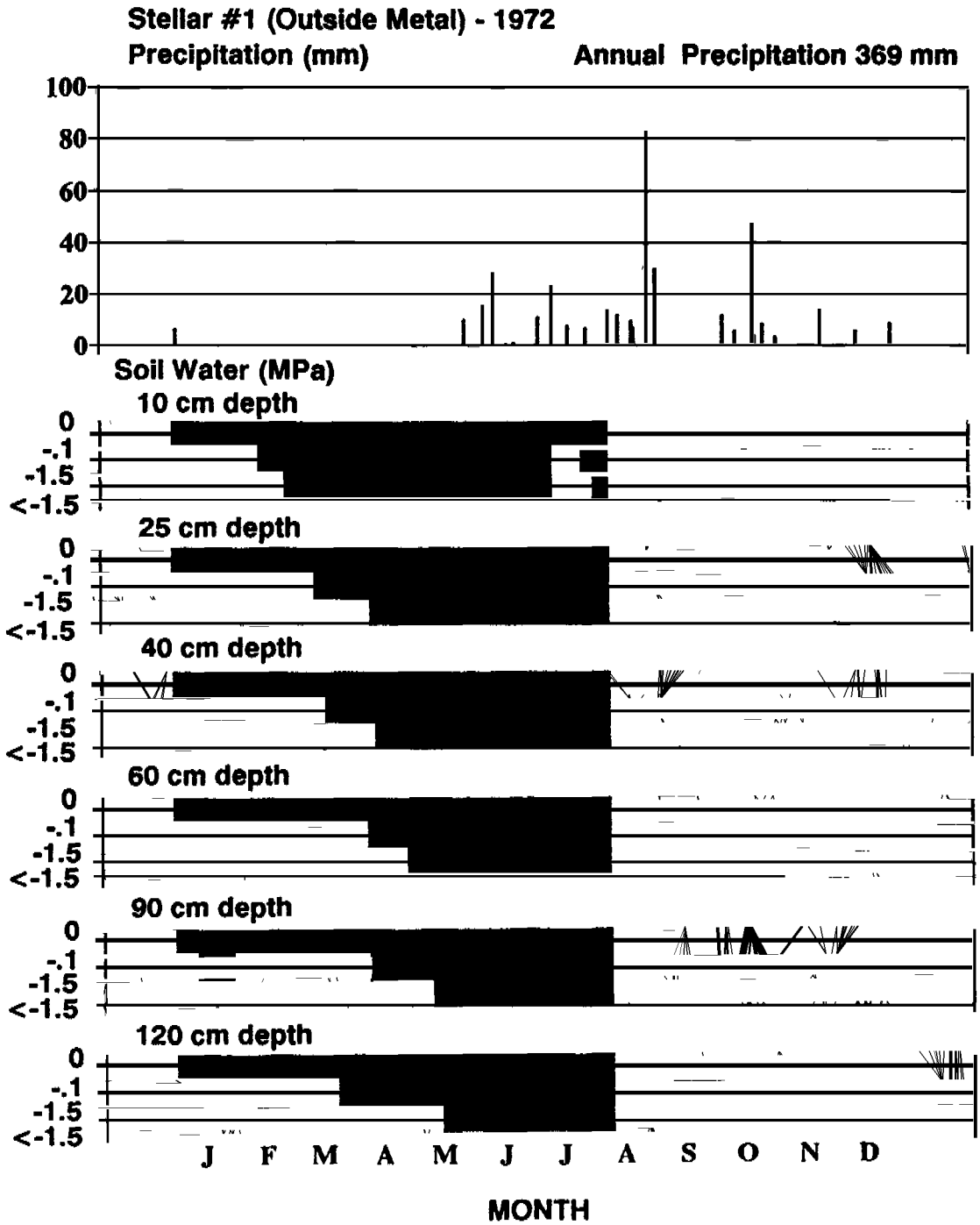


Figure 282. Annual (369 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside a sheet metal cylinder for January 1-August 7, 1972 at the Stellar #1 site.

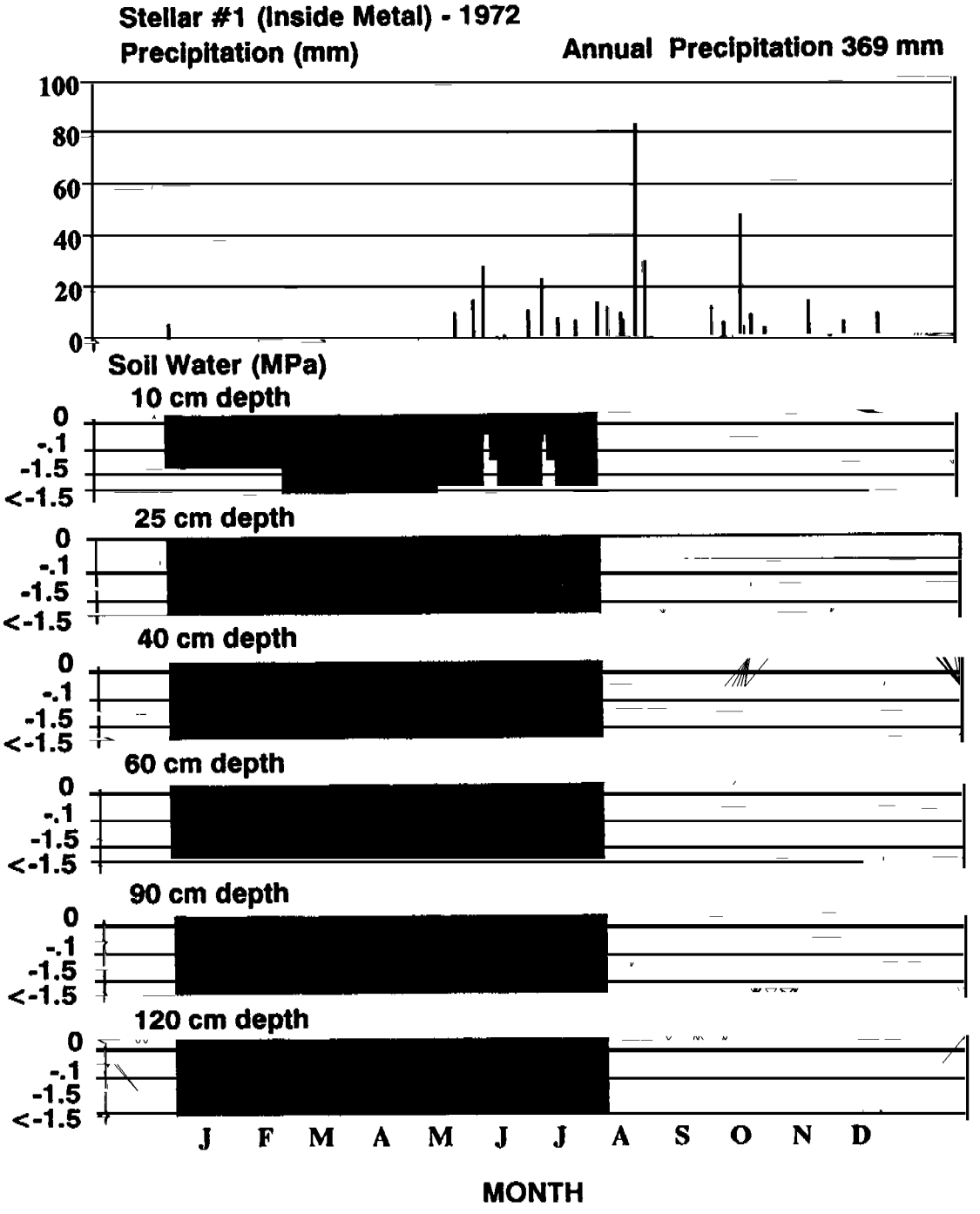


Figure 283. Annual (369 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside a sheet metal cylinder for January 1-August 7, 1972 at the Stellar #1 site.

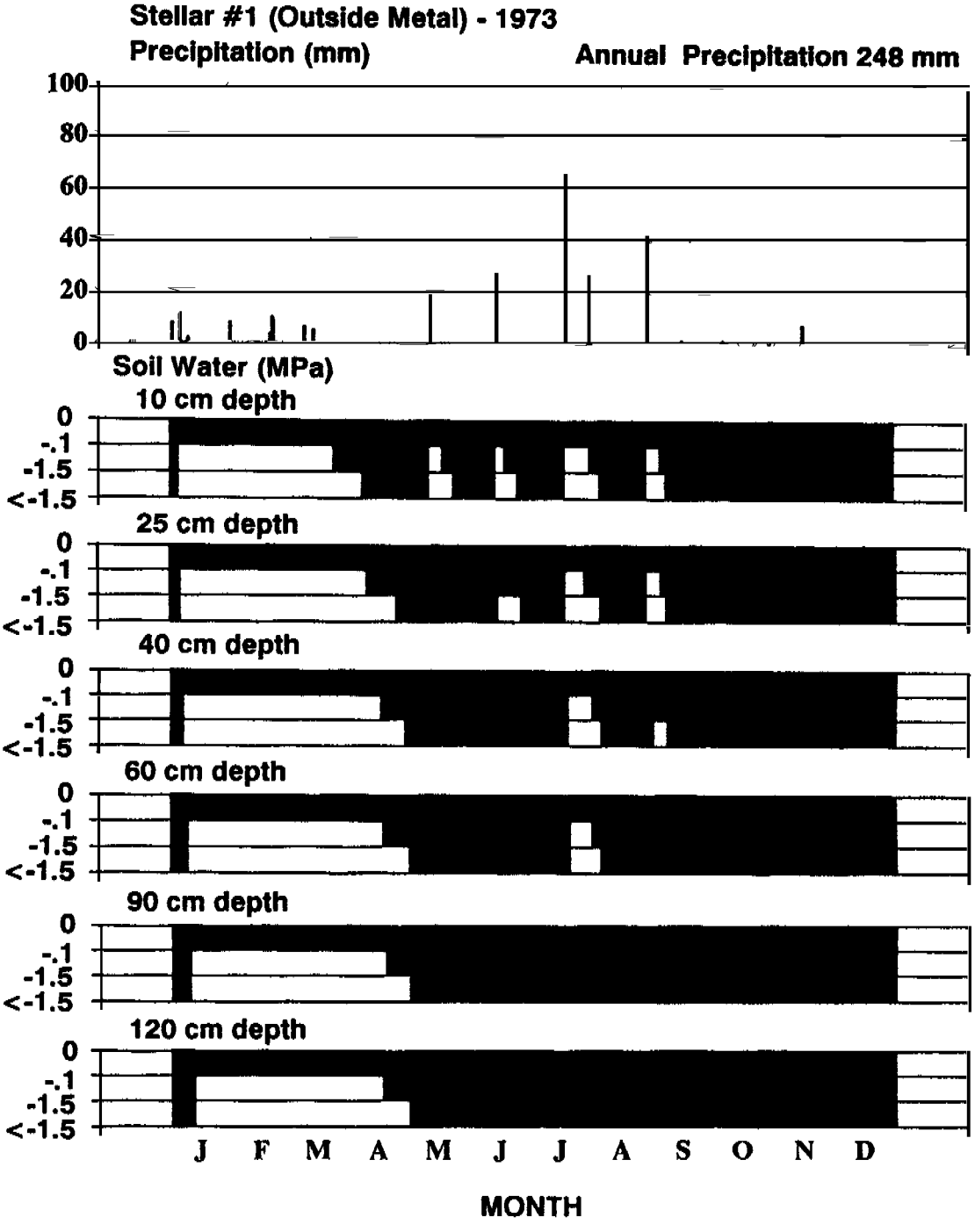


Figure 284. Annual precipitation (248 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1973.

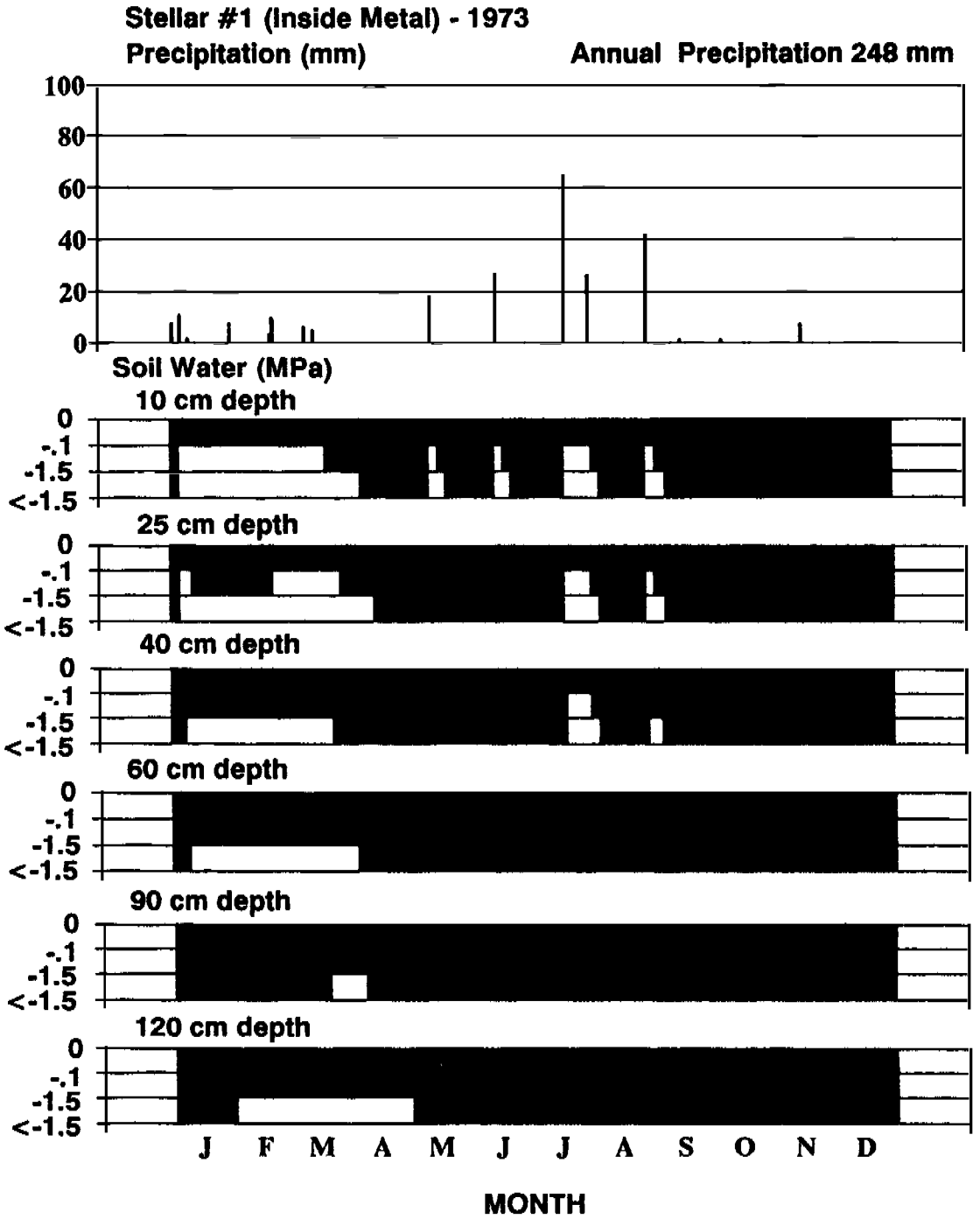


Figure 285. Annual precipitation (248 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1973.

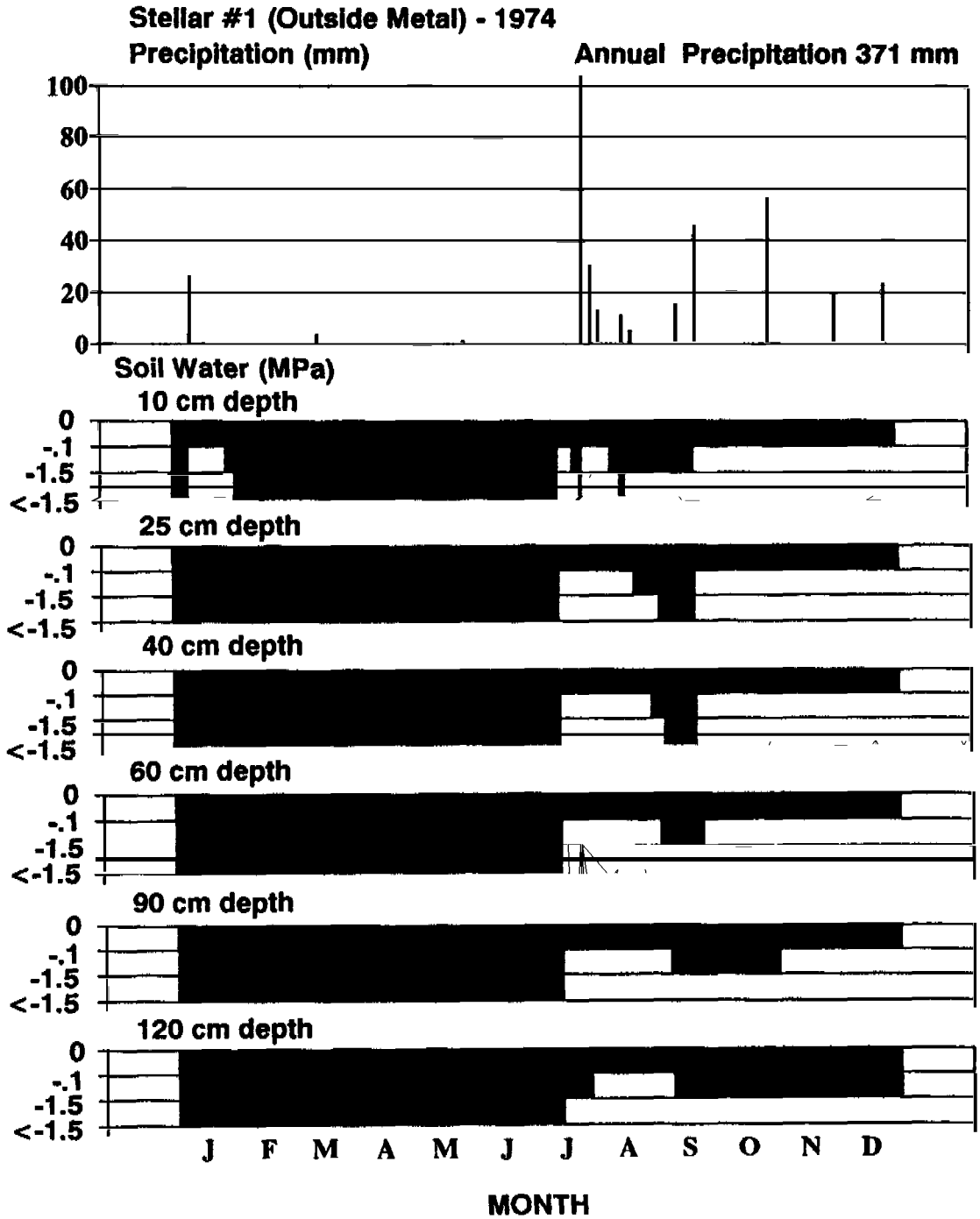


Figure 286. Annual precipitation (371 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1974.

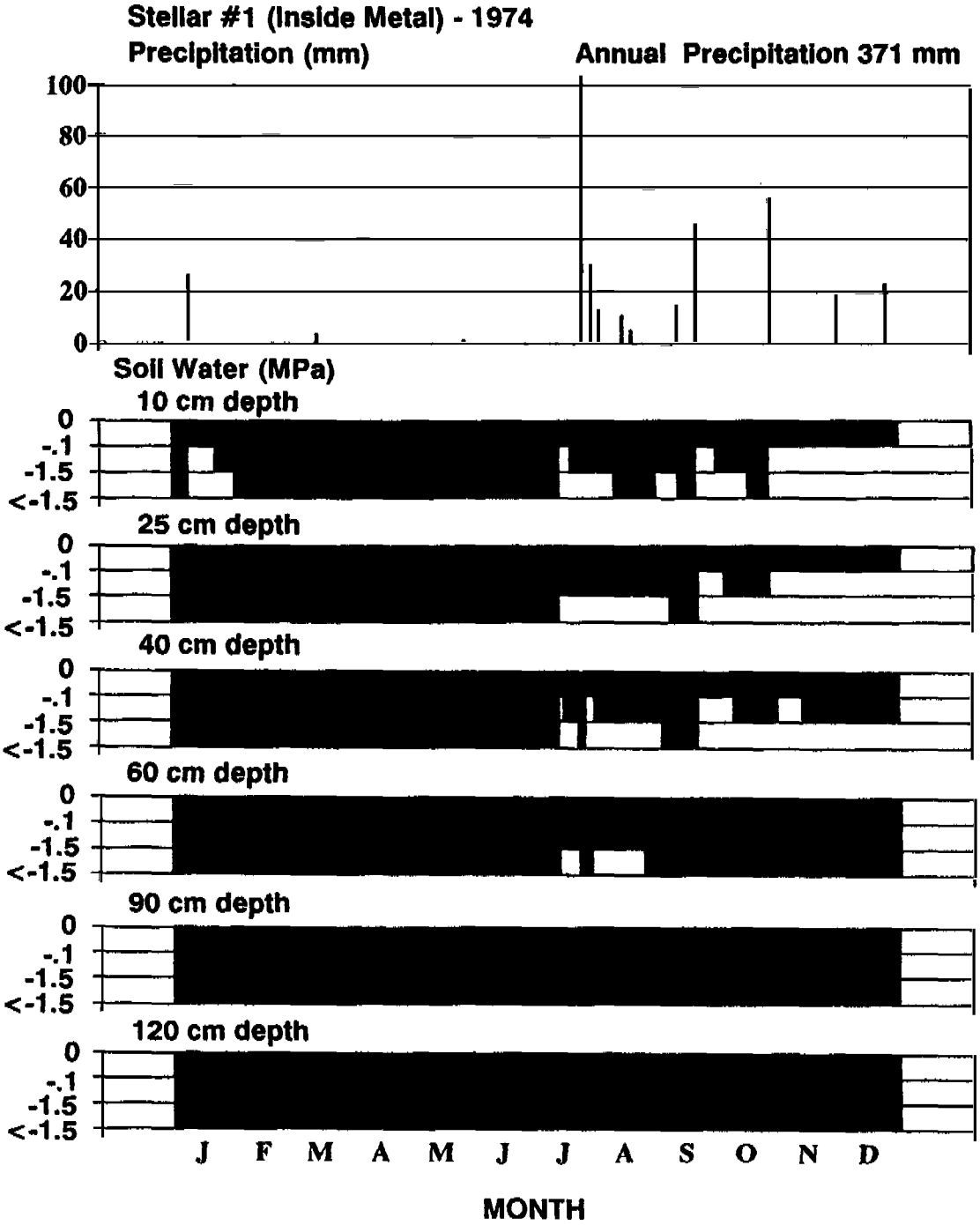


Figure 287. Annual precipitation (371 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 sit for 1974.

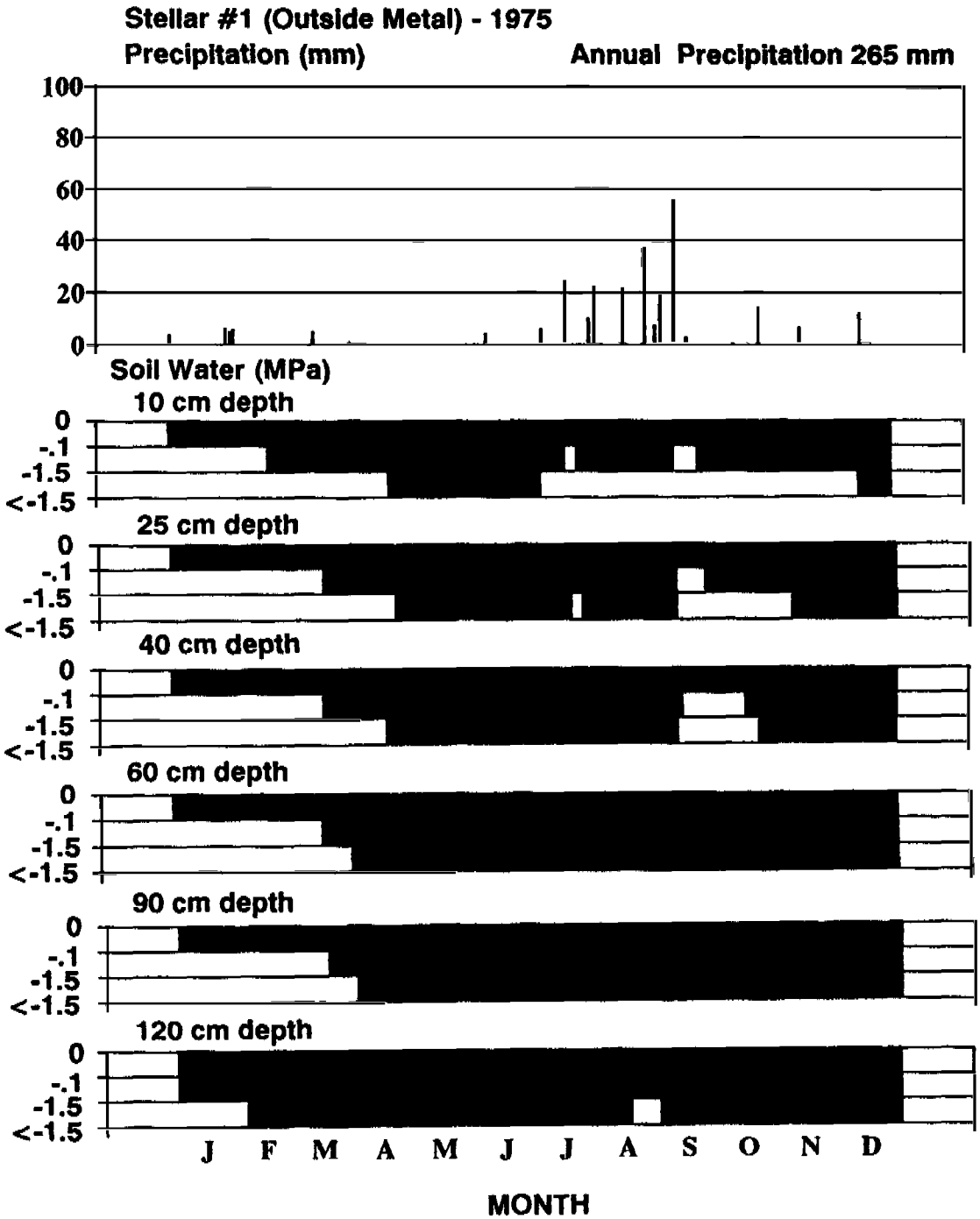


Figure 288. Annual precipitation (265 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1975.

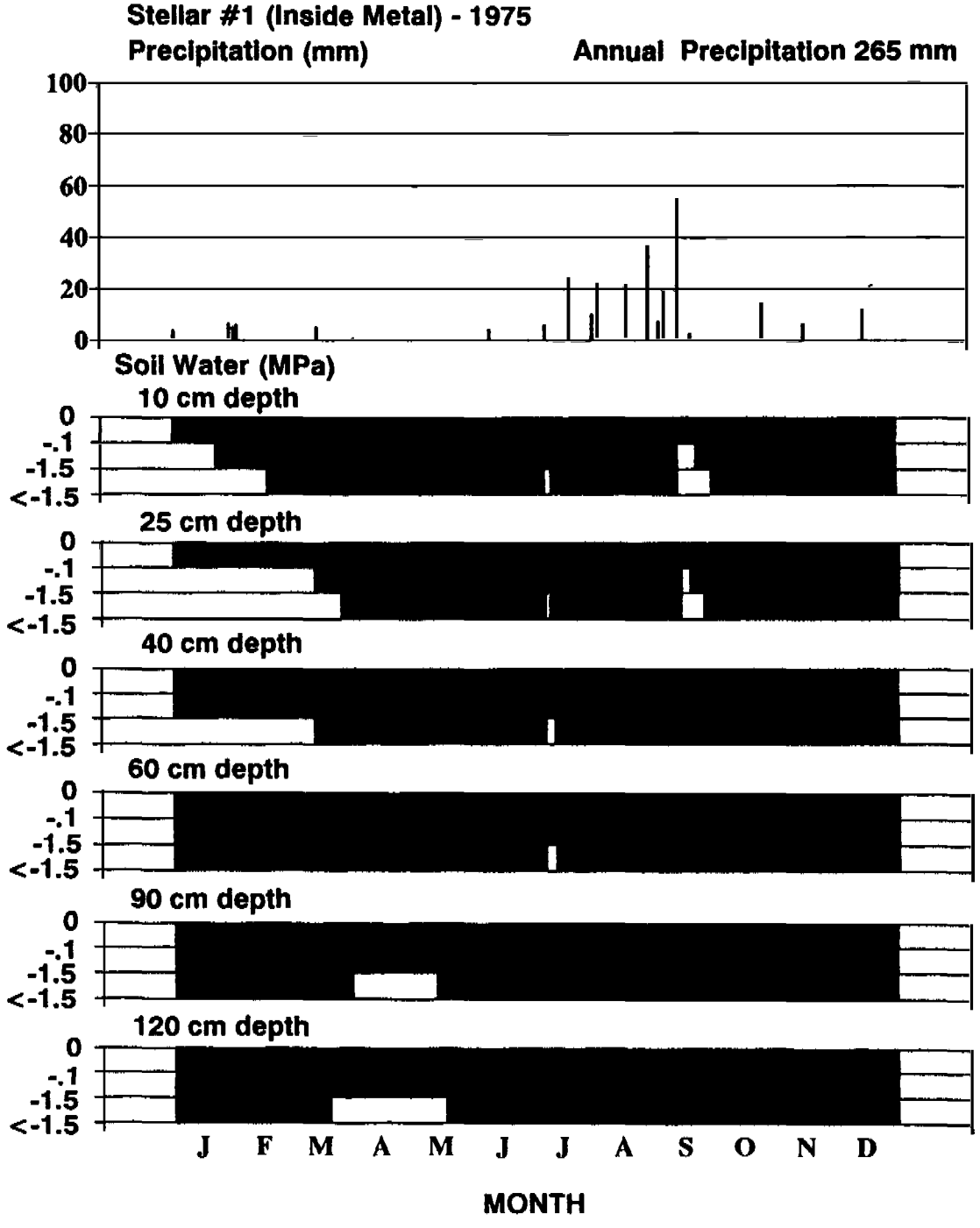


Figure 289. Annual precipitation (265 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1975.

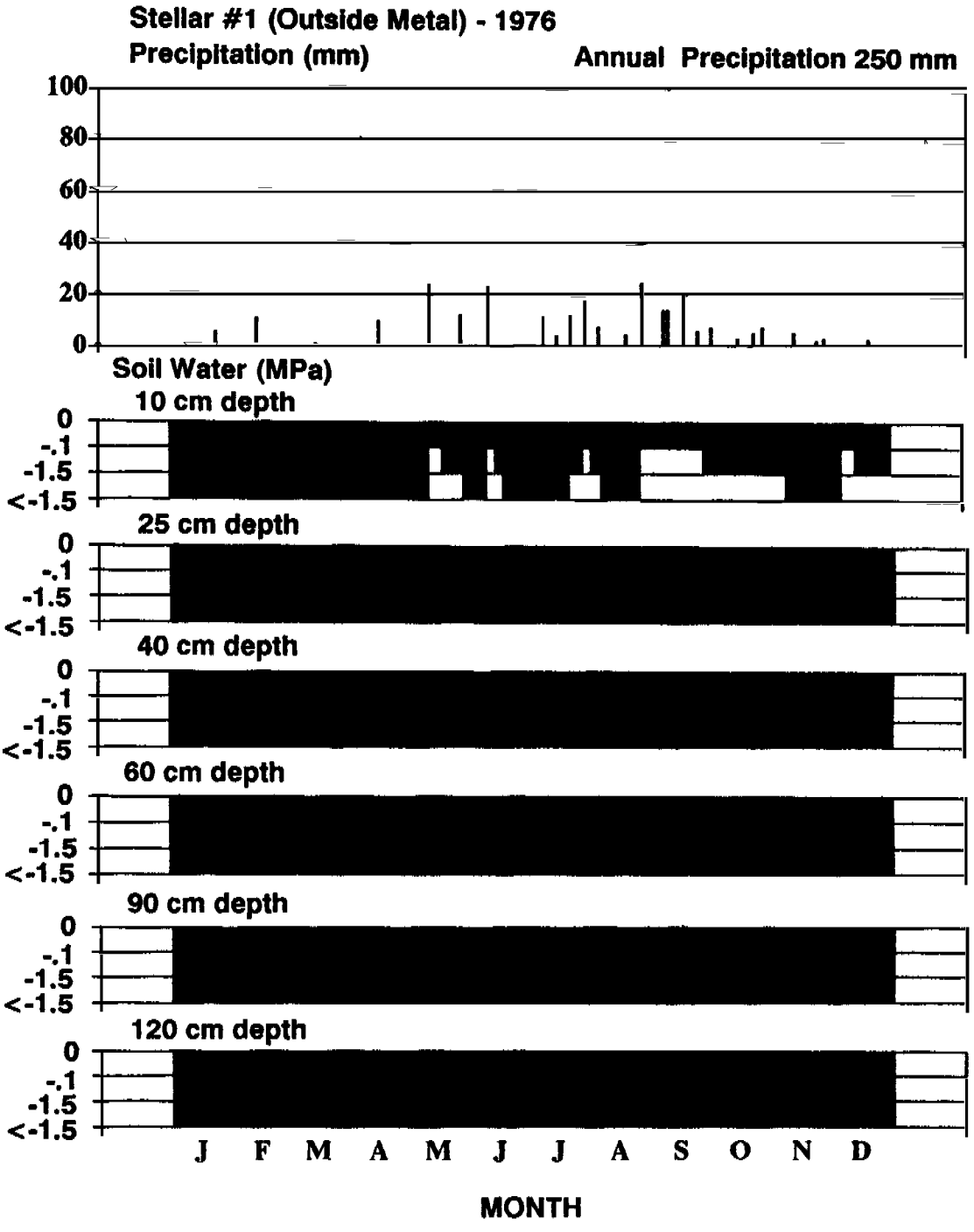


Figure 290. Annual precipitation (250 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Stellar #1 site for 1976.

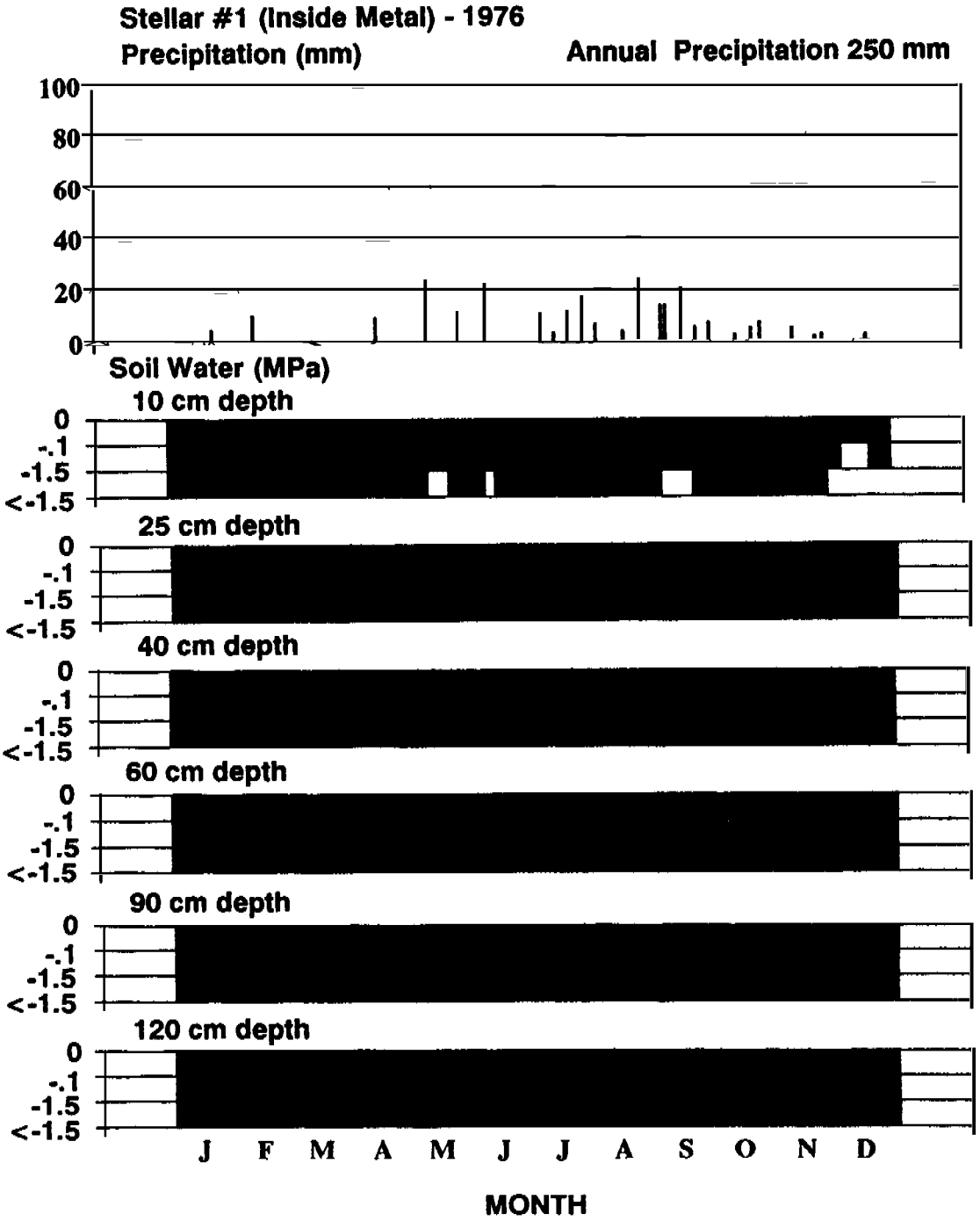


Figure 291. Annual precipitation (250 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Stellar #1 site for 1976.

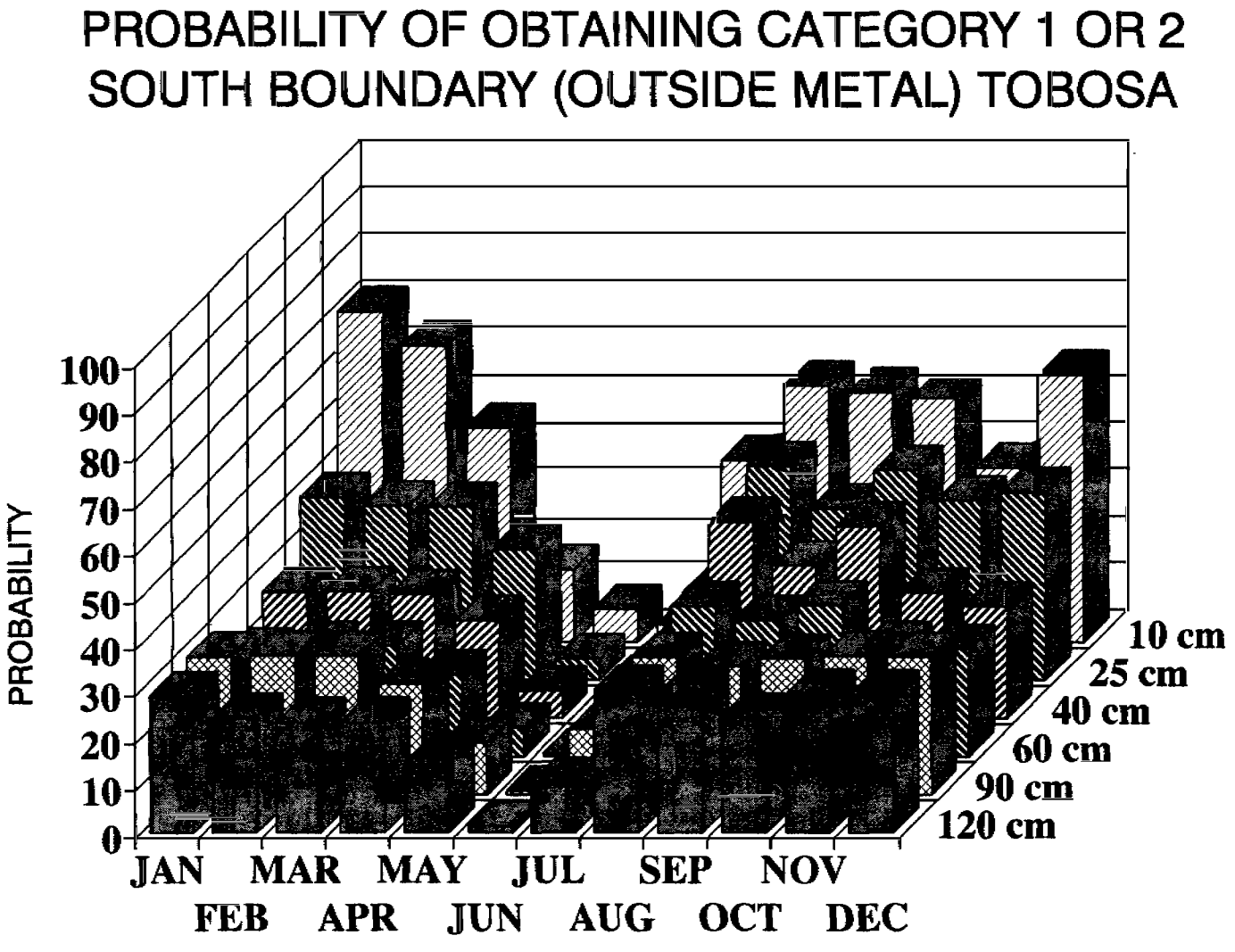


Figure 292. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm outside a sheet metal cylinder at the Stellar #1 site.

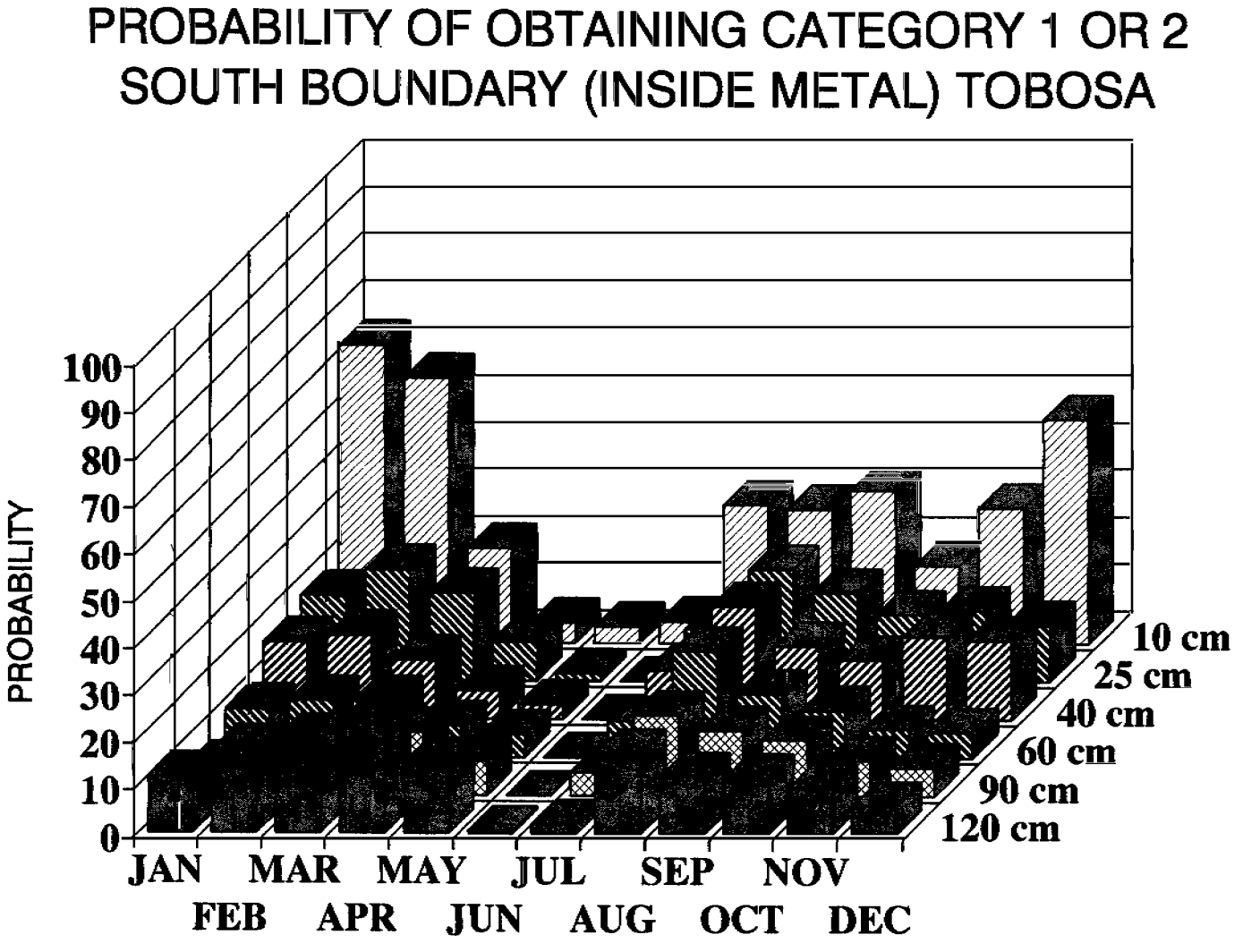


Figure 293. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm inside a sheet metal cylinder at the Stellar #1 site.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, 14 of 20 years had soil water <-1.5 MPa outside the sheet metal cylinder more than half the time at 10 cm; 17 of 20 years at 25 cm; 18 of 20 years at 40 cm; and 15 of 18 years at soil depths of 60, 90, and 120 cm. Fourteen of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 11 of 20 years at 25 cm; 12 of 20 years at 40 cm; 11 of 18 years at 60 cm; 9 of 18 years at 90 cm; and 10 of 18 years at a depth of 120 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25 cm depth (outside the cylinder), 11 of 18 years and >30 consecutive days in the four months after the summer solstice 10 of 18 years when soil water was obtained the entire year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was observed in both years.

Site Reagan (R)

Site R (figs. 226, 253, 294, 295, table 11) is in the exclosure at the south boundary on the Jornada Experimental Range. This site is about 140 m east of site S1 (fig. 251). The study trench is about 6 m north of the north fence of the exclosure. Perennial vegetation is primarily burrograss.

Soils. The soil water blocks are in the Ustollic Calciorthid Reagan (fig. 295, table 11). Diagnostic horizons are an ochric epipedon and a calcic horizon. The soil is on the Petts Tank surface of late Pleistocene age (tables 1, 2), and has formed in basin-floor sediments derived primarily from sedimentary rocks such as limestone, siltstone, sandstone, and shale, with some sediments derived from igneous rocks. Petts Tank sediments bury Jornada I sediments, which emerge at the surface to the west (fig. 253). The Reagan study trench penetrated the buried Bt horizon of the Jornada I soil (table 11). The area is level.

This soil is calcareous throughout and has formed in high-carbonate parent materials. Studies of a similar soil Reagan (60-17; see p. 830, 831, Gile and Grossman, 1979, for laboratory data and description) near this site indicate that not all carbonate originally in the parent materials has been leached from upper horizons. Present moisture is clearly insufficient to remove carbonate from these horizons. Further, this soil was formed in part during the late Pleistocene full-glacial, when there was more effective moisture than now. This indicates that even this greater effective moisture was insufficient to remove the carbonate from upper horizons.

Soil Water, Precipitation, and Yields. The gypsum resistance blocks were installed in two replications at depths of 10, 25, and 40 cm on August 16, 1957 and at depths of 60, 90, and 120 cm on August 7, 1959 within a livestock exclosure at the south boundary. On July 31, 1959 two replications of blocks were installed at depths of 10, 25, 40, 60, 90, and 120 cm within a sheet metal cylinder that excluded run-in water from adjacent slopes. The

Figure 294. Landscape of the basin floor at Site R (fig. 226) and the Ustollic Calciorthid Reagan, at the Sbr site in the Jornada Experimental Range. Stakes and wires to the soil water blocks are both inside and outside the large metal cylinder. Photographed May 1971.

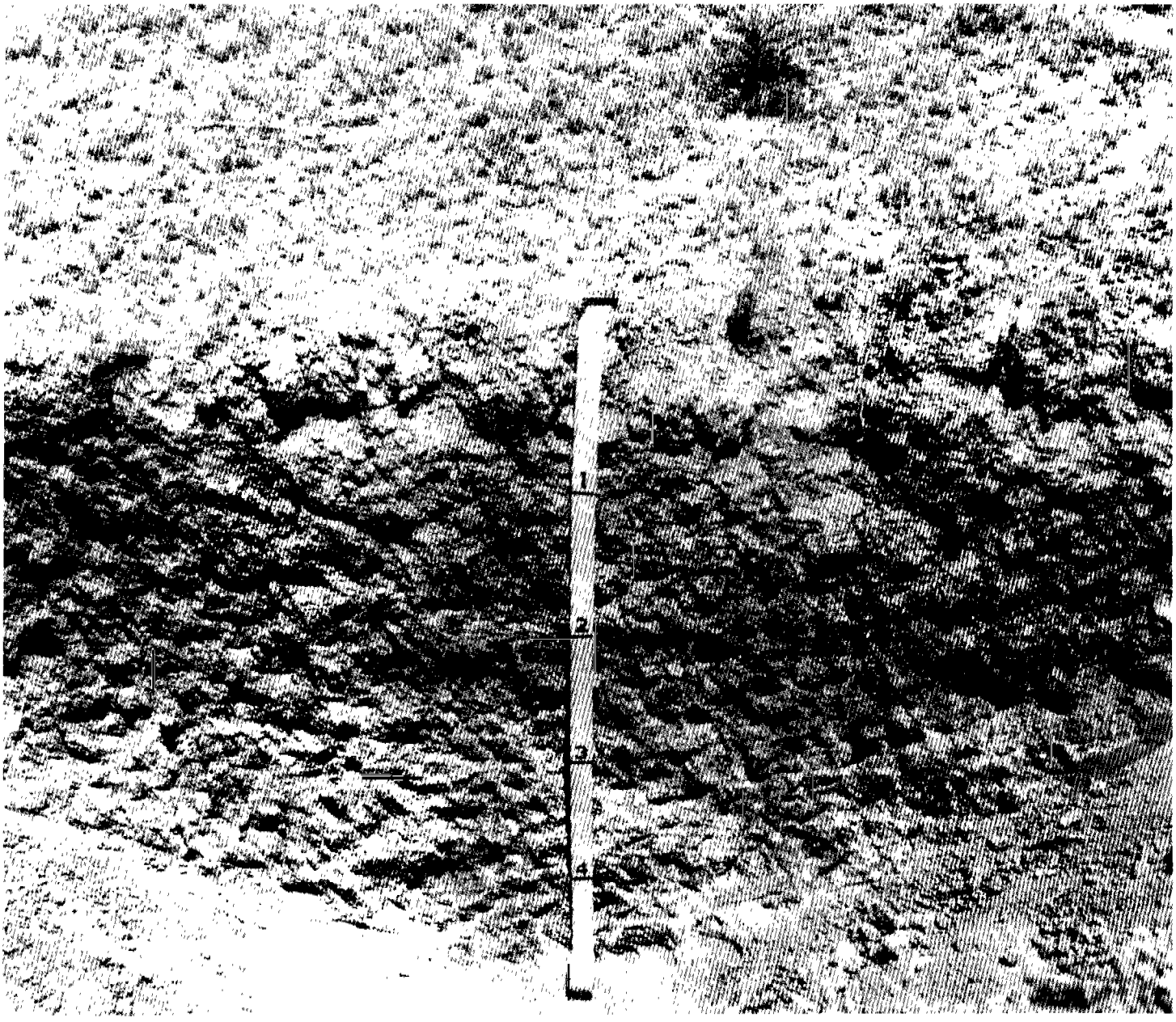


Figure 295. Profile of the Ustollic Calciorthid Reagan. The buried Bt horizon is at a depth of about 3 1/2 ft. Scale is in feet.

exclosure was 0.8 ha and extended from an area dominated by burrograss to one dominated by tobosa. This section discusses the area dominated by burrograss. The rain gauge at this location was established July 15, 1958. Daily precipitation between August 16, 1957 and July 15, 1958 can be obtained from Stellar #2 which is 1.1 km from the South Boundary Exclosure. The precipitation between August 16-December 31, 1957 was 195 mm. The matric potential of the soil water at 10 cm was >-1.5 MPa August 16-September 18 and October 13-December 24, 1957 (fig. 296). The moisture control section, 25-cm soil depth, had water >-1.5 MPa August 16-18, September 1-17, and October 13, 1957-May 6, 1958 (figs. 296, 297). There was soil water >-1.5 MPa at the 40-cm depth September 1-18 and October 14, 1957-May 18, 1958 (figs. 296, 297). The burrograss on 25, 30.5-cm x 1.5-m quadrats was clipped to ground level each fall. The 1957 yield of burrograss was 946 kg/ha (s.e.=94 kg/ha).

The precipitation at Stellar #2 January 1-July 14, 1958 was 94 mm. The precipitation at this location July 15-December 31, 1958 was 178 mm. The 25-cm depth had soil water >-1.5 MPa July 29-August 20 and August 25-31, 1958 besides that during the winter and early spring (fig. 297). Burrograss yielded 1660 kg/ha (s.e.=128 kg/ha).

The precipitation at this location for 1959 was 239 mm (figs. 298, 299). The 25-cm soil depth outside the cylinder had water >-1.5 MPa July 29-September 20 (fig. 298). The 25-cm depth inside the cylinder had soil water >-1.5 MPa July 31-September 10 (fig. 299) indicating that run-in contributed 10 extra days of soil water >-1.5 MPa to the 25-cm depth in September 1959. Estimates of burrograss production in fall 1959 were 3017 kg/ha (s.e.=163 kg/ha).

The precipitation for 1960 was 162 mm (figs. 300, 301). No soil water >-1.5 MPa was recorded below the 10-cm depth. The 10-cm depth had brief periods of soil water >-1.5 MPa both outside and inside the metal cylinder (figs. 300, 301). Burrograss production was estimated at 89 kg/ha (s.e.=11 kg/ha).

Annual precipitation was above average in 1961 and 1962. Outside the cylinder, there was soil water >-1.5 MPa at 25 cm January 27, 1961-March 12 (fig. 302); September 6-October 6; November 16, 1961-March 17, 1962 (figs. 302, 304); July 21-29; August 1-6; and September 25-October 20, 1962 (fig. 304). Soil water inside the metal at 25 cm was >-1.5 MPa January 25, 1961-March 12 (fig. 303) and November 22, 1961-April 13, 1962 (figs. 303, 305). There was more soil water >-1.5 MPa outside the cylinder particularly during September, 1961 and during the summer and early fall of 1962. Burrograss yielded 754 kg/ha (s.e.=68 kg/ha) in 1961 and 1135 kg/ha (s.e.=47 kg/ha) in 1962.

The 1963 precipitation was 234 mm (figs. 306, 307). Inside the metal cylinder at the 25-cm depth, the soil water was between -0.1 and -1.5 MPa August 21-September 23 (fig. 307) whereas outside

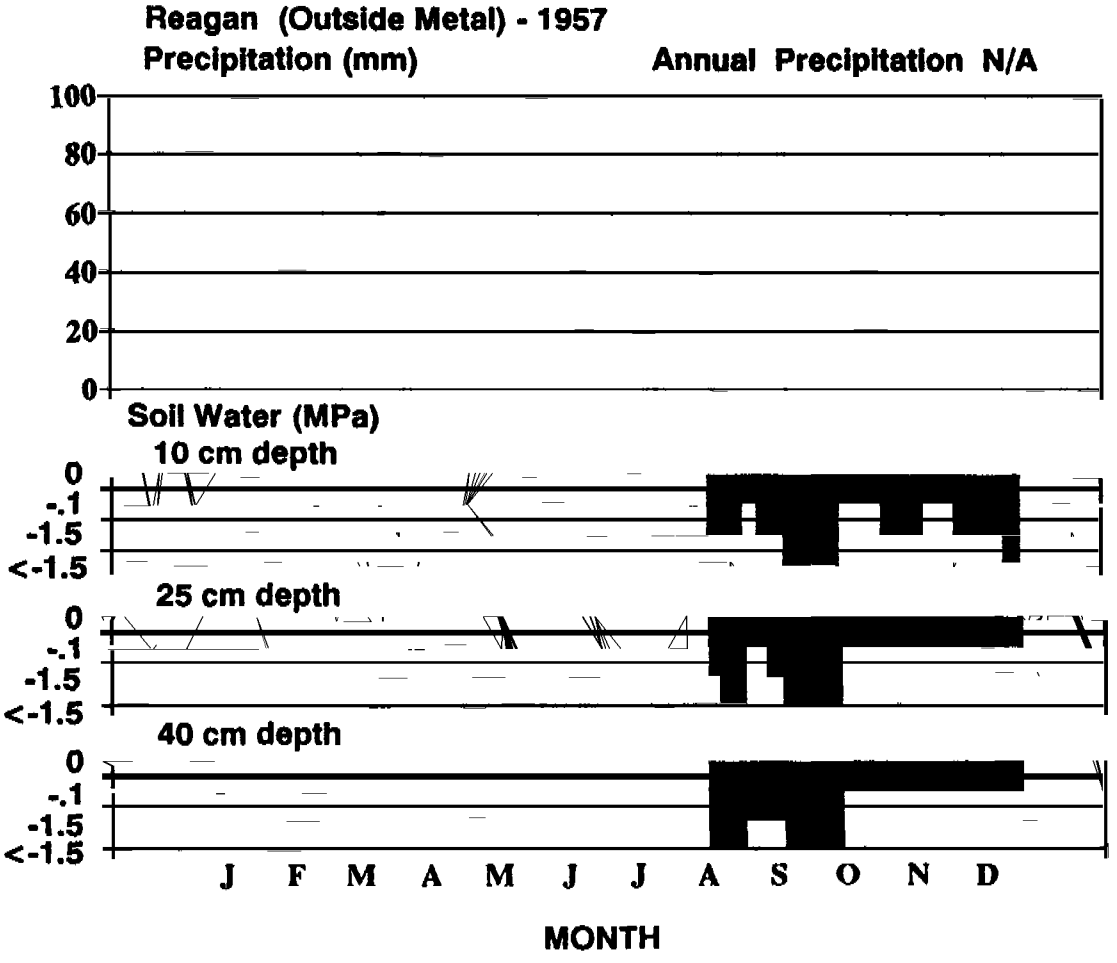


Figure 296. The matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 16-December 31, 1957 outside a sheet metal cylinder at the Reagan site.

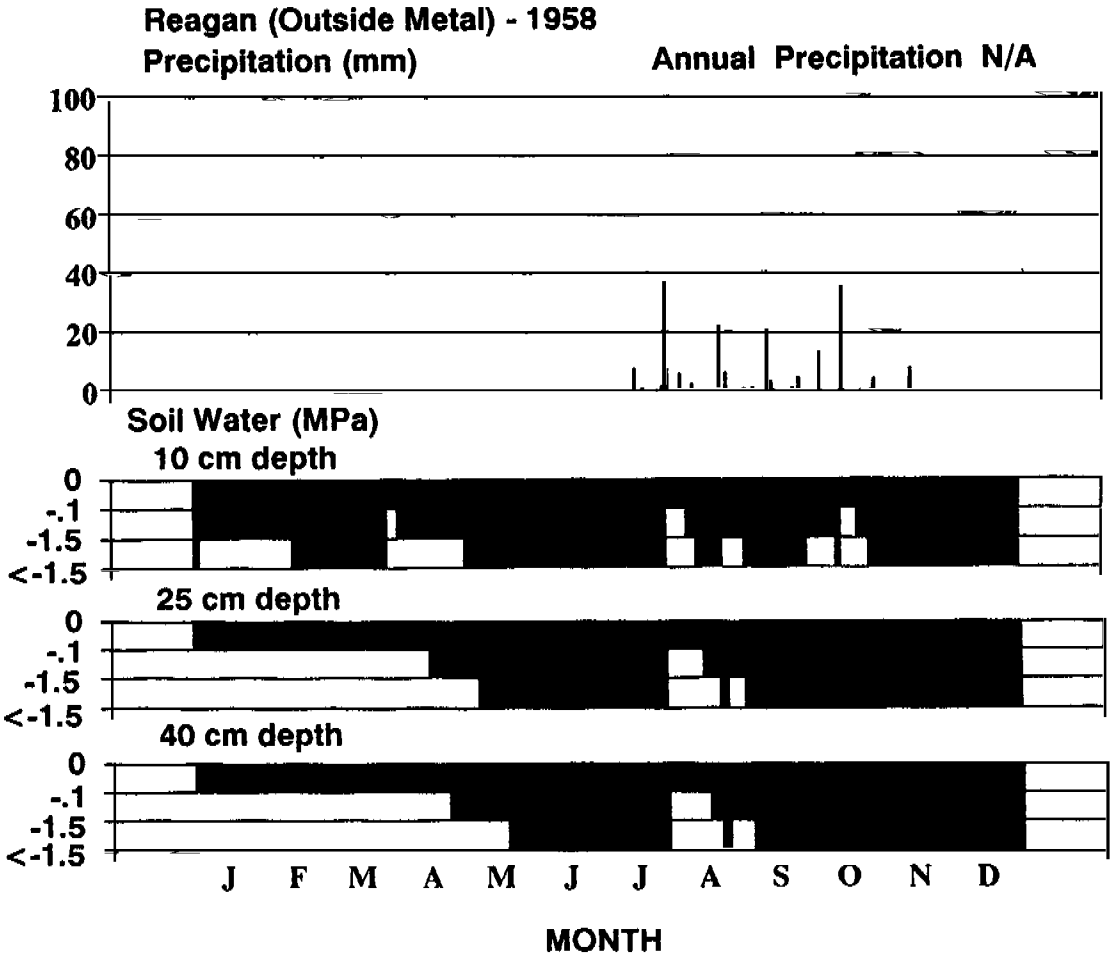


Figure 297. Daily precipitation (mm) for July 15-December 31, 1958 and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for 1958 outside a sheet metal cylinder at the Reagan site.

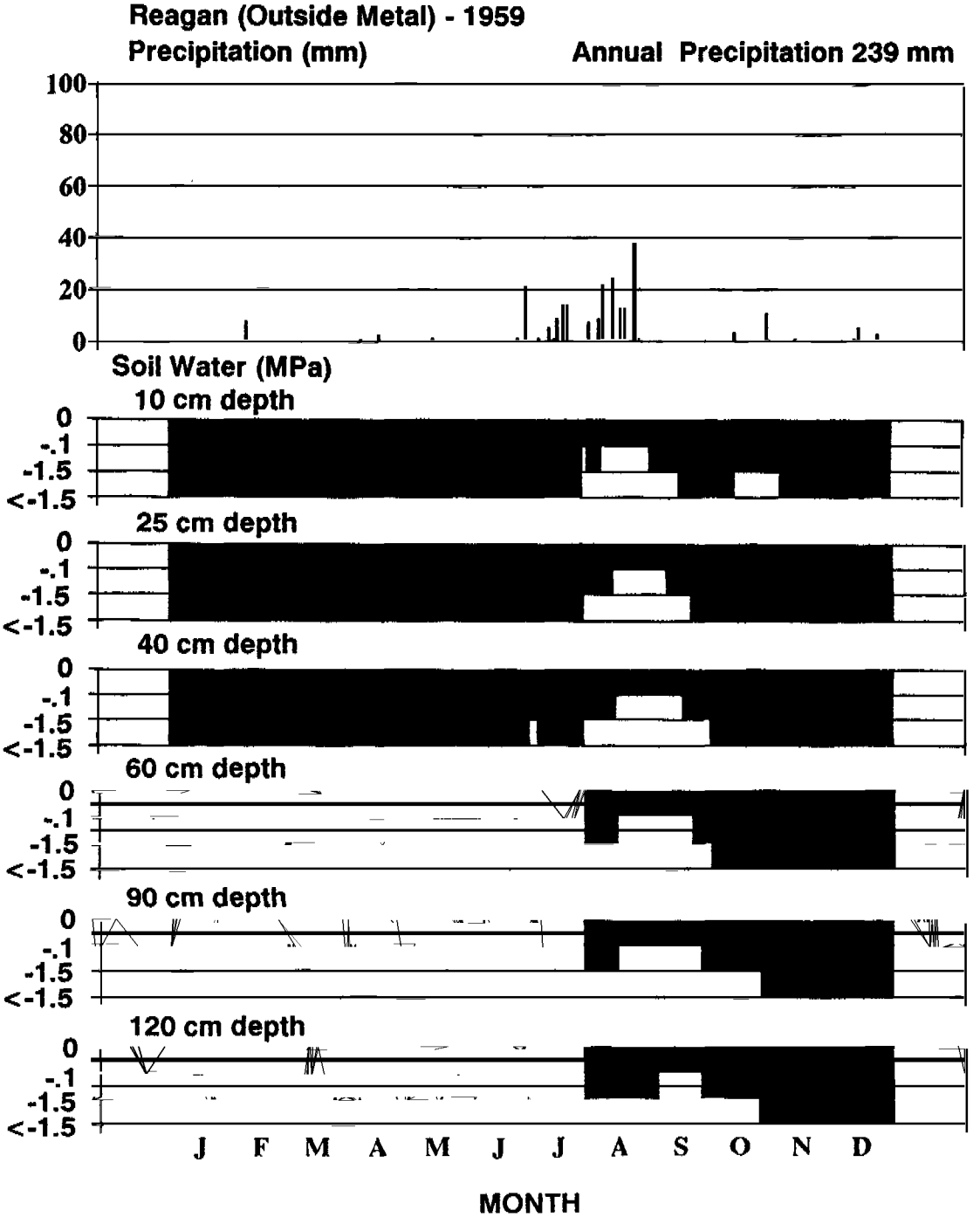


Figure 298. Annual precipitation (239 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm outside a sheet metal cylinder at the Reagan site for 1959. Also shown is the soil water at depths of 60, 90, and 120 cm August 7-December 31, 1959.

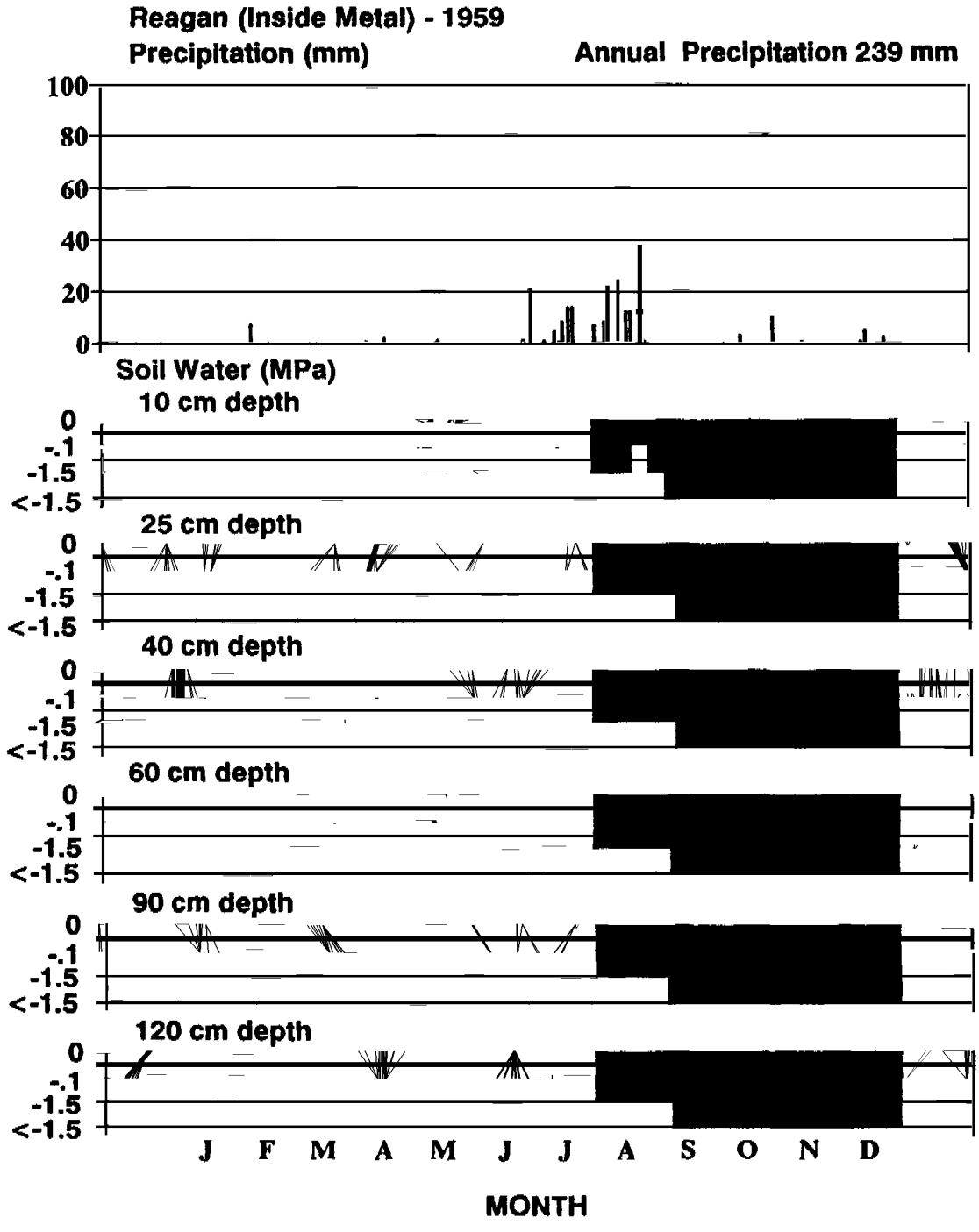


Figure 299. Annual (239 mm) and daily (mm) precipitation for 1959, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm July 31-December 31, 1959 inside a sheet metal cylinder at th Reagan site.

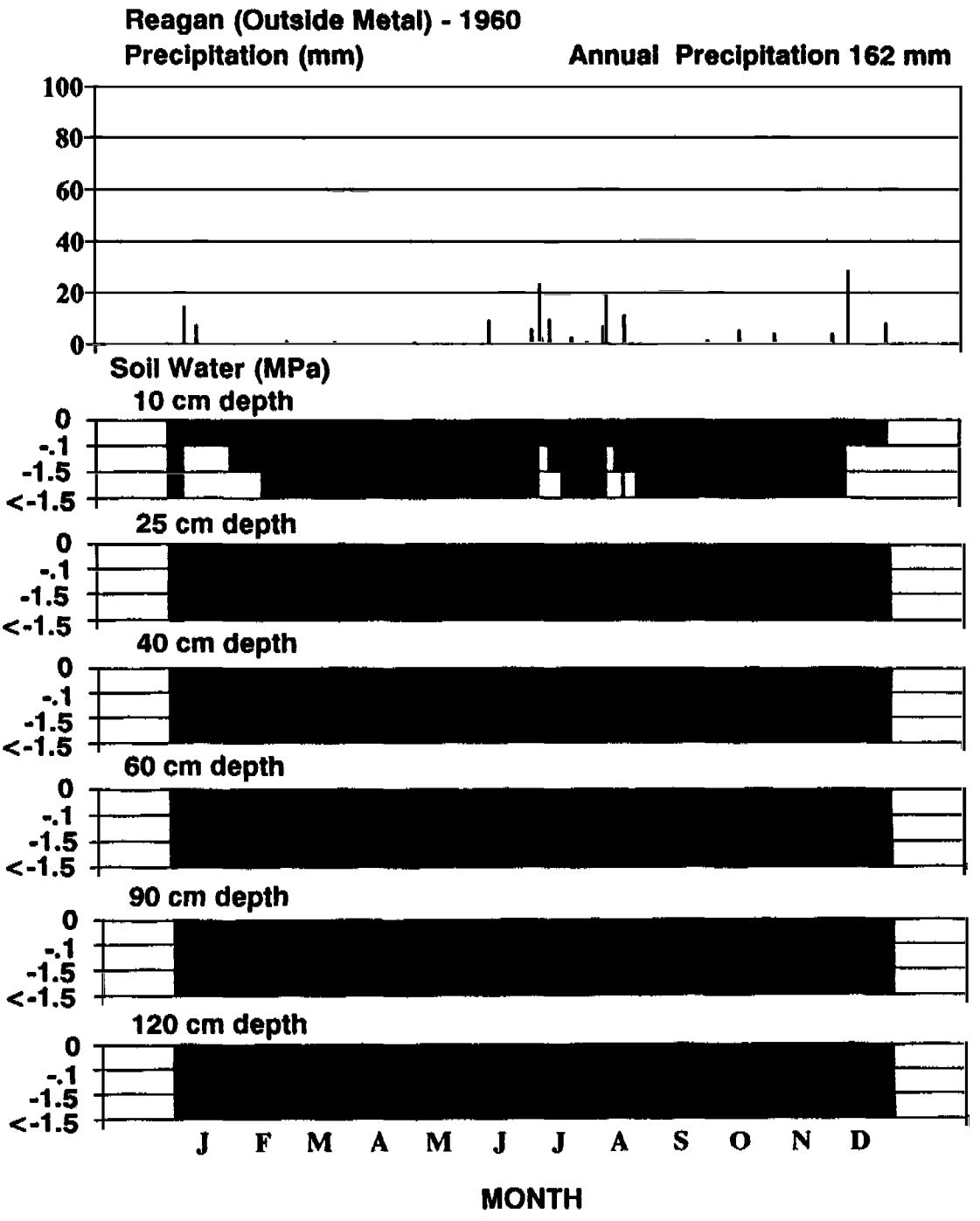


Figure 300. Annual precipitation (162 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1960.

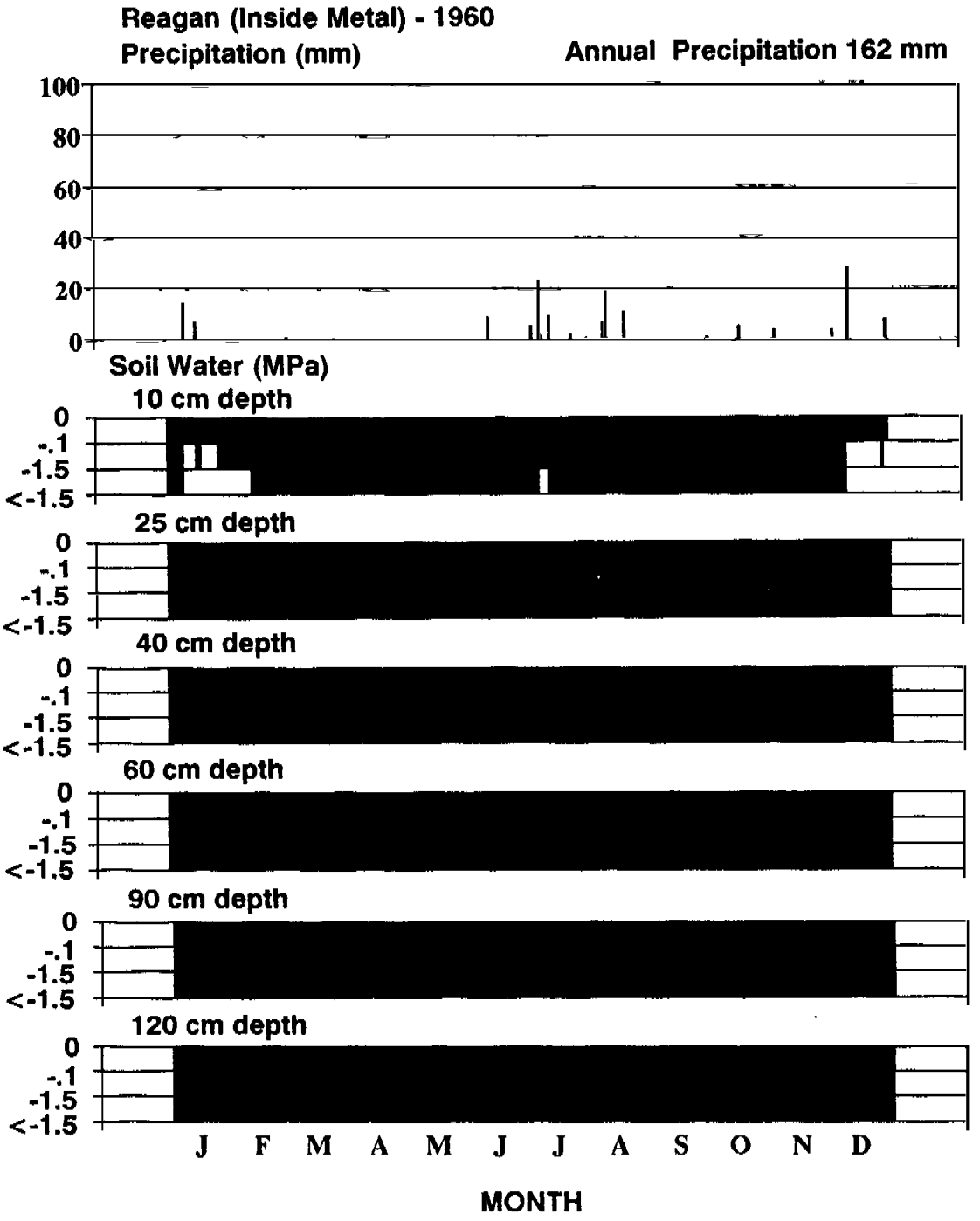


Figure 301. Annual precipitation (162 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1960.

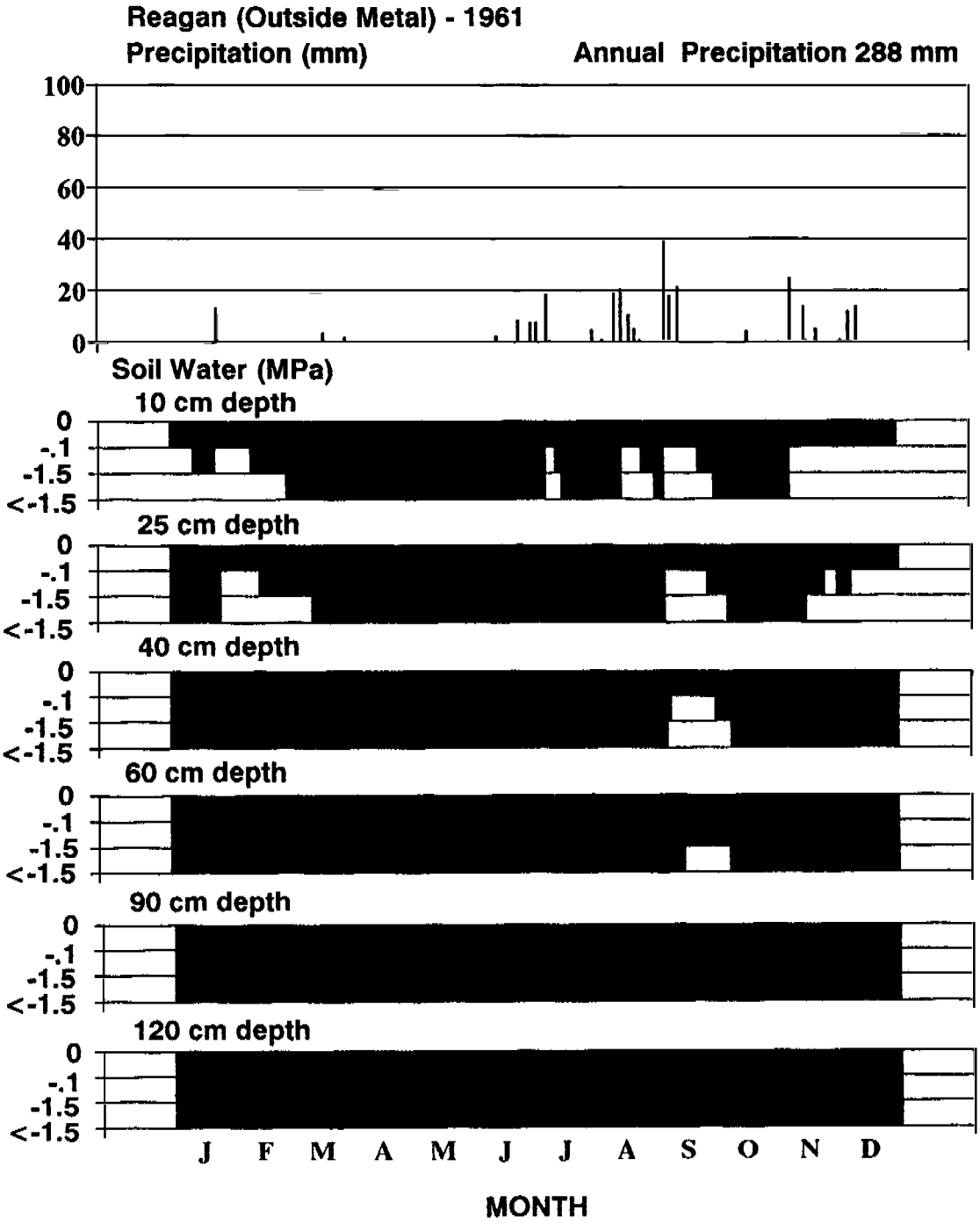


Figure 302. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1961.

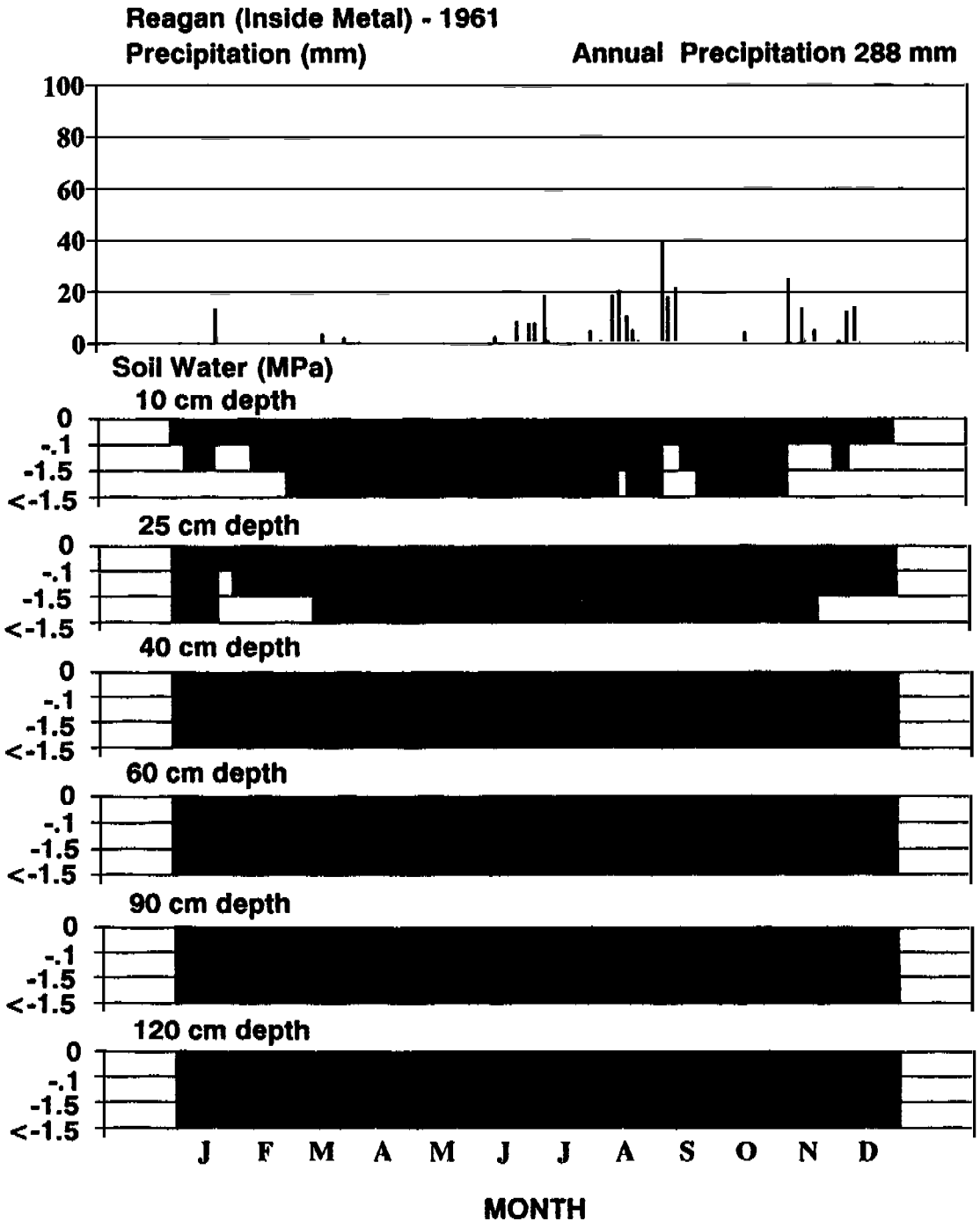


Figure 303. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1961.

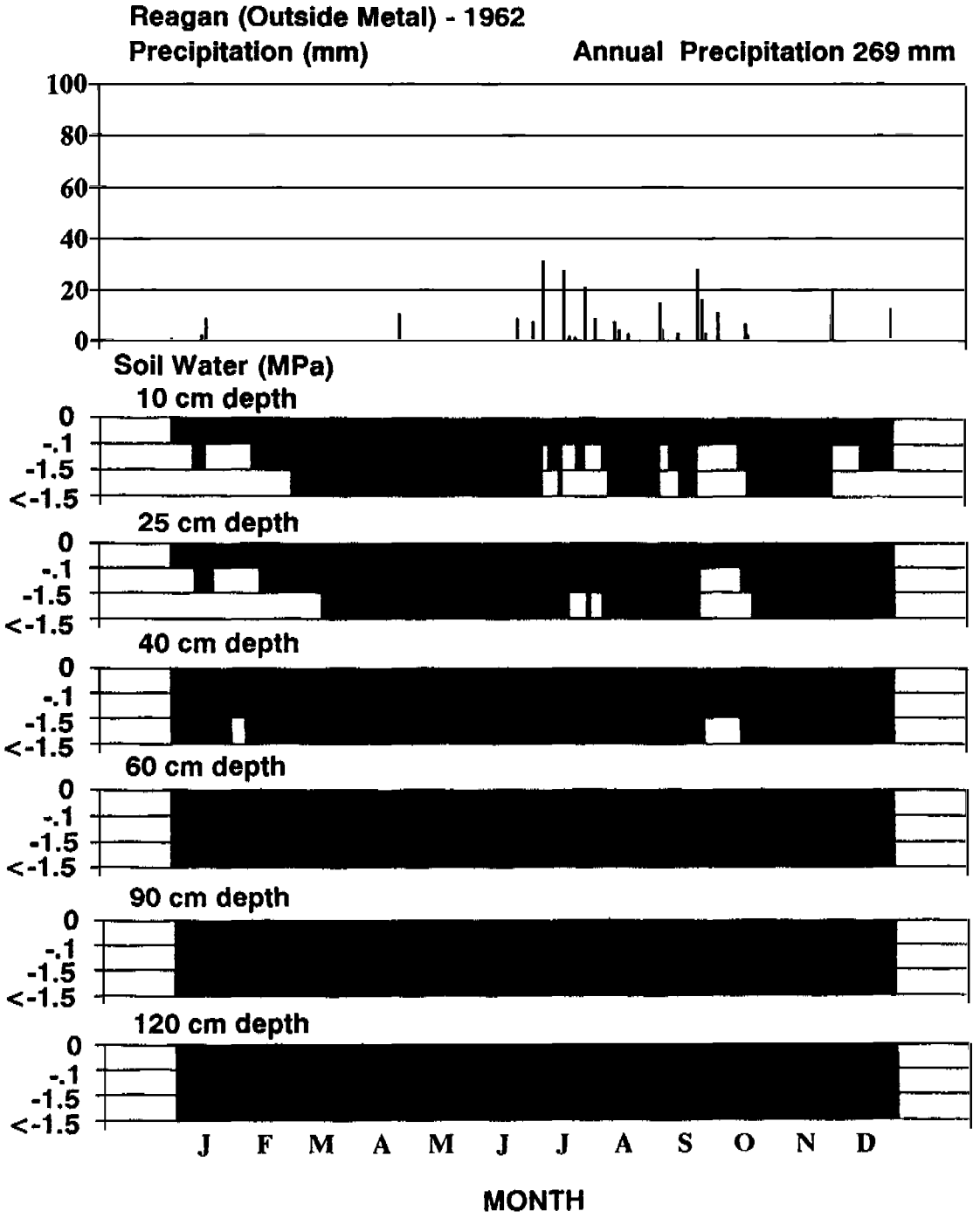


Figure 304. Annual precipitation (269 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1962.

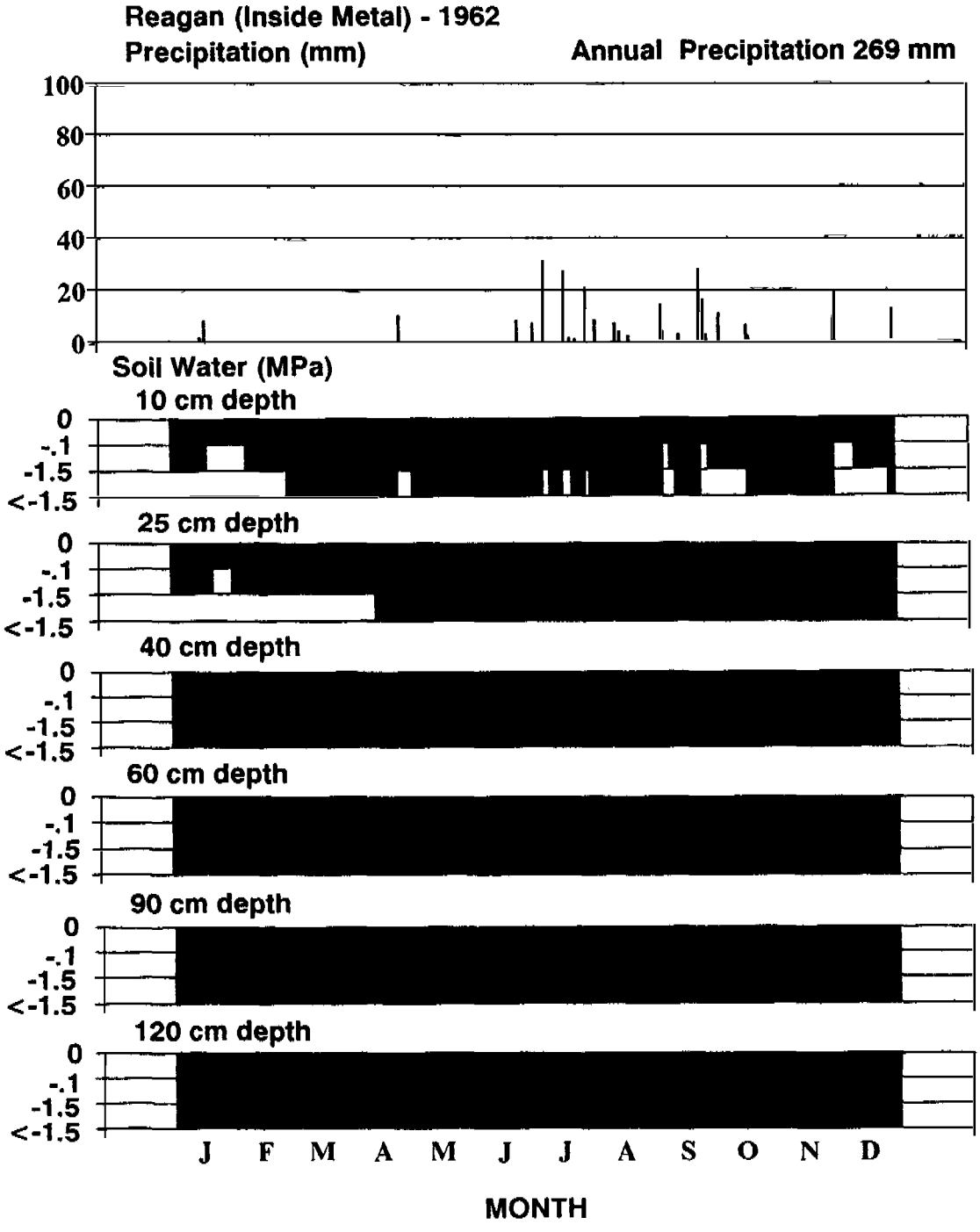


Figure 305. Annual precipitation (269 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1962.

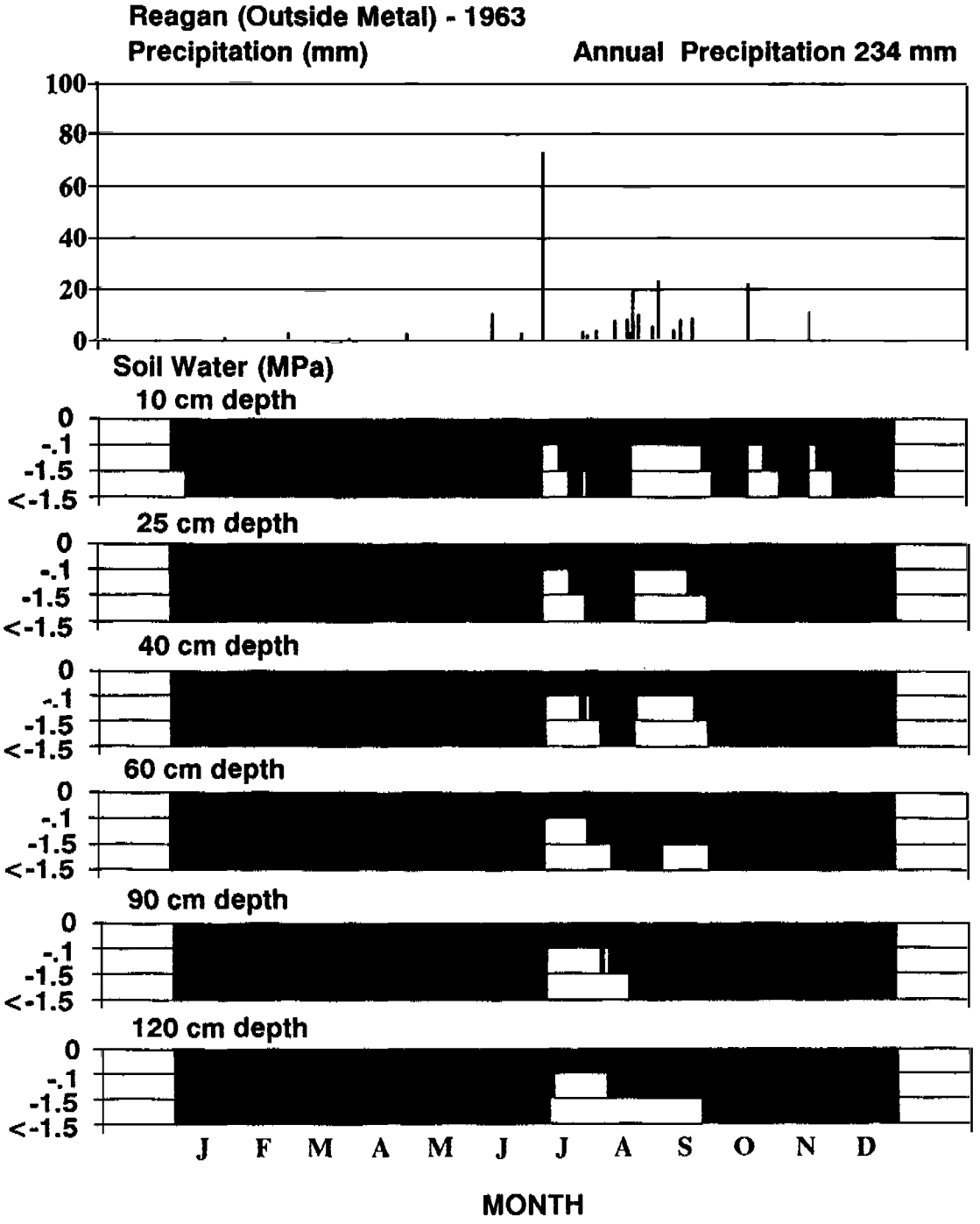


Figure 306. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1963.

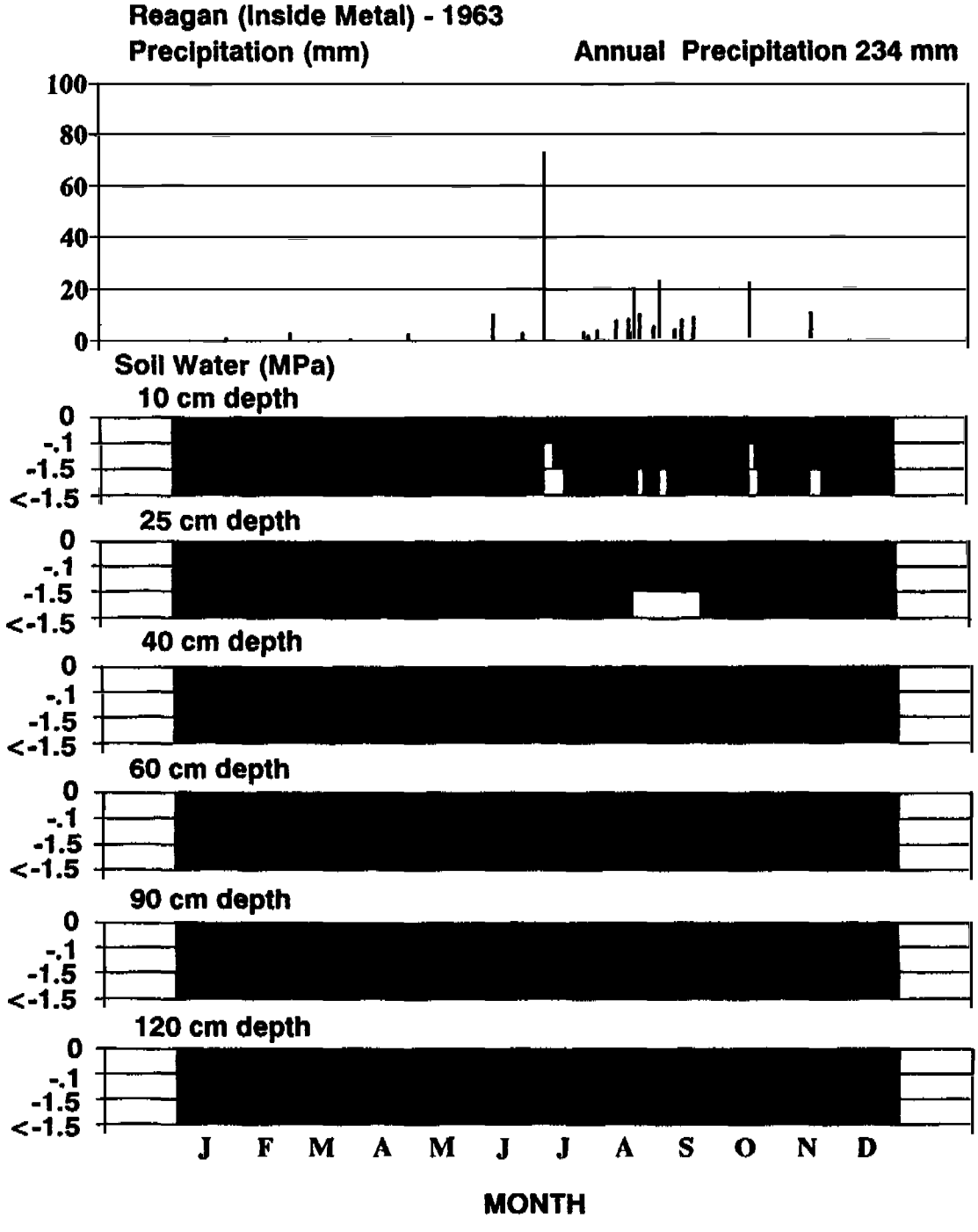


Figure 307. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1963.

the metal at 25 cm it was >-1.5 MPa July 8-28 and August 23-September 27 (fig. 306). There was also more soil water >-1.5 MPa at the deeper levels outside the metal cylinder. Burrograss production in 1963 was 1745 kg/ha (s.e.=116 kg/ha).

Annual precipitation was below average for the next 3 years, 1964-66 (figs. 308-313). The matric potential of the soil water at 25 cm outside the metal was >-1.5 MPa September 11-October 14, 1964 (fig. 308) and August 2-28, 1966 (fig. 312) while none was recorded at this depth inside the metal cylinder (figs. 309, 311, 313). Annual yields of burrograss were 142 kg/ha (s.e.=19 kg/ha), 70 kg/ha (s.e.=16 kg/ha), and 719 kg/ha (s.e.=56 kg/ha) for 1964-66, respectively.

For the next three years, 1967-1969, annual precipitation was 292, 288, and 242 mm, respectively (figs. 314-319). Inside the metal at the 25-cm depth, water was >-1.5 MPa August 6, 1967-May 5, 1968 (figs. 315, 317); August 5-15, 1968 (fig. 317); and February 1-12, 1969 (fig. 319). The soil water outside the metal at 25 cm was >-1.5 MPa June 29, 1967-July 26 (fig. 314); August 5, 1967-May 4, 1968 (figs. 314, 316); July 5-16; July 29-August 18, 1968 (fig. 316); July 11-18, 1969 (fig. 318); and September 2-9, 1969. Production of burrograss was 849 kg/ha (s.e.=87 kg/ha) in 1967, 469 kg/ha (s.e.=48 kg/ha) in 1968, and 973 kg/ha (s.e.=73 kg/ha) in 1969.

Burrograss produced 216 kg/ha (s.e.=19 kg/ha) in 1970. Annual precipitation was 153 mm (figs. 320, 321). Matric potential of the soil water at 25 cm inside the metal was <-1.5 MPa the entire year (fig. 321) while outside the metal it was >-1.5 MPa August 2-12 and October 2-November 4 (fig. 320).

Annual precipitation for the next 6 years, 1971-76, was >245 mm each year (figs. 322-333). Estimated yields of burrograss were 810 kg/ha (s.e.=64 kg/ha) in 1971, 1314 kg/ha (s.e.=87 kg/ha) in 1972, 1202 kg/ha (s.e.=120 kg/ha) in 1973, 689 kg/ha (s.e.=57 kg/ha) in 1974, 1217 kg/ha (s.e.=84 kg/ha) in 1975, and 495 kg/ha (s.e.=43 kg/ha) in 1976. Inside the metal cylinder at the 25-cm depth soil water was >-1.5 MPa January 7, 1973-April 24 (fig. 327); July 20-August 5; August 30-September 4, 1973; July 15, 1974-August 6 (fig. 329); and December 26, 1974-January 21, 1975 (figs. 329, 331); whereas outside the metal it was >-1.5 MPa August 18, 1971-September 16 (fig. 322); October 29-November 2, 1971; January 7, 1973-April 13 (fig. 326); June 15-23; July 19-August 5; August 29-September 7, 1973 (fig. 326); July 15, 1974-August 31 (fig. 328); September 21, 1974-January 31, 1975 (figs. 328, 330); September 13-30, 1975; and November 30-December 2, 1976 (fig. 332). Soil water was not determined August 8-December 31, 1972.

Annual precipitation for 1959-76 averaged 244 mm. Precipitation was below average for five years, about average for five years, and above average for eight years. Burrograss yields for 1957-76 averaged 926 kg/ha. The probability of the matric potential of the soil water >-1.5 MPa at the 25-cm depth inside the metal cylinder averaged 18.7% for December-April, 0.6% for May-June, 11.9% for July-September, and 6.8% for October-November

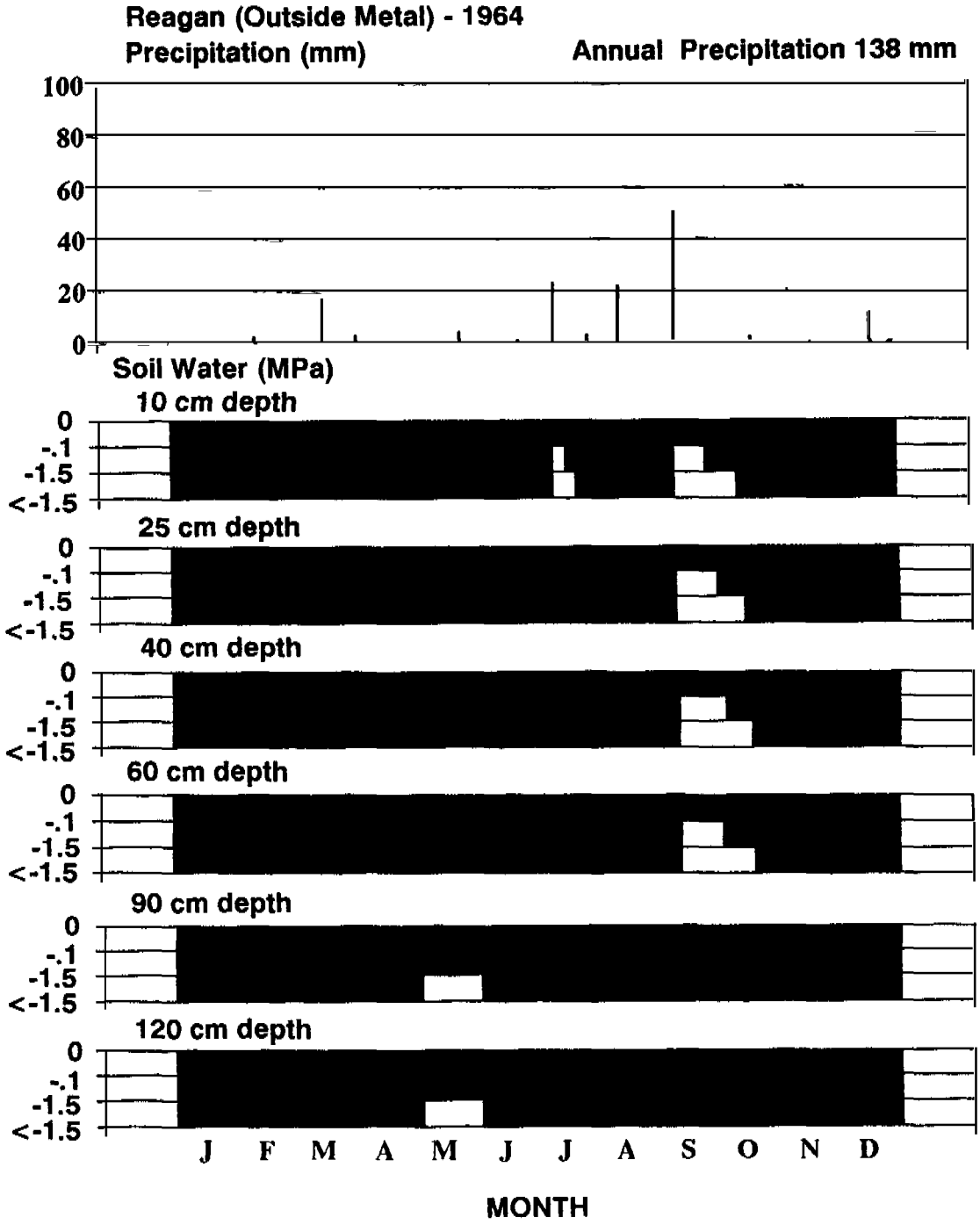


Figure 308. Annual precipitation (138 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1964.

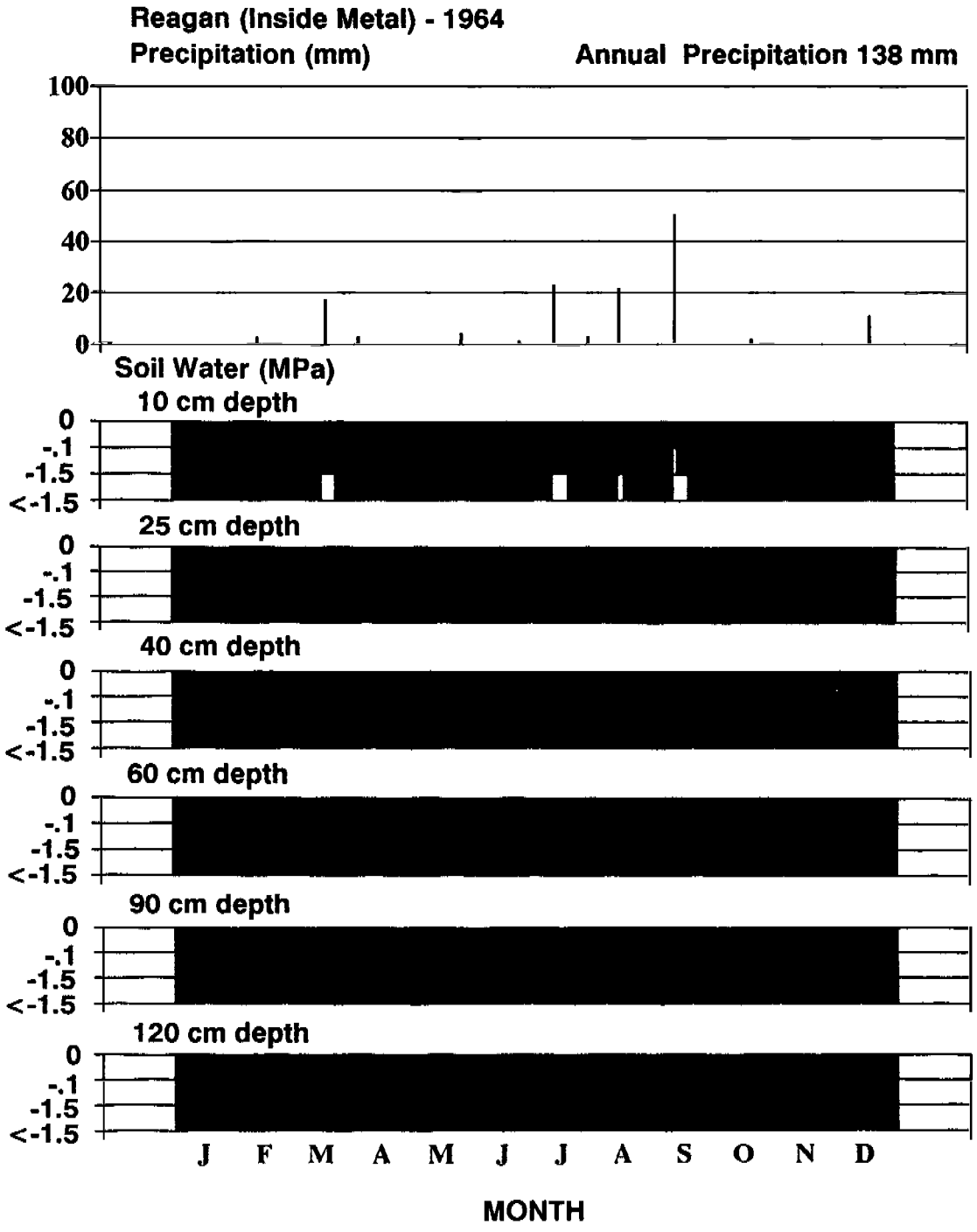


Figure 309. Annual precipitation (138 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1964.

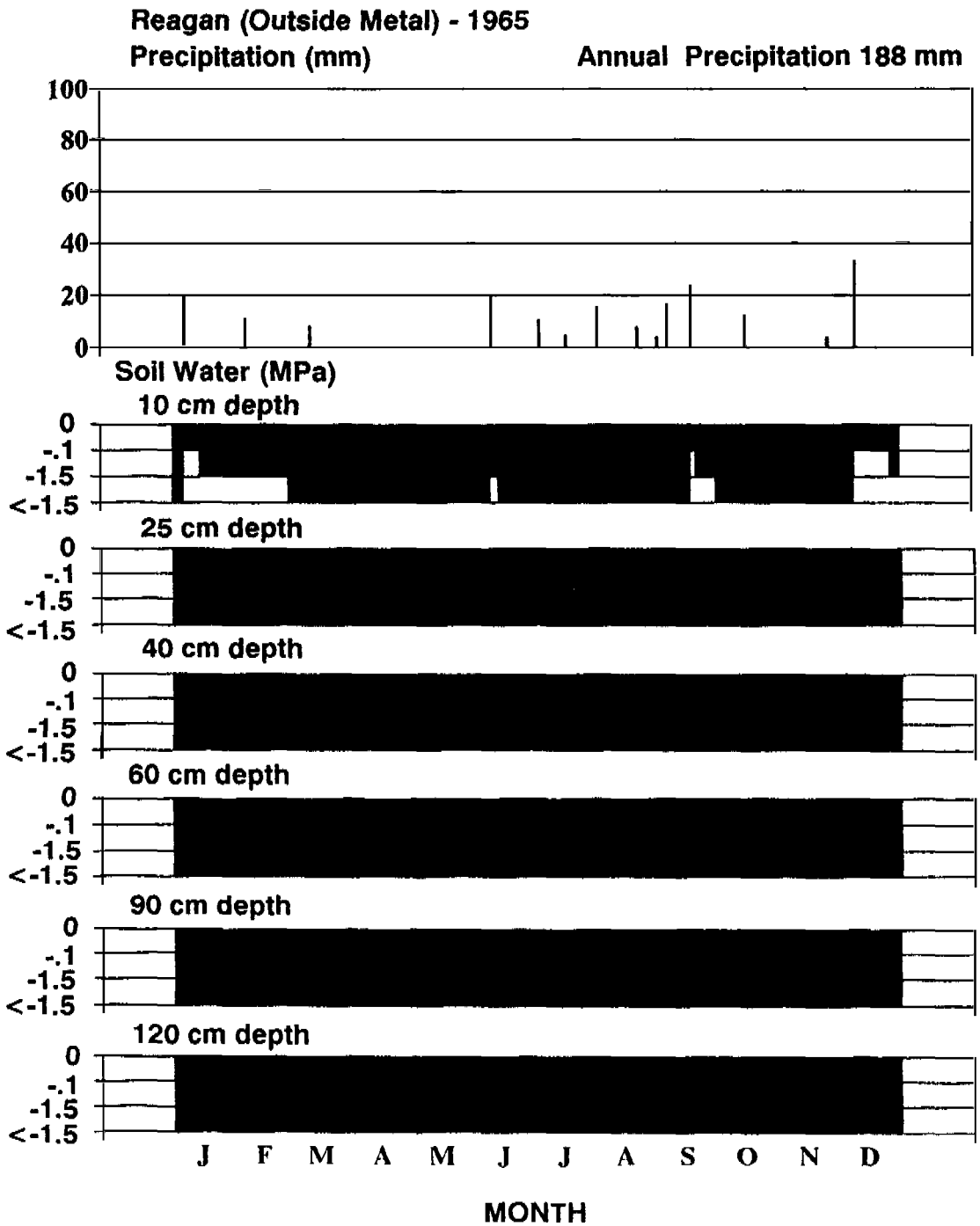


Figure 310. Annual precipitation (188 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1965.

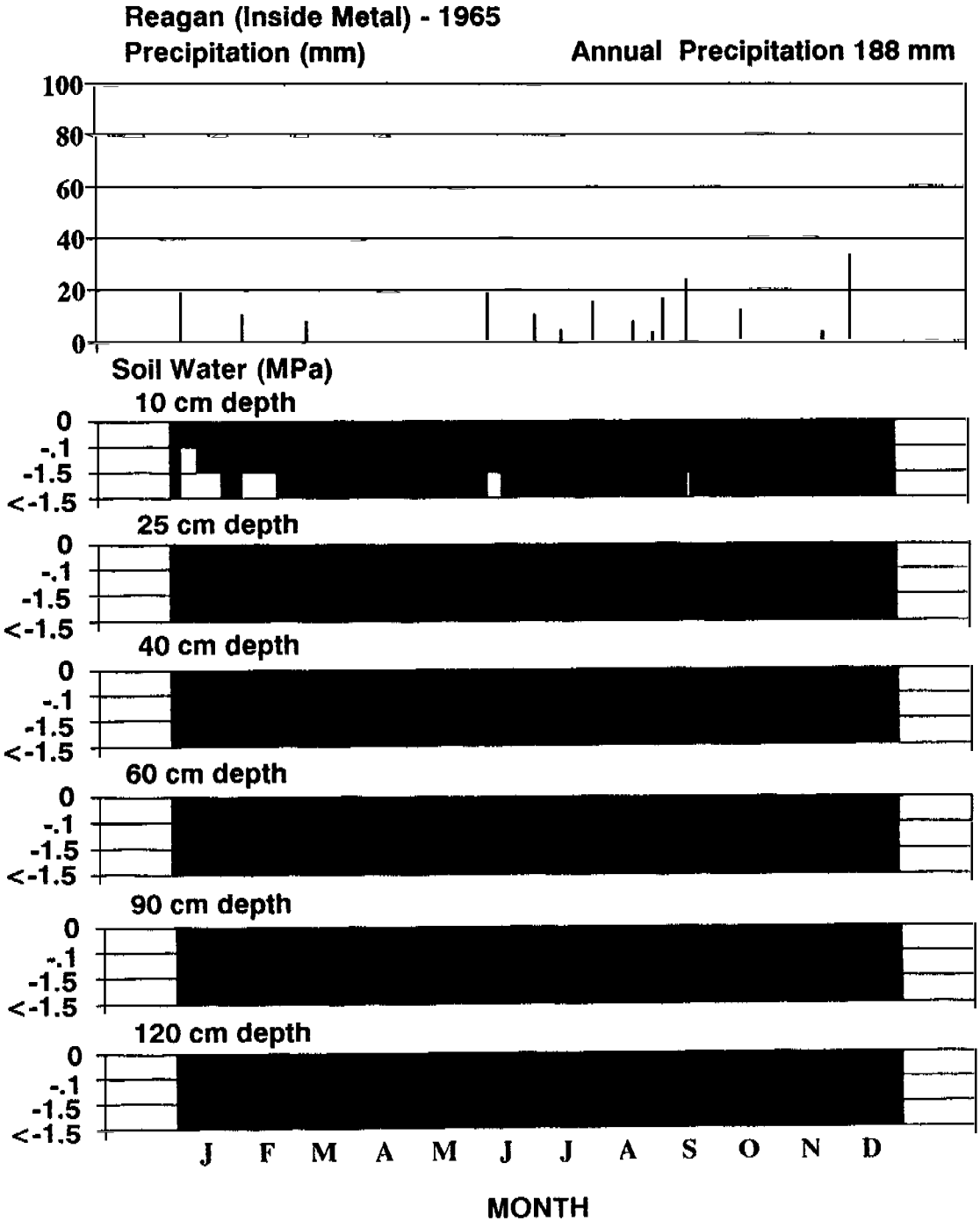


Figure 311. Annual precipitation (188 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1965.

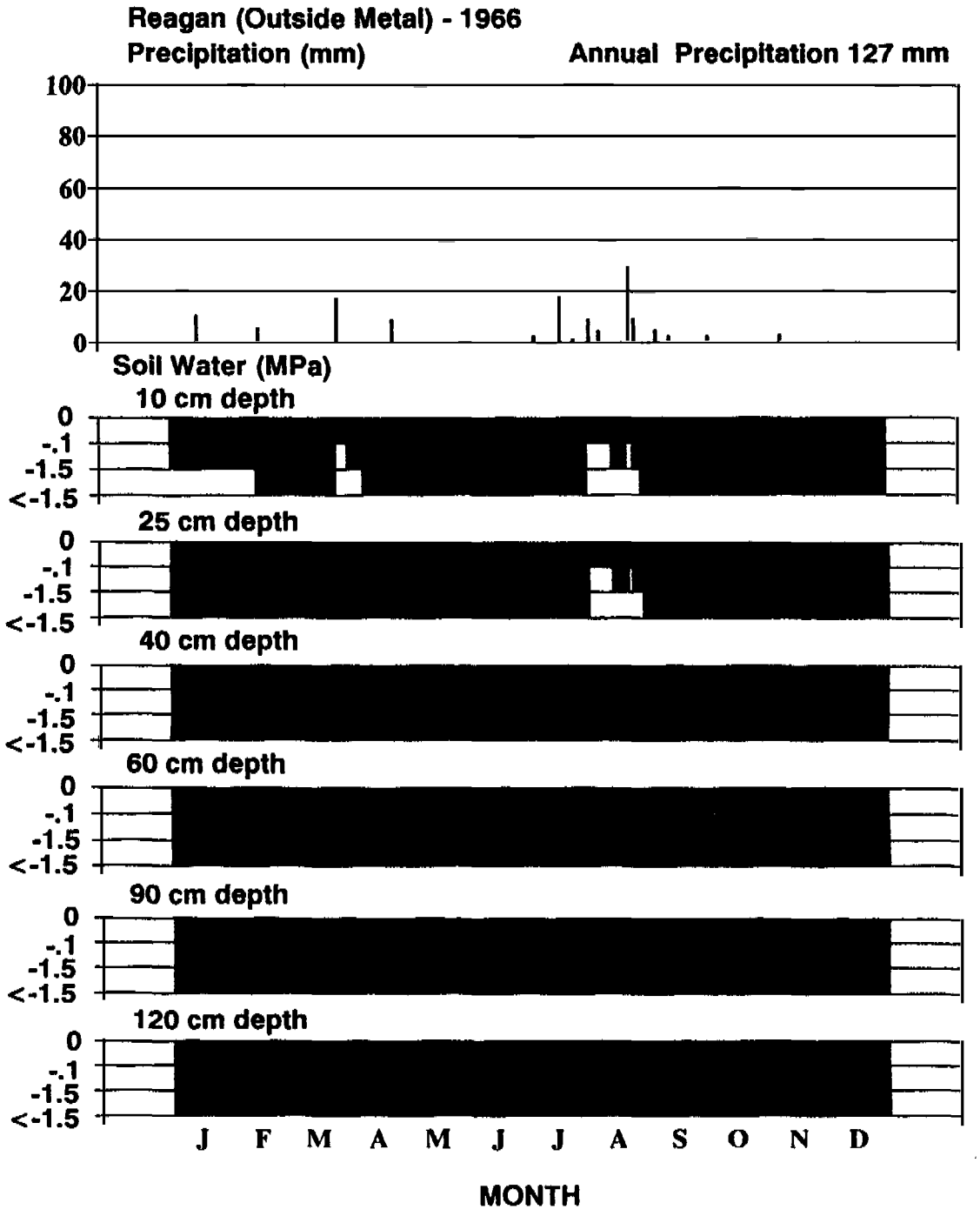


Figure 312. Annual precipitation (127 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1966.

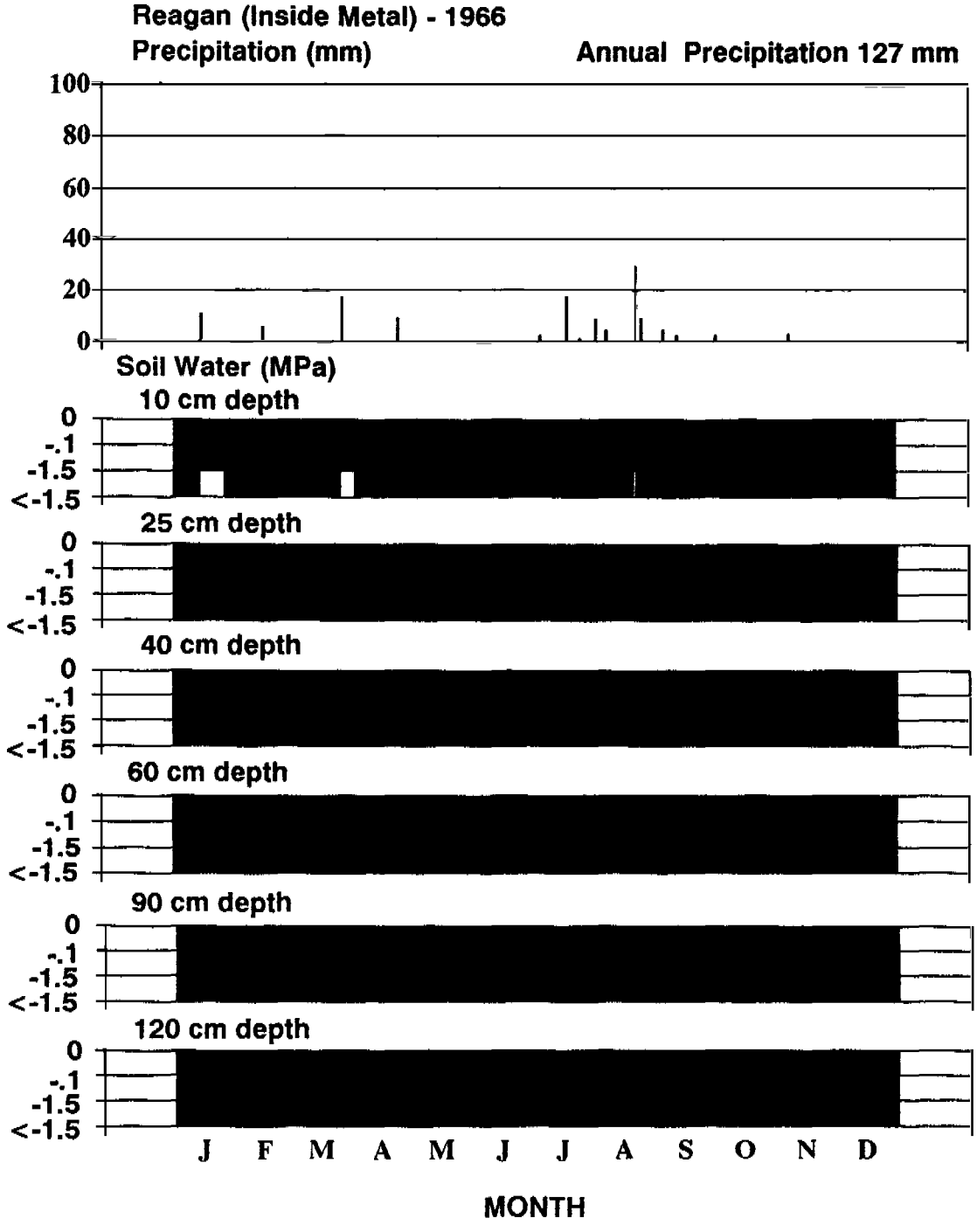


Figure 313. Annual precipitation (127 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1966.

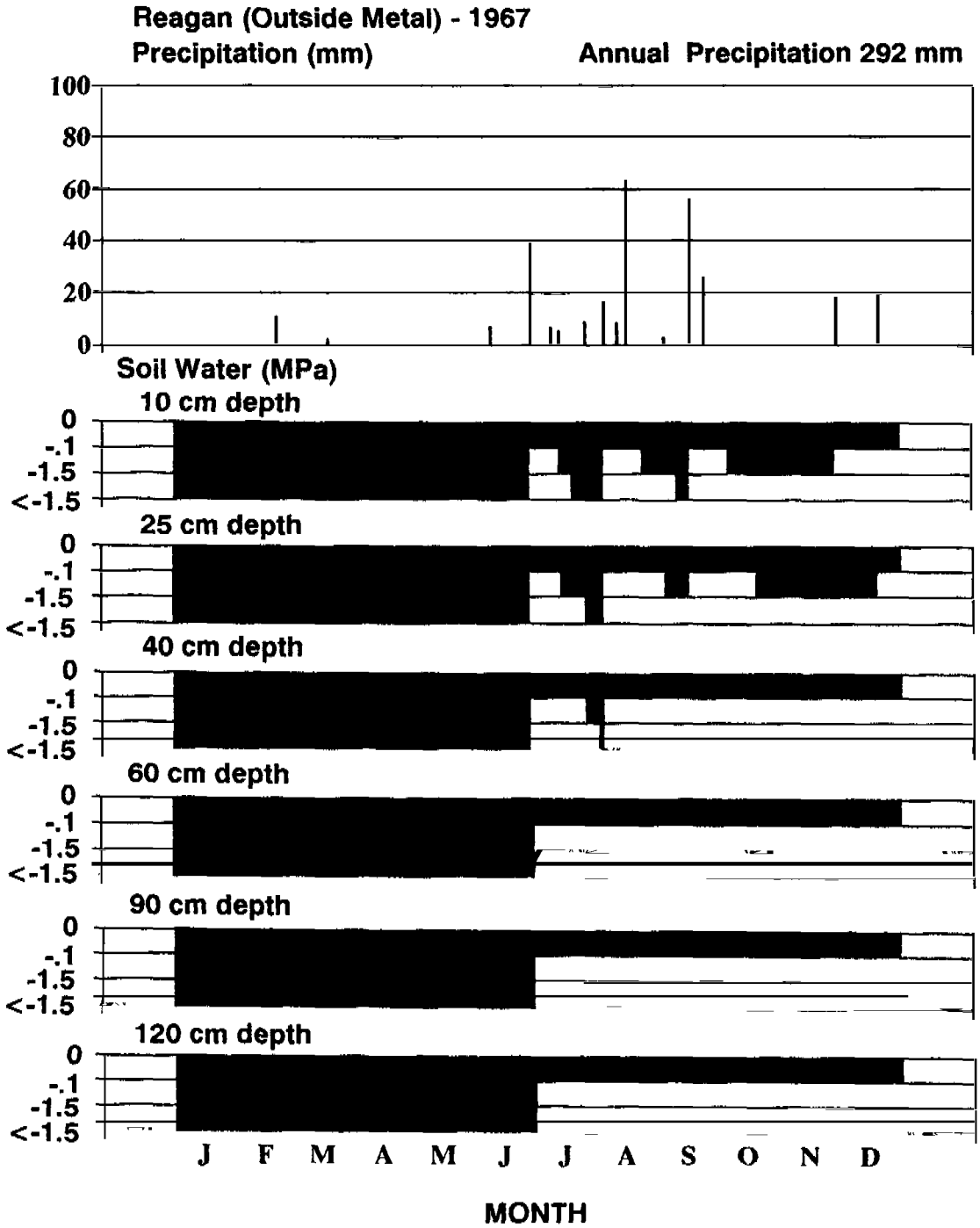


Figure 314. Annual precipitation (292 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1967.

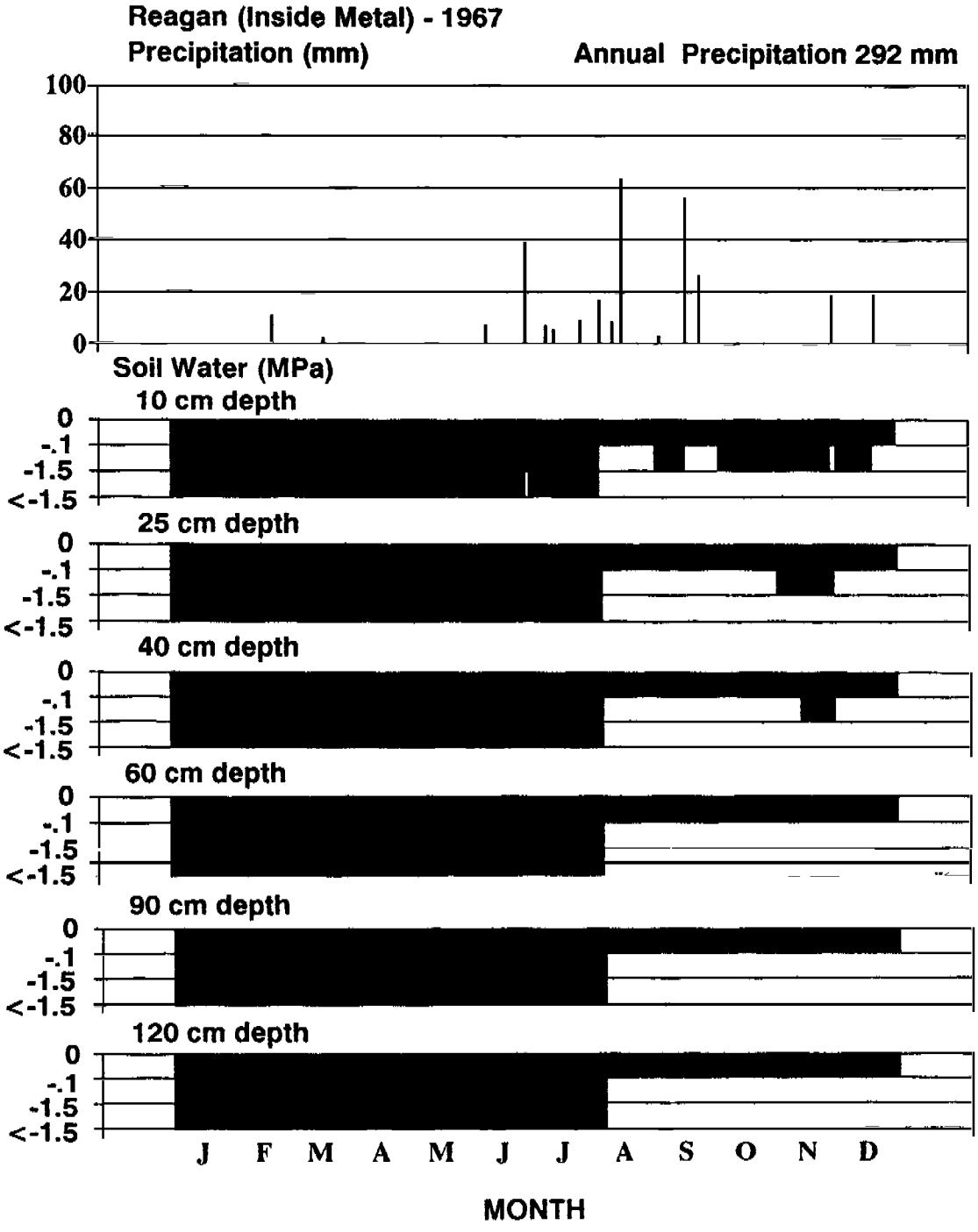


Figure 315. Annual precipitation (292 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1967.

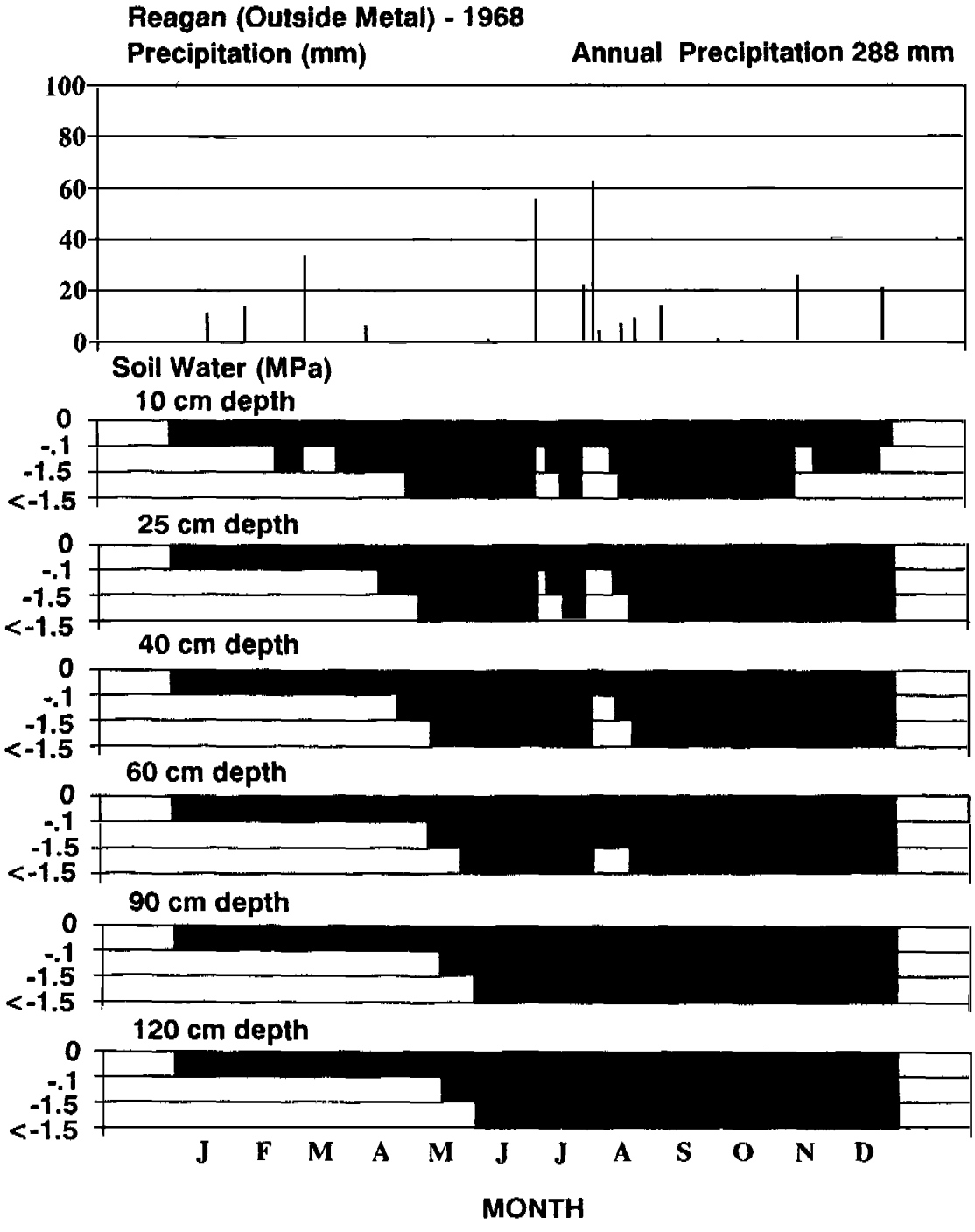


Figure 316. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1968.

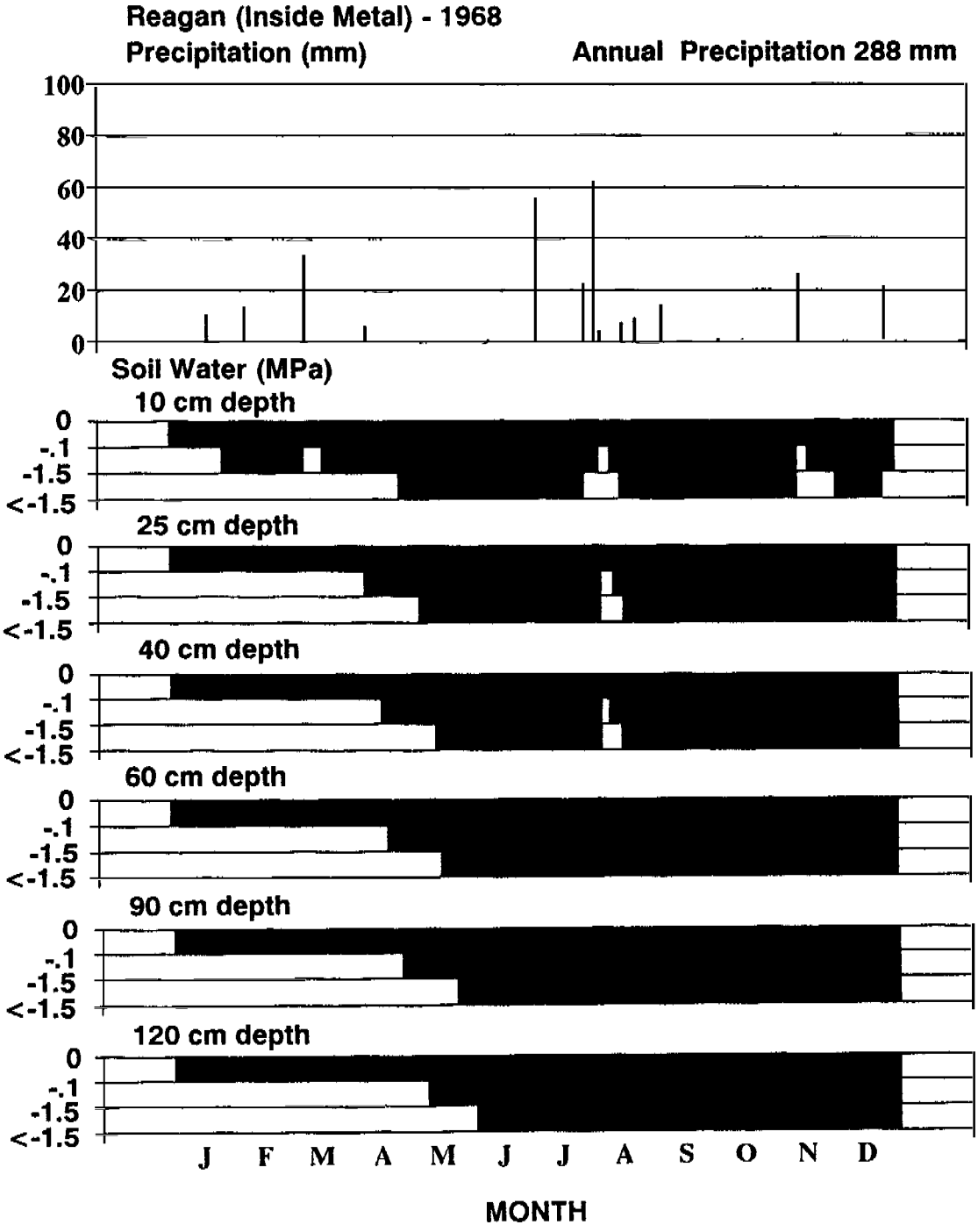


Figure 317. Annual precipitation (288 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1968.

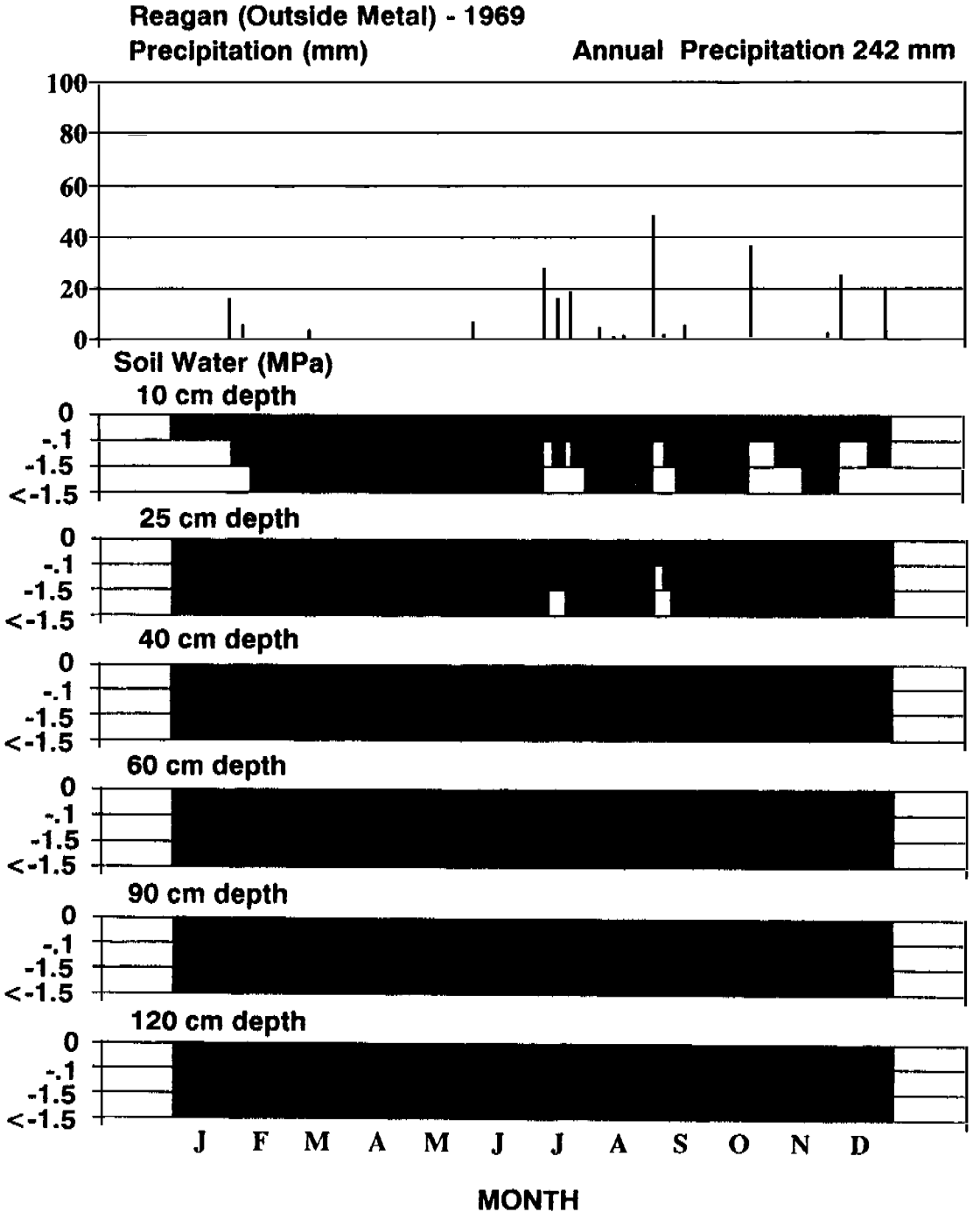


Figure 318. Annual precipitation (242 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1969.

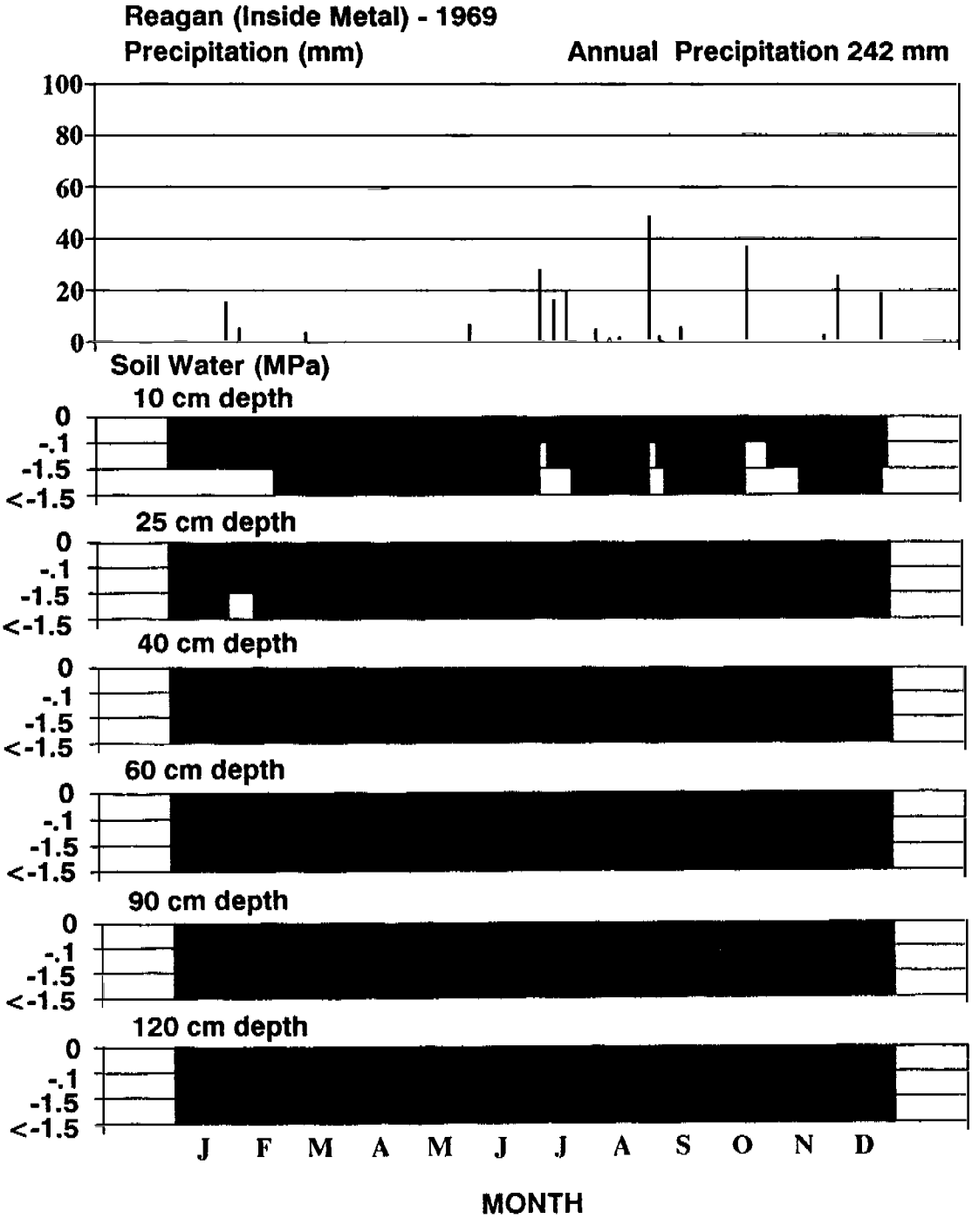


Figure 319. Annual precipitation (242 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1969.

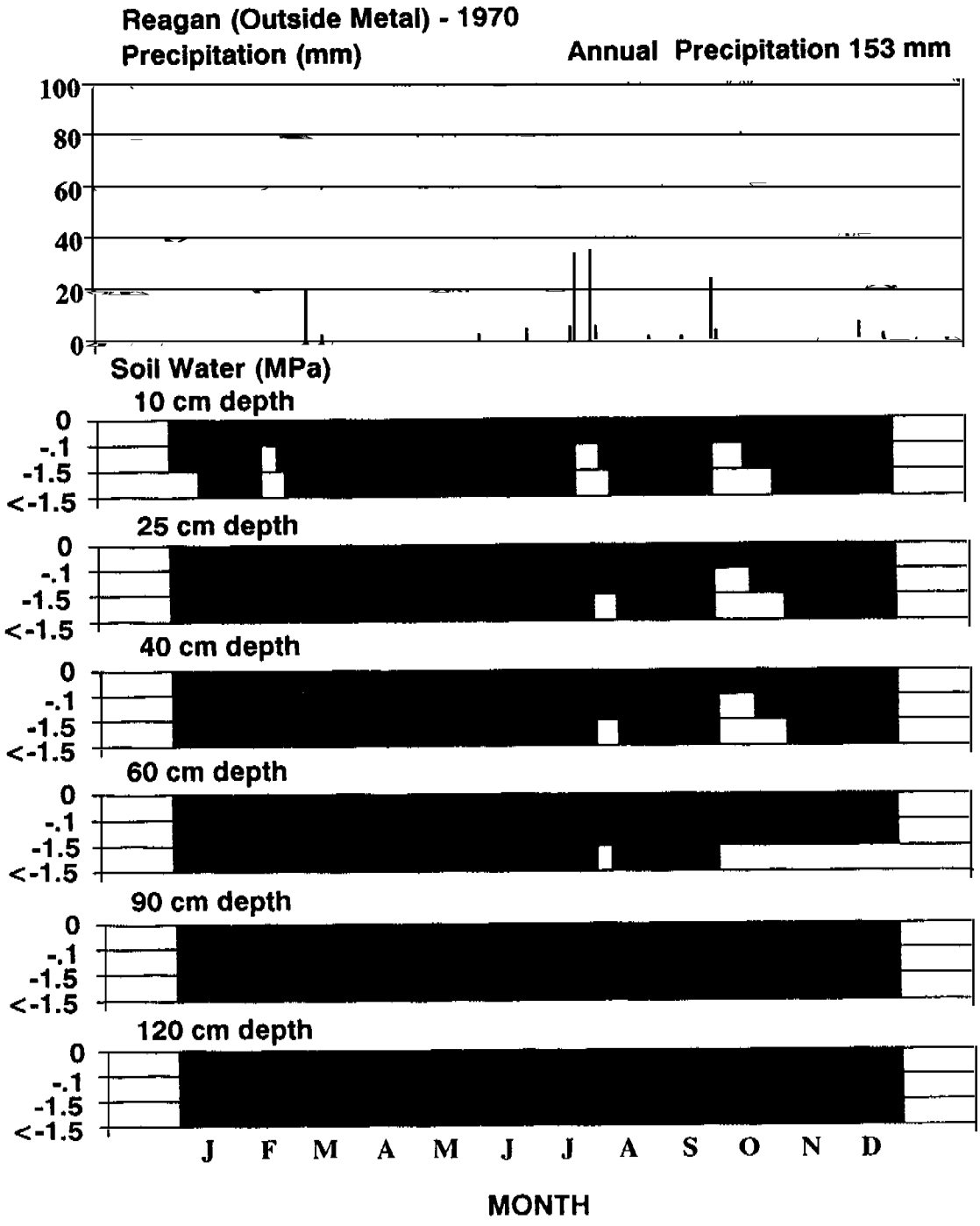


Figure 320. Annual precipitation (153 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1970.

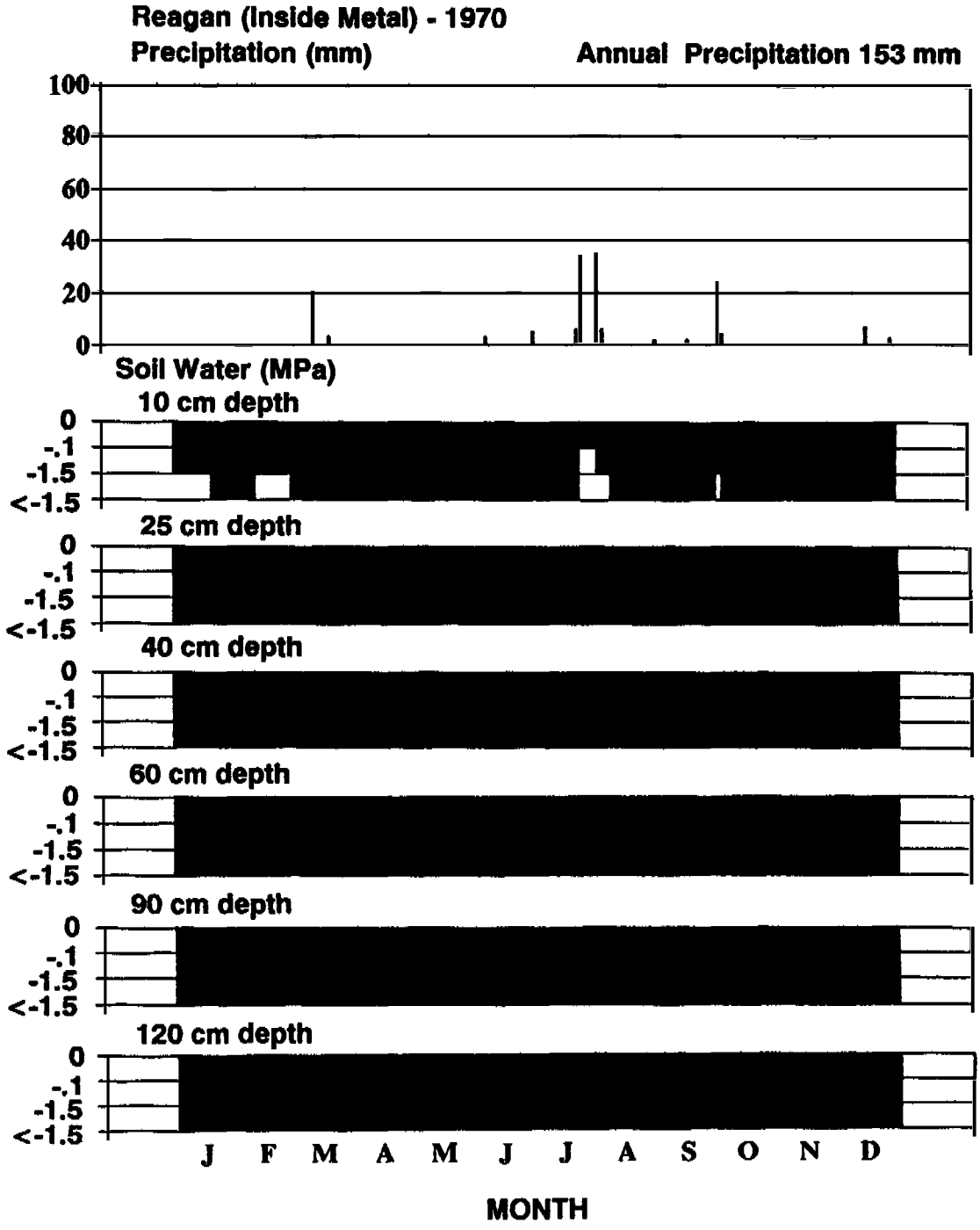


Figure 321. Annual precipitation (153 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1970.

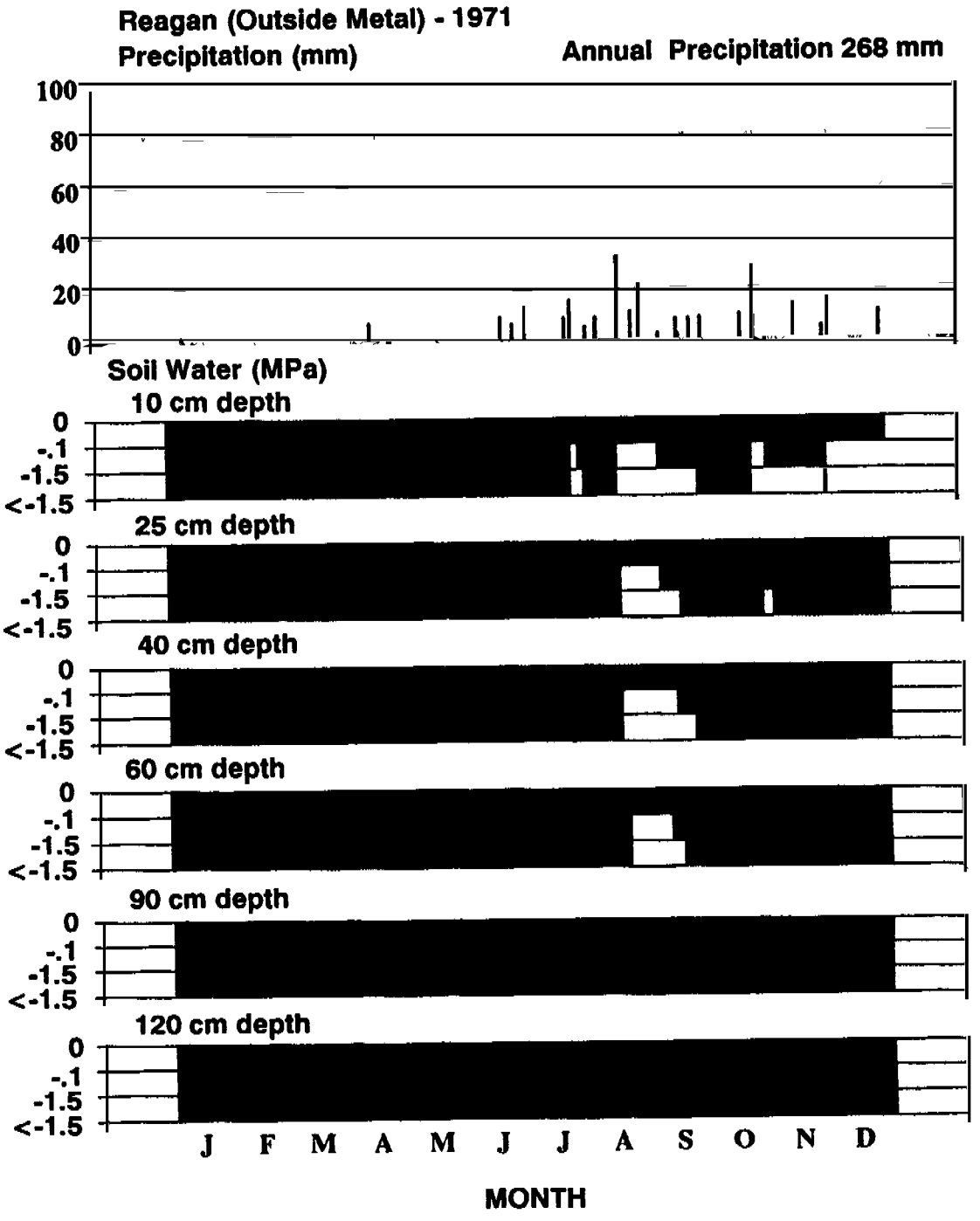


Figure 322. Annual precipitation (268 mm), daily precipitation (mm), and the matric potential of the soil water (MPA) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1971.

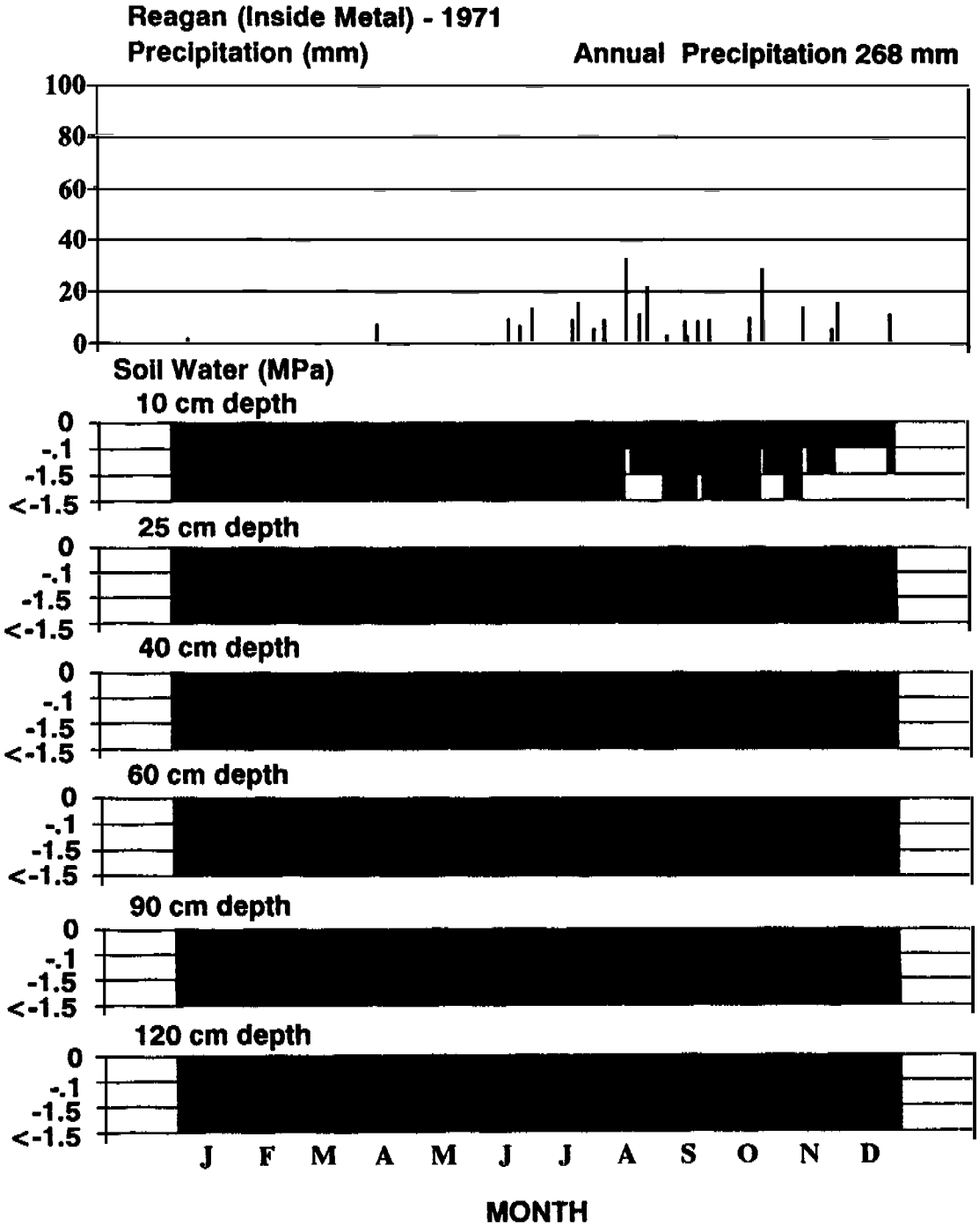


Figure 323. Annual precipitation (268 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1971.

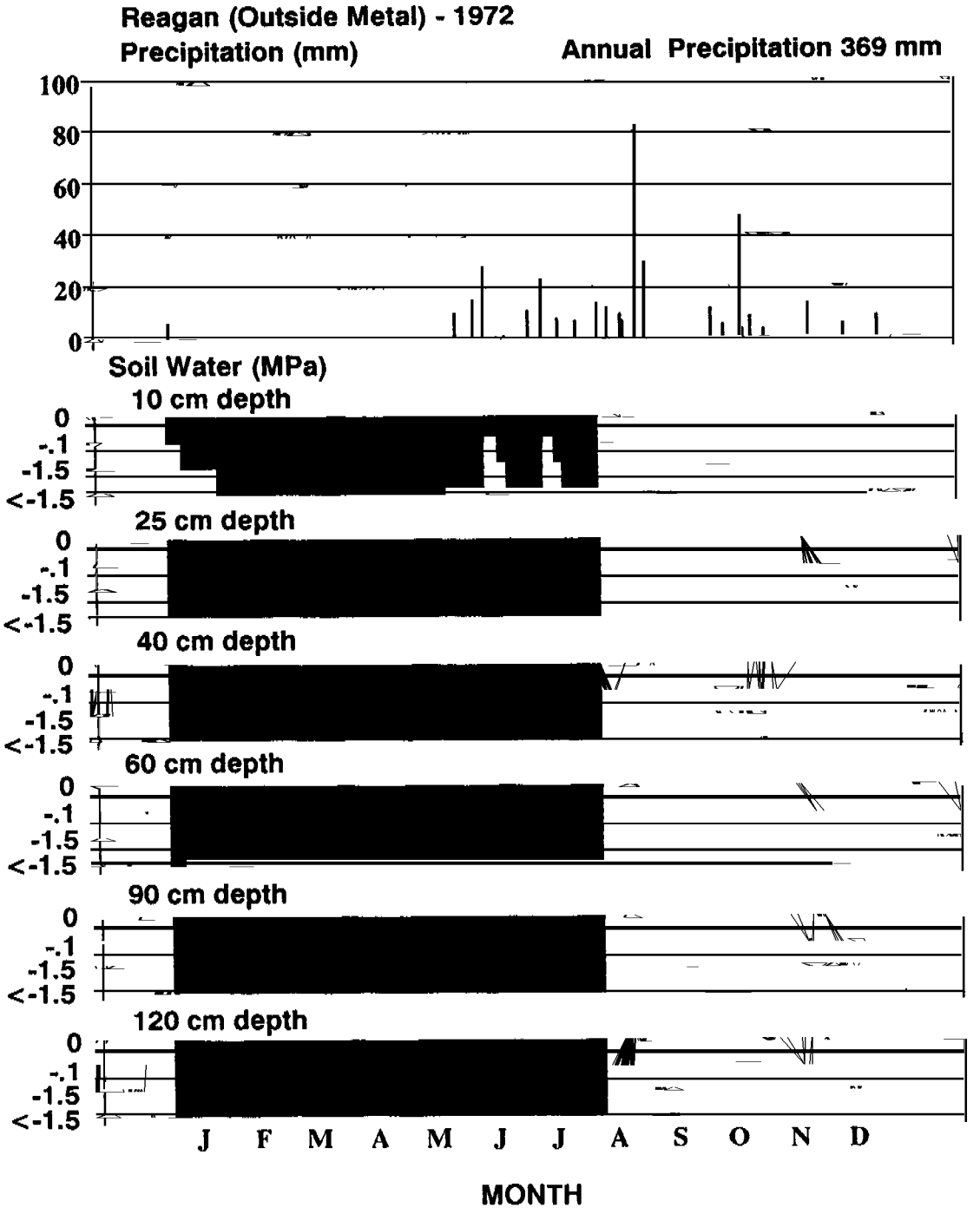


Figure 324. Annual (369 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside a sheet metal cylinder for January 1-August 7, 1972 at the Reagan site.

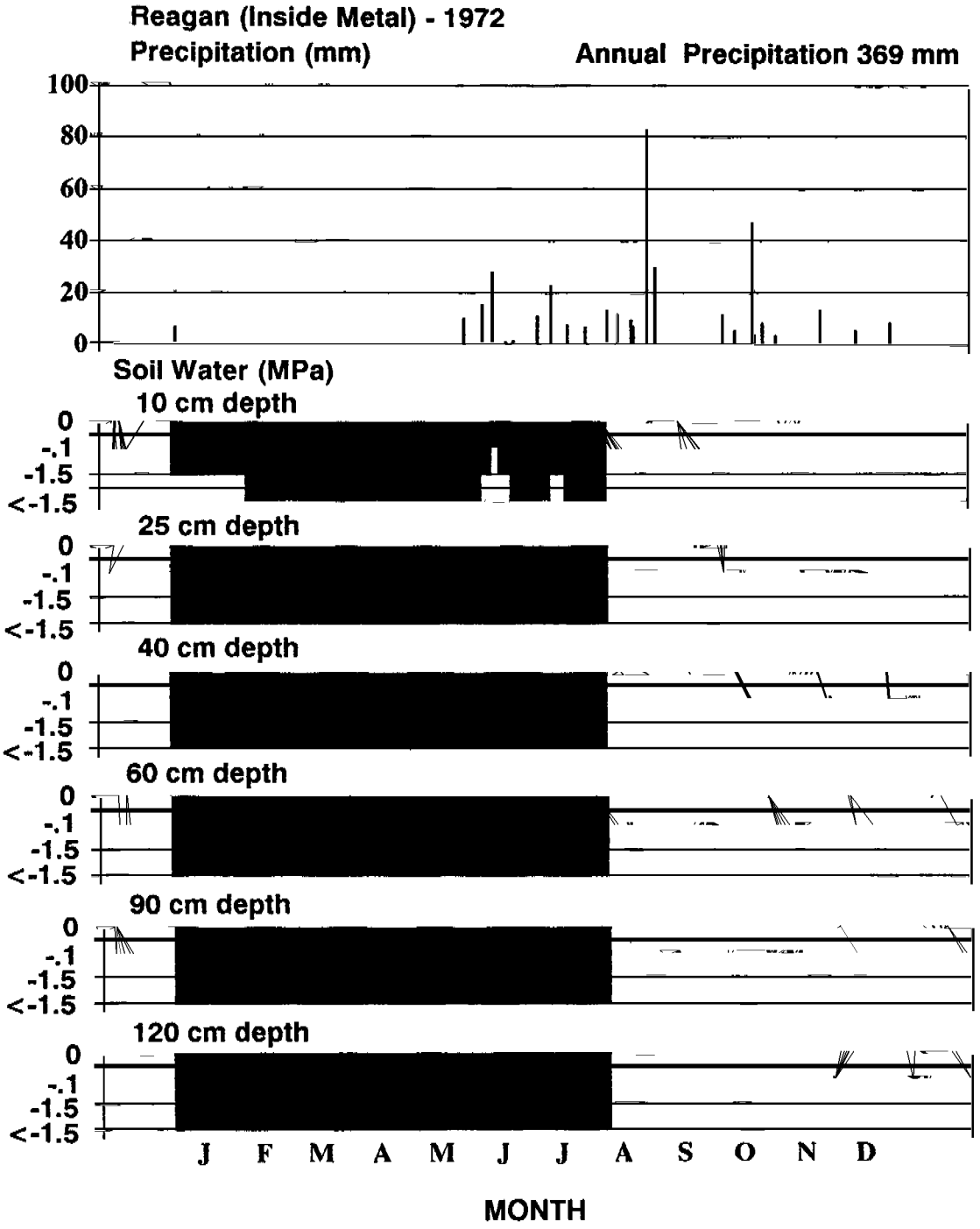


Figure 325. Annual (369 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside a sheet metal cylinder for January 1-August 7, 1972 at the Reagan site.

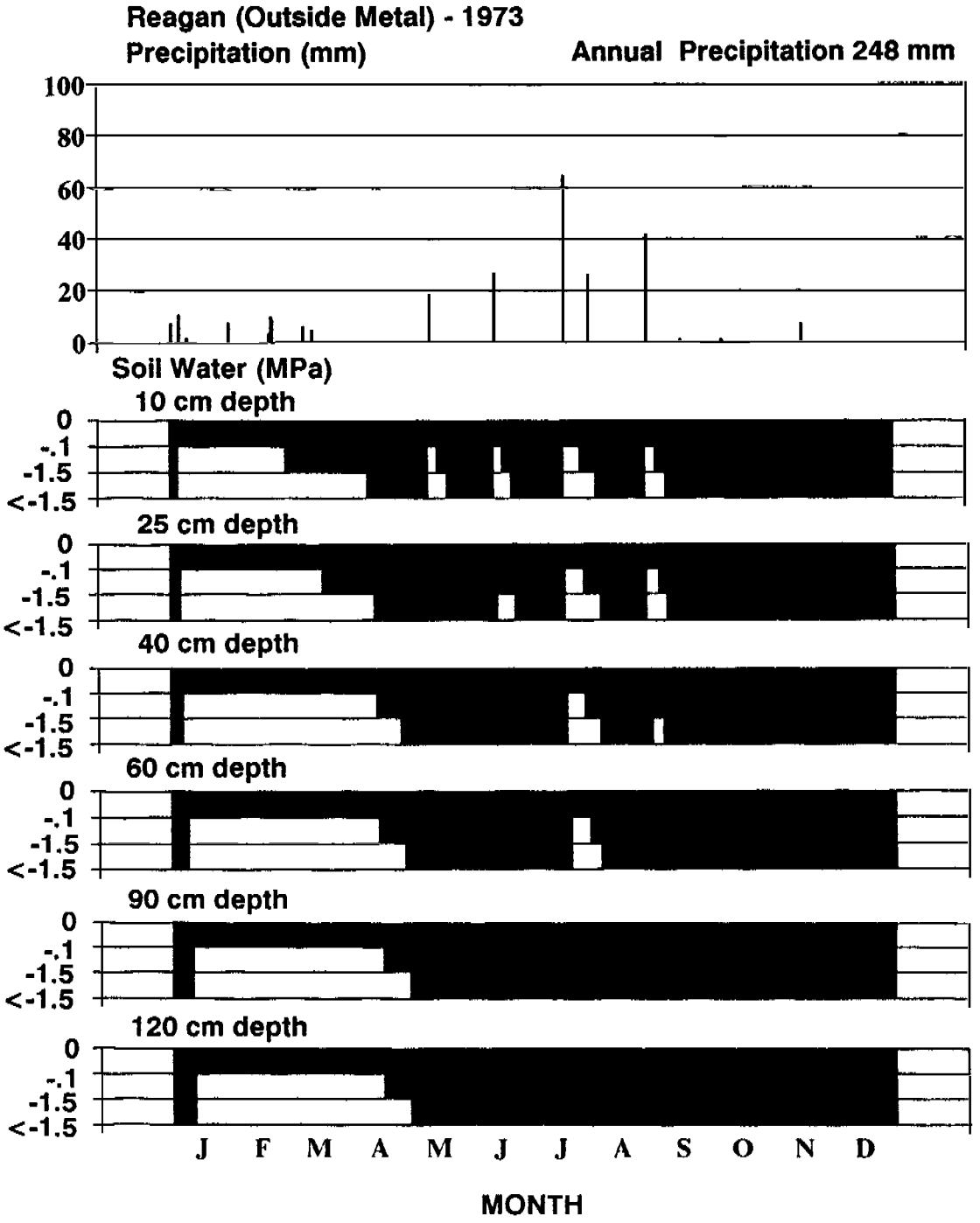


Figure 326. Annual precipitation (248 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1973.

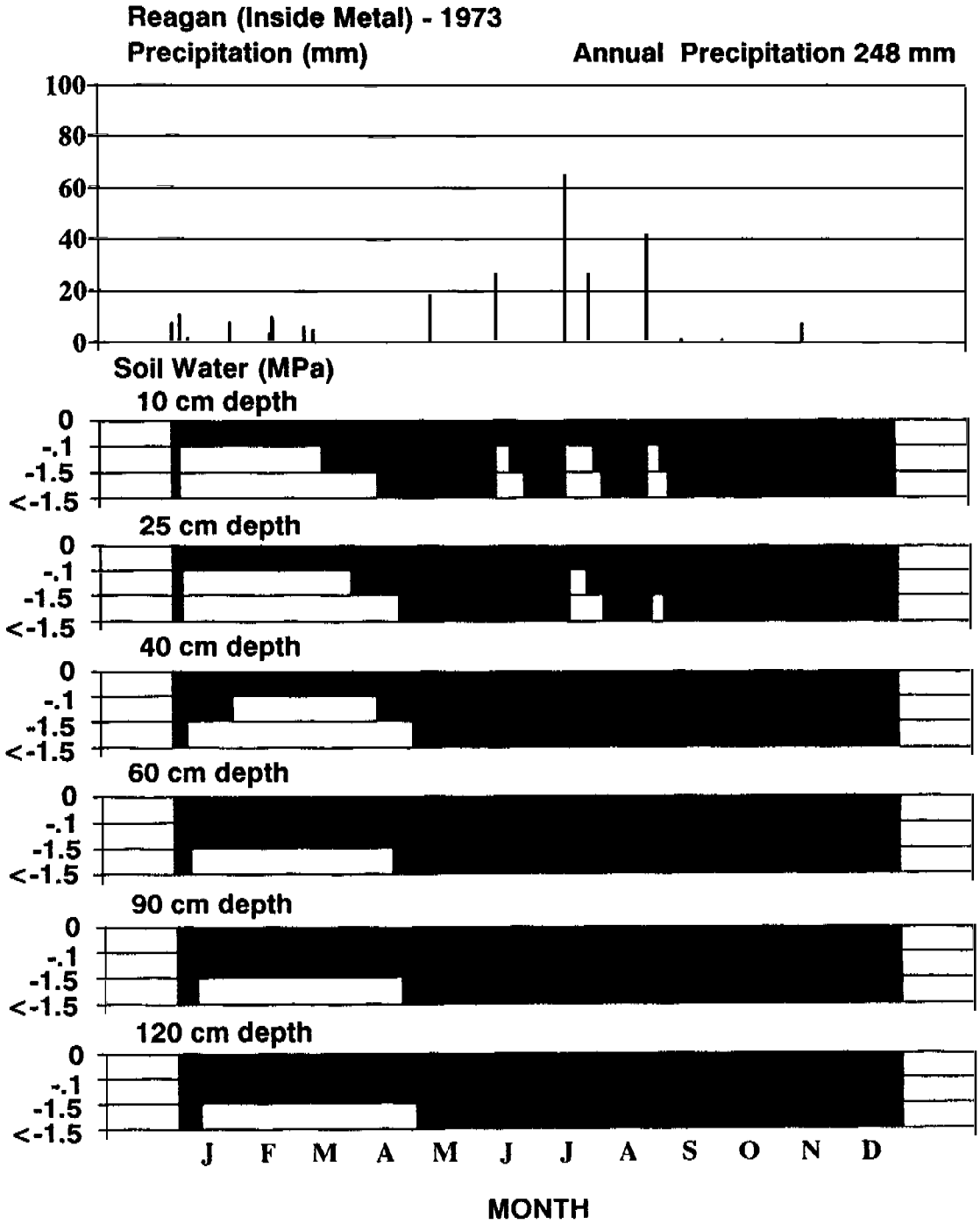


Figure 327. Annual precipitation (248 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1973.

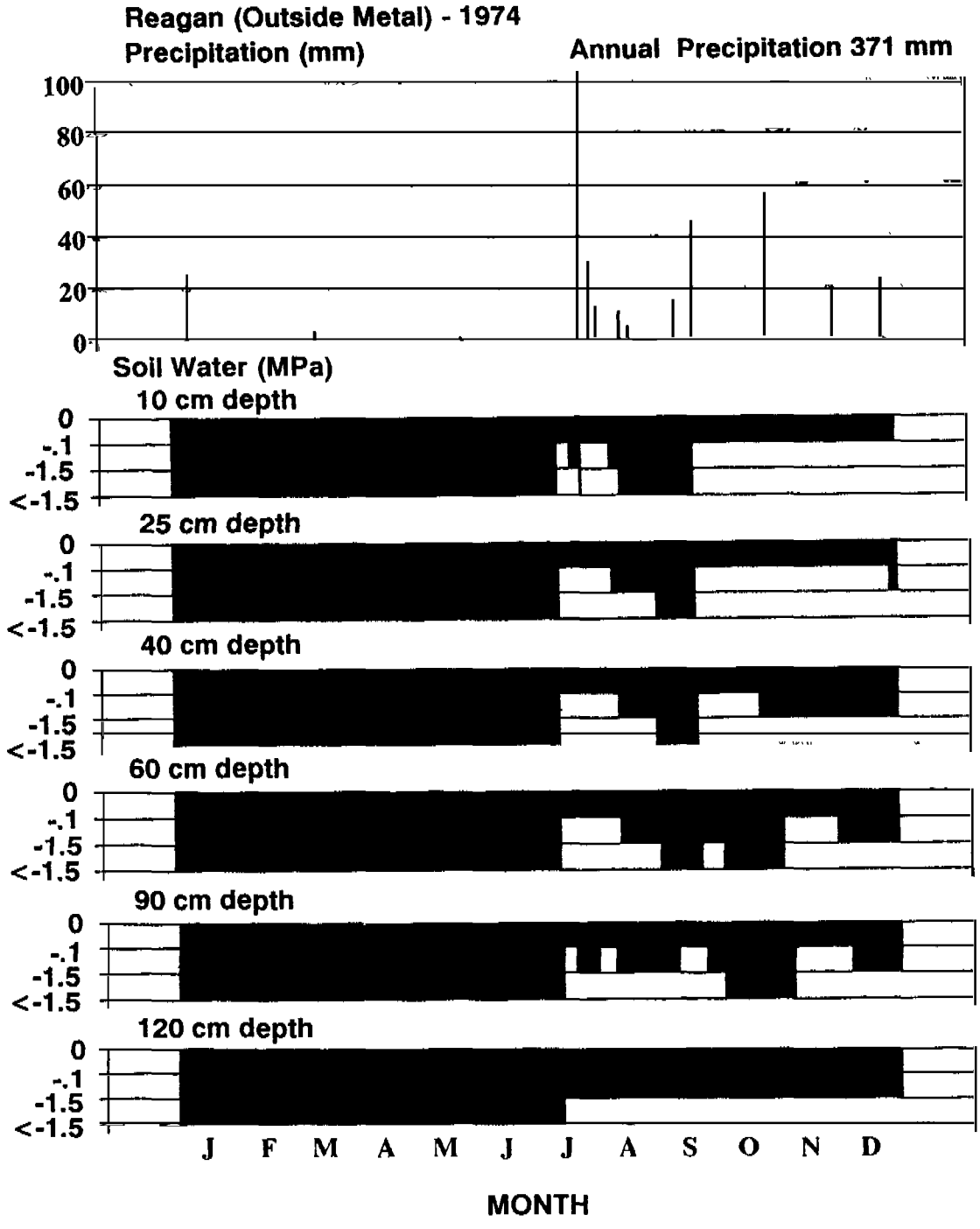


Figure 328. Annual precipitation (371 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1974.

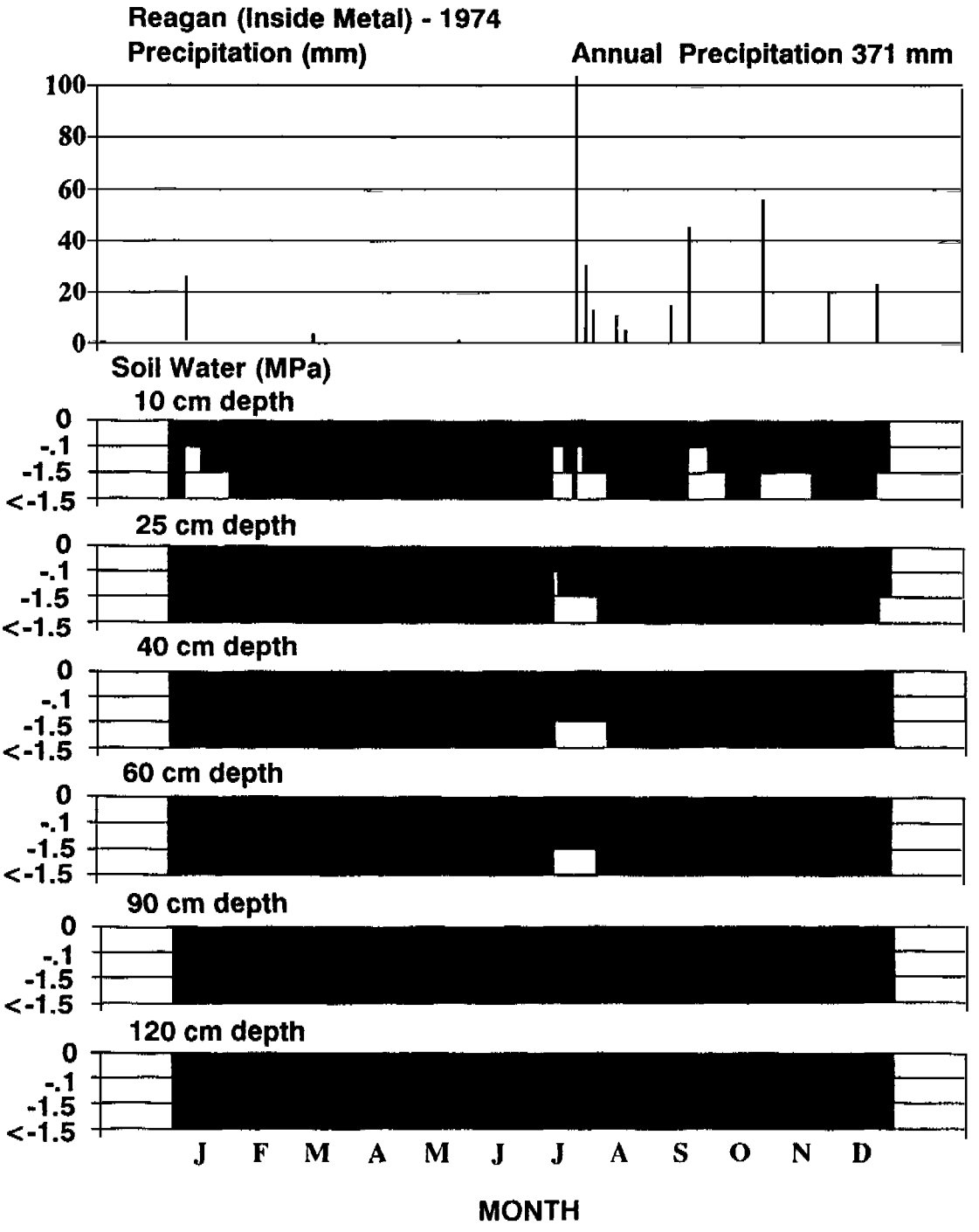


Figure 329. Annual precipitation (371 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1974.

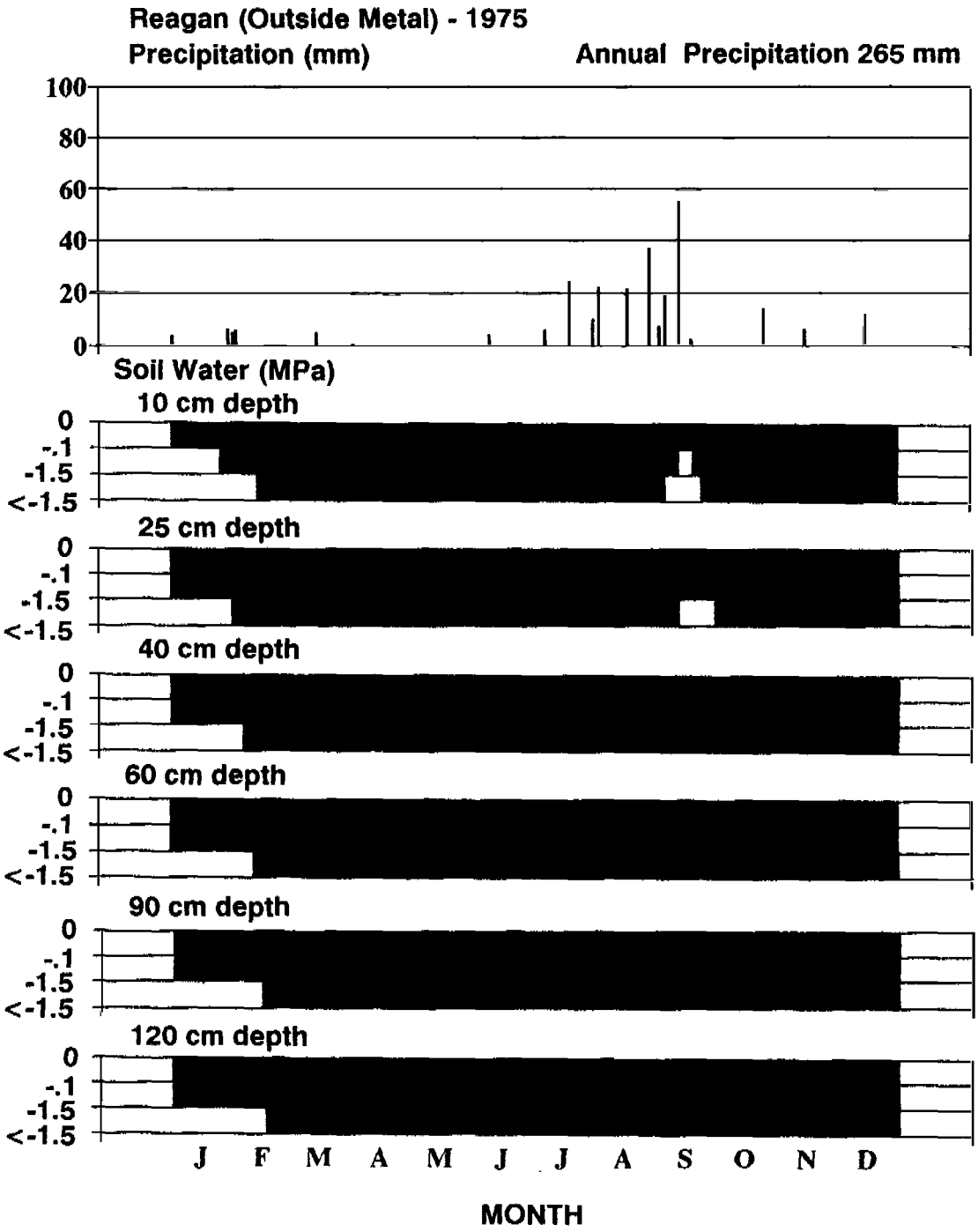


Figure 330. Annual precipitation (265 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1975.

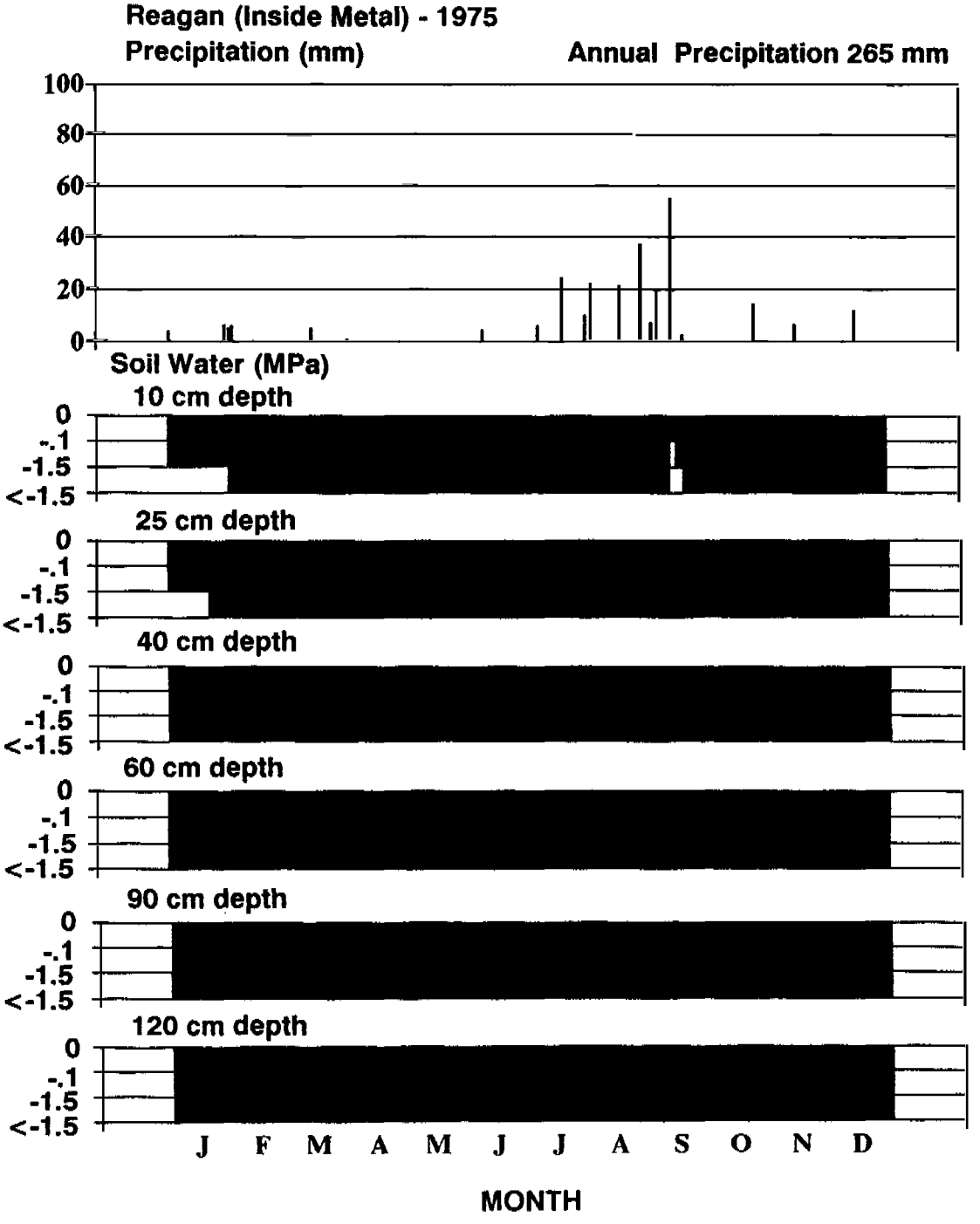


Figure 331. Annual precipitation (265 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1975.

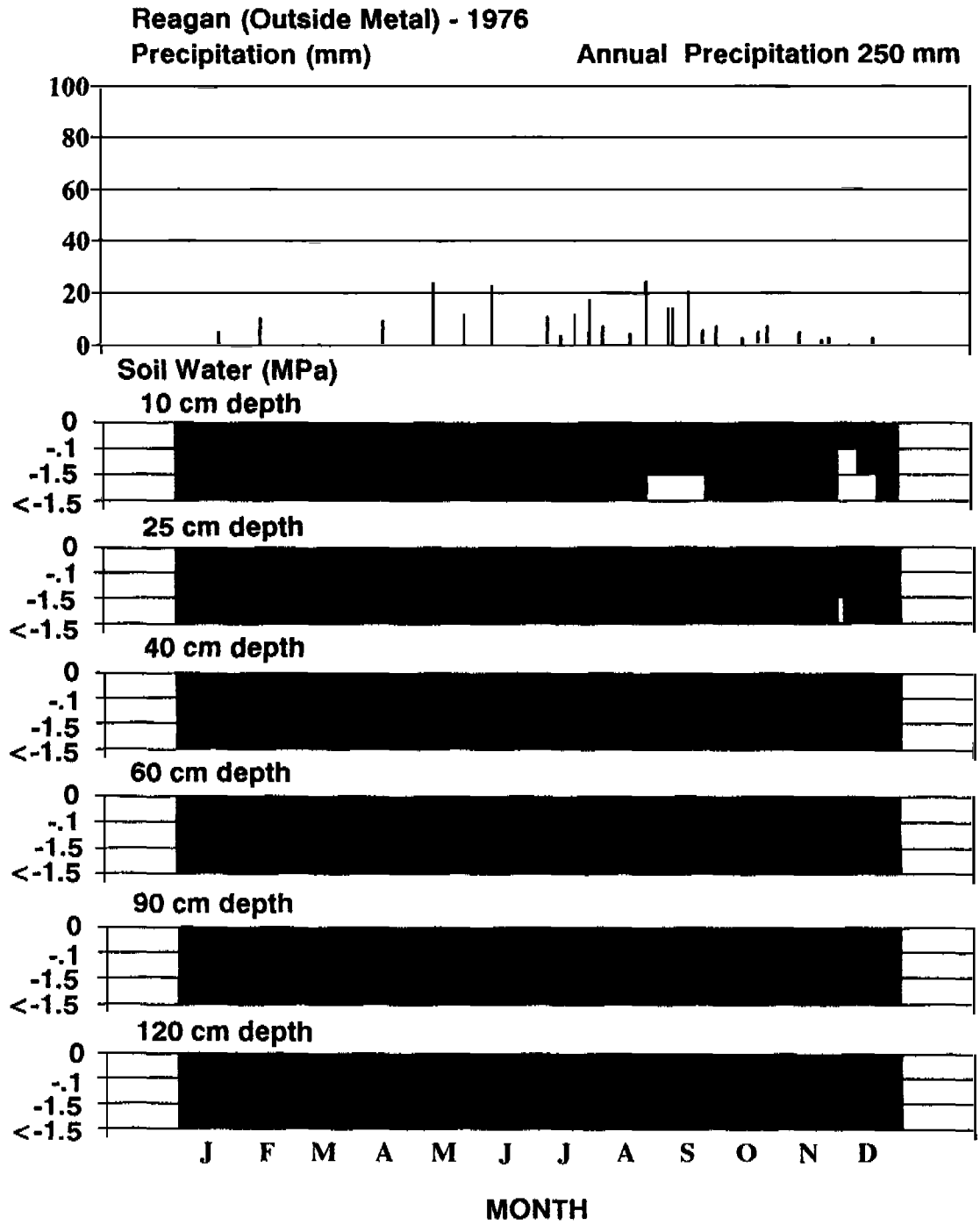


Figure 332. Annual precipitation (250 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Reagan site for 1976.

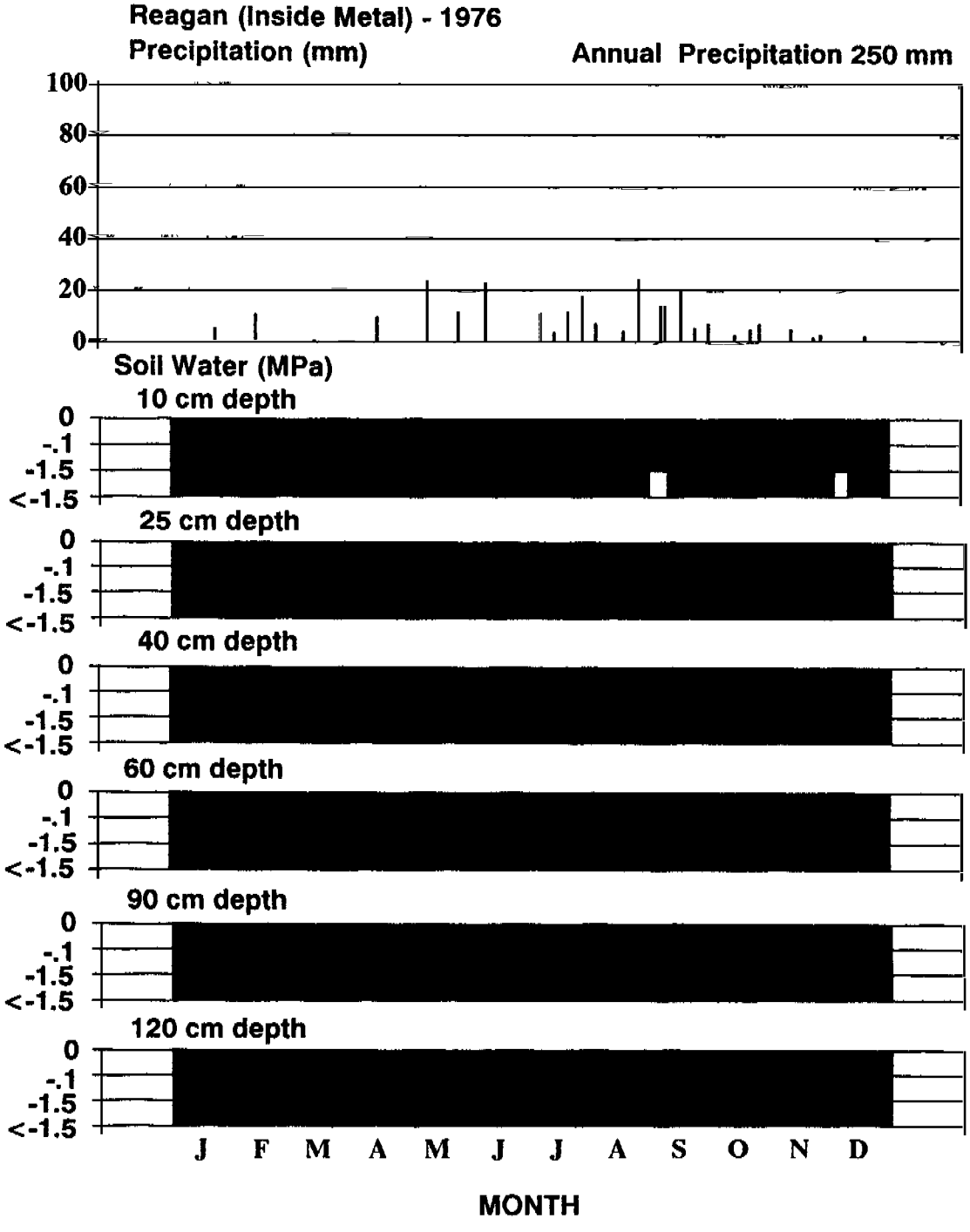


Figure 333. Annual precipitation (250 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Reagan site for 1976.

(fig. 335). Outside the metal cylinder the probabilities at the same depth averaged 21.4% for December-April, 1.9% for May-June, 30.6% for July-September, and 22.9% for October-November (fig. 334). Approximately 42% of the soil water at 25 cm was due to run-in.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, 18 of 20 years had soil water <-1.5 MPa outside the sheet metal cylinder more than half the time at depths of 10 and 40 cm; 19 of 20 years at 25 cm; and 17 of 18 years at soil depths of 60, 90, and 120 cm. Sixteen of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 15 of 20 years at 25 and 40 cm; 15 of 18 years at 60 and 90 cm; and 14 of 18 years at a depth of 120 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 6 of 18 years and >30 consecutive days in the four months after June 21, the summer solstice, 7 of 18 years when the soil water data were complete for the entire year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was met in 1957.

Site Stellar #2 (S2)

Site S2 (figs. 226, 336, 337, table 12) is in the Stuart Exclosure on the Jornada Experimental Range. The sampled pedon is 1.7 m south of the south fence of the exclosure. Perennial vegetation is dominantly a thick stand of tobosa.

Soils. The soil water blocks are in the Ustollic Haplargid Stellar #2 (figs. 336, 337, table 12; Stellar #2 description and primary data). Diagnostic horizons are an ochric epipedon, an argillic horizon, and a calcic horizon. Laboratory and morphological data confirm the presence of these horizons (table 12). Stellar #2 is on the Jornada II surface of late Pleistocene age (tables 1, 2; fig. 253), and has formed in fan-piedmont sediments derived from rhyolite, monzonite, andesite, and latite. Although not sampled, the buried Bt horizon of the Jornada I soil (fig. 253) was located by auger at a depth of 185 cm. Slope is 1% to the east.

Stellar #2 has the most prominent E horizon observed in the arid part of the study area. Expression of the E horizon is strong enough that transitional horizons to both the A and B horizons are evident (table 12). The EA horizon has the clay minimum for the soil (table 12). The E horizon must have formed almost wholly in the late Pleistocene. Clay increase in the E and EB horizons suggest that the present regime for clay in the E horizon involves primarily or wholly clay illuviation instead of clay eluviation.

Upper horizons contain more organic carbon than many Mollisols (table 12). However, the horizons are too light-colored for a mollic epipedon. Although no linear depressions and holes are evident at the sample site (fig. 337), distinct linear depressions do occur in the northern and western parts of the exclosure. As at the Veatch sites, these depressions must be responsible for the

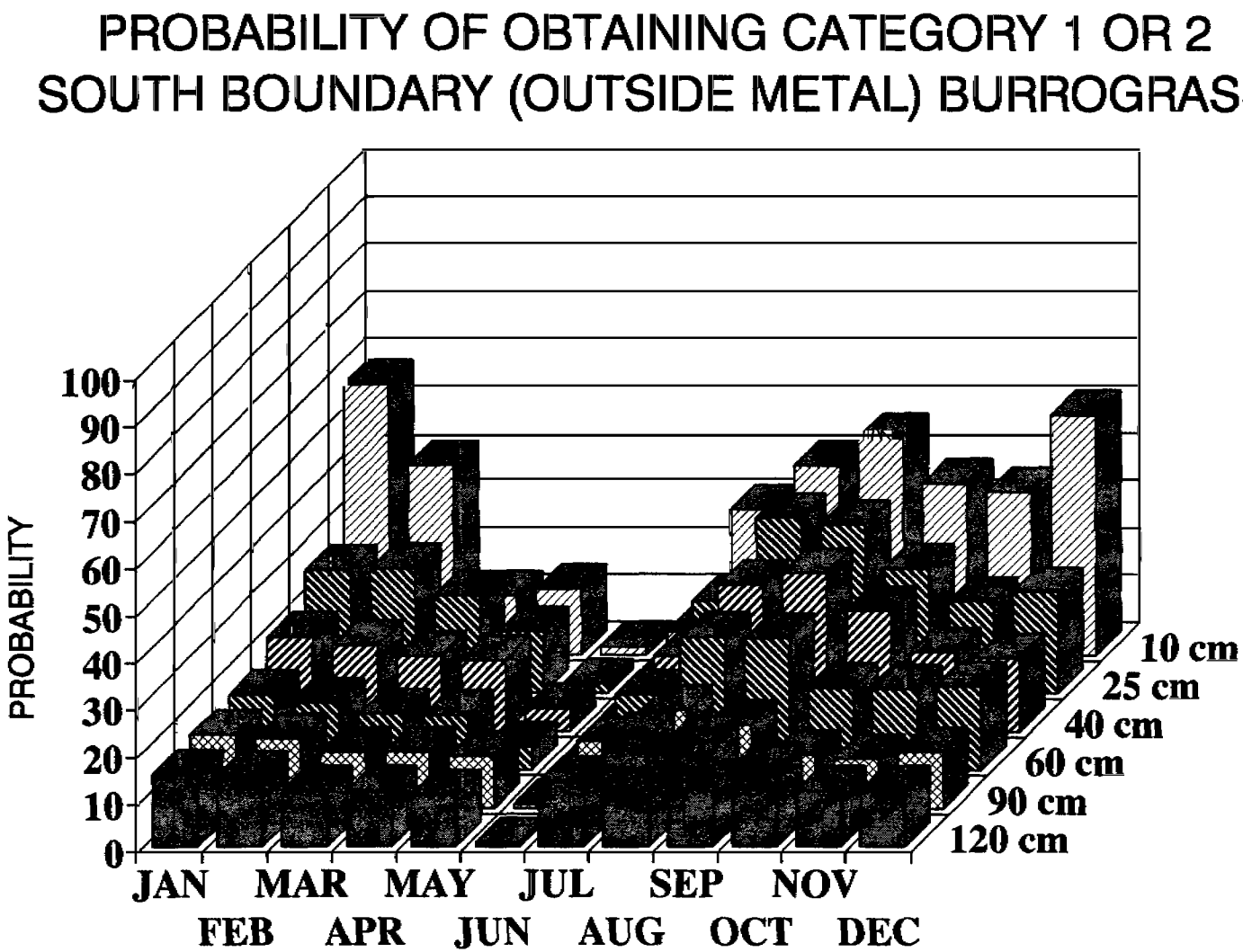


Figure 334. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm outside a sheet metal cylinder at the Reagan site.

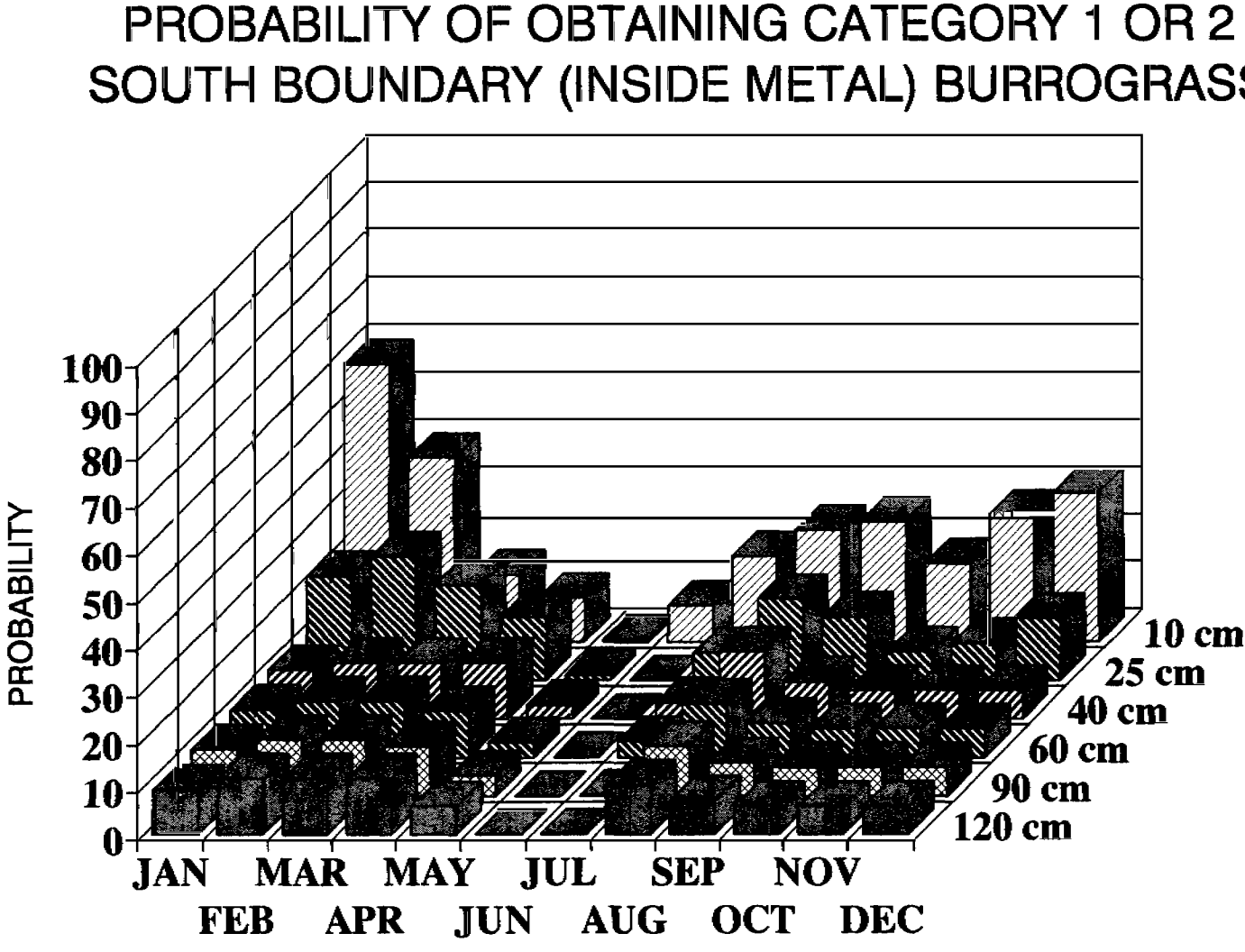


Figure 335. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm inside a sheet metal cylinder at the Reagan site.

Table 12. Characteristics of the Ustollic Haplargid, Stellar (S90NM-013-008), at site S2.

Horizon	Depth cm	Hue	Value/chroma Dry	Value/chroma Moist	Structure	Consistence Dry	Consistence Moist	Eff. with HCl	Textural class	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay < 0.002 mm	Organic C	$CaCO_3$
										%				
A	0-4	5YR	6/2	4/2	2m,cpl	sh,s	vfr	es	l	50	29	21	2.21	1
EA	4-14	7.5YR	7/3	4/3	lm,csbk	h	fr	es	vfsl	57	26	17	0.96	1
E	14-22	5YR	6/2.5	4/2.5	lf,msbk	vh	fi	nc	l	30	44	26	1.03	TR
EB	22-29	5YR	5.5/3	4/3	lf,msbk	vh	fi	nc	cl	27	37	36	0.66	–
Bt1	29-39	5YR	5/4	3.5/4	lm,csbk	vh	fi	nc	cl	35	30	35	0.48	1
Bt2	39-54	5YR	5.5/4	4/4	2mpr-lmsbk	vh	fi	e	cl	32	33	35	0.43	1
Btk1	54-68	5YR	5.5/4	4/4	2mpr-lf, msbk	vh	fi	e	cl	33	36	32	0.30	2
Btk2	68-78	5YR	5.5/4	4/4	2mpr-lf, msbk	vh	fi	e,es	cl	32	35	33	0.26	4
Btk3	78-97	4YR	5.5/4	4/4	2mpr-lfsbk	vh	fi	es	cl	36	26	38	0.22	6
Klt	97-105	5YR 5YR 5YR	6.5/4 9/4 5/4	5/4 8/4	lf,vfsbk	h,vh	fi	es	c	28	30	42	0.20	21
K21	105-118	5YR 5YR	7/3 9/4	5.5/4	lvfsbk	h	fi	ev	c	23	36	41	0.19	30

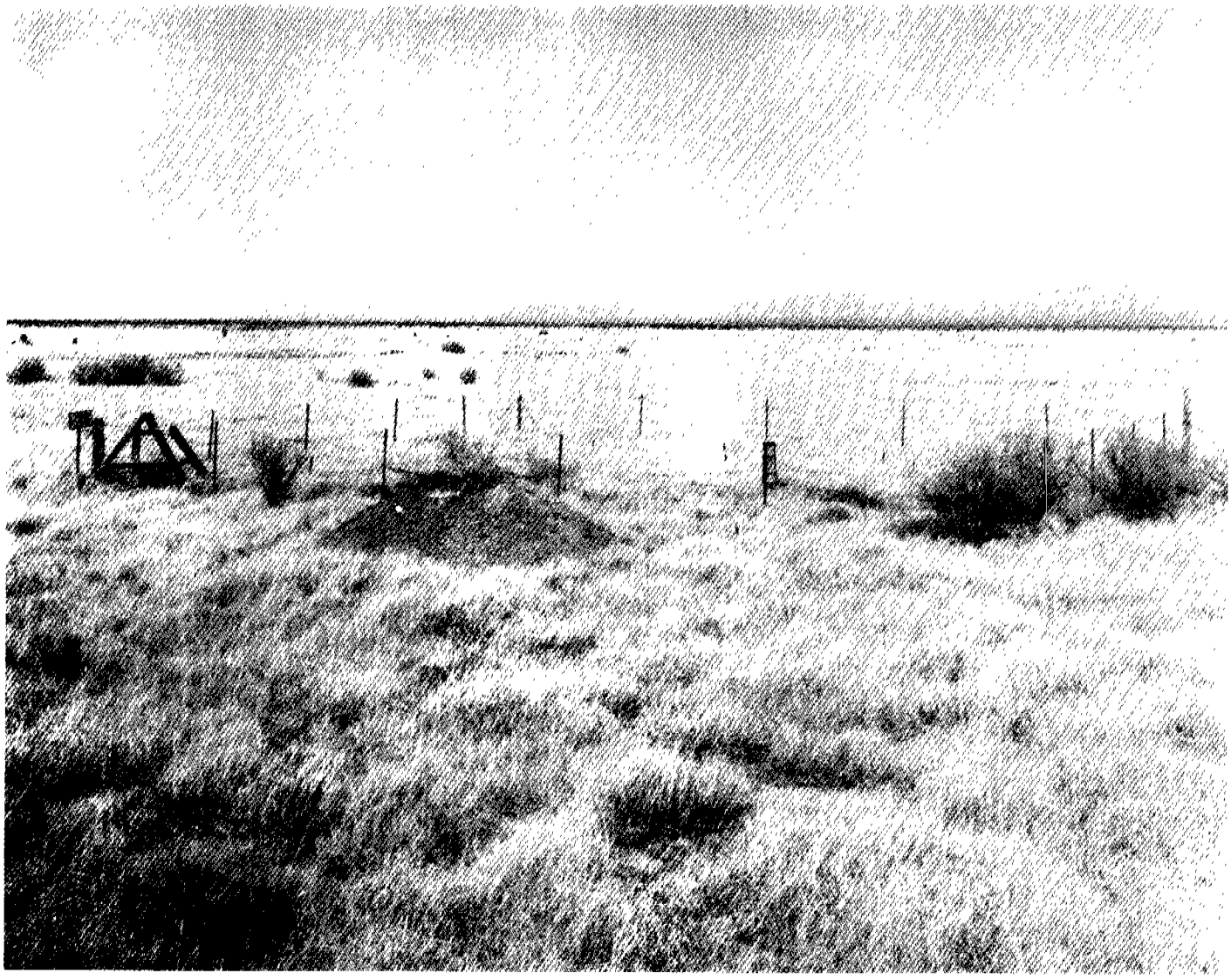


Figure 336. Landscape of the fan-piedmont toeslope at Site S2 (fig. 226) and the Ustollic Haplargid Stellar #2, in the Stuart exclosure in the Jornada Experimental Range. The nonrecording rain gauge is inside the exclosure. Note the dense stand of tobosa, about the most dense in the study area. Slope in the foreground is from left to right. Photographed February 1990.

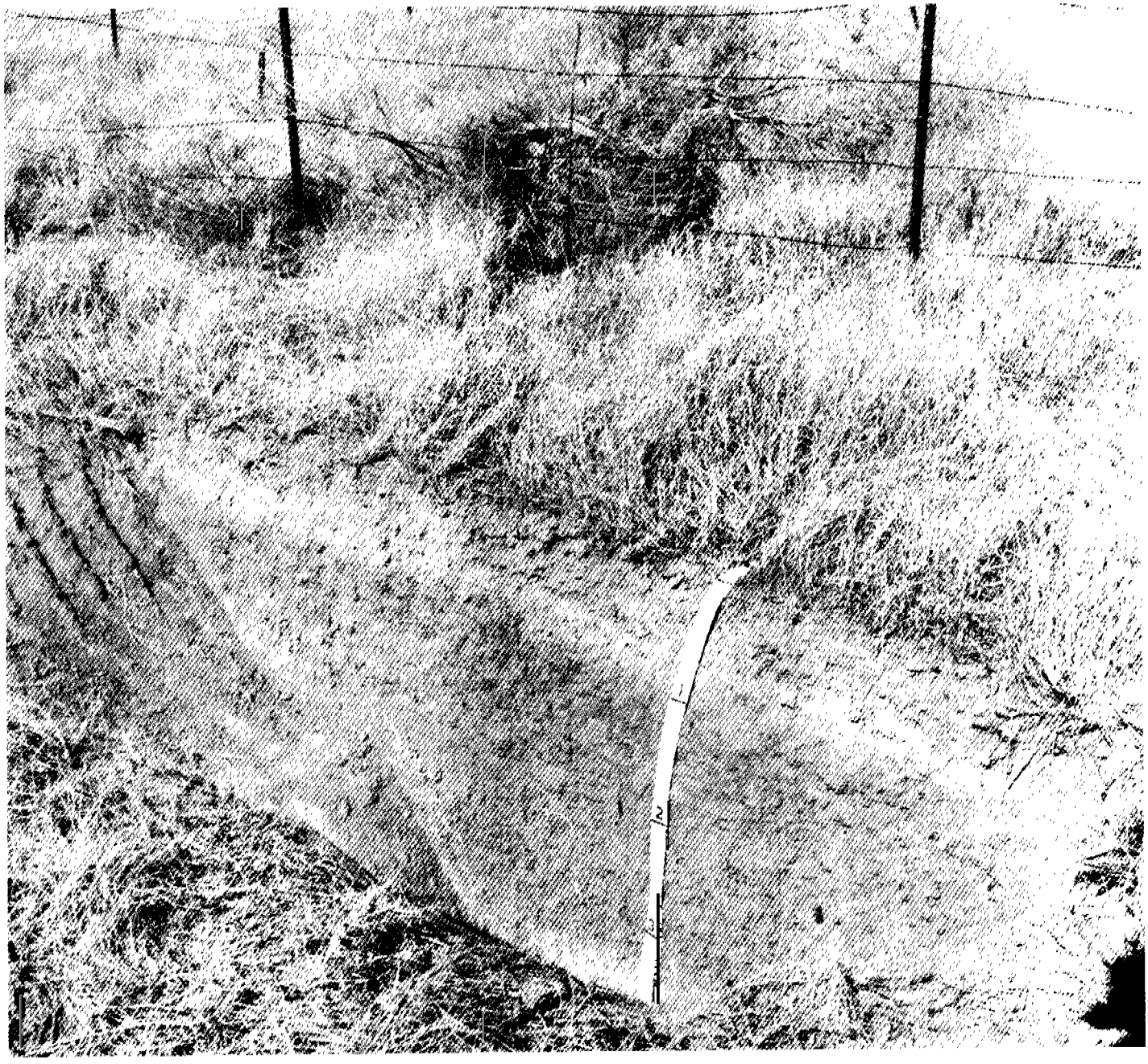


Figure 337. Profile of the Ustollic Haplargid Stellar #2. Note the prominent, light-colored E horizon in the upper part of the soil. Scale is in feet.

USDA-Soil Conservation Service
Pedon Narrative Description
Soil Series: Stellar
Classification: Fine, mixed, thermic Ustollic Haplargid
NSSL ID#: 90P0499
Soil Survey #: S90NM-013-008
Location: The SW1/4SW1/4NW1/4 section 15, T.21S., R.2E., in the Stuart exclosure on the Jornada Experimental Range. The southeast corner of the exclosure is 23 m north of the road to Stuart Well. The sampled pedon is 6.8 m south of the nonrecording rain gauge and 1.7 m south of the fence on the south side of the exclosure.
Elevation: 4300 ft, 1311 m
Landform: Coalescent fan-piedmont sloping 1% to the east
Geomorphic Surface: Jornada II
Parent Material: Jornada II sediments derived from monzonite, rhyolite, andesite and latite
Vegetation: Thick cover of tobosa and a few tarbush
Described By: L.H. Gile
Date: March 12, 1990

A--0 to 4 cm; pinkish gray (5YR 6/2) loam; brown to dark brown (5YR 4/2) moist; moderate medium and coarse platy structure; slightly hard and soft, very friable; strongly effervescent; abrupt smooth boundary.

EA--4 to 14 cm; pinkish gray to pink (7.5YR 7/3) very fine sandy loam; brown to dark brown (7.5YR 4/3) moist; weak medium coarse subangular blocky structure; hard, friable; roots; strongly effervescent; abrupt smooth boundary.

E--14 to 22 cm; pinkish gray (5YR 6/2,5) loam; dark reddish gray (5YR 4/2.5) moist; weak fine medium subangular blocky structure; very hard, firm; noncalcareous; abrupt smooth boundary.

EB--22 to 29 cm; reddish brown (5YR 5.5/3) clay loam; reddish brown (5YR 4/3) moist; moderate medium prismatic parting to weak fine subangular blocky structure; very hard, firm; noncalcareous; clear wavy boundary.

Bt1--29 to 39 cm; reddish brown (5YR 5/4) clay loam; dark reddish brown (5YR 3.5/4) moist; moderate medium prismatic parting to weak medium coarse subangular blocky structure; very hard, friable; sand grains coated with oriented clay; noncalcareous; clear wavy boundary.

Bt2--39 to 54 cm; reddish brown (5YR 5/4 clay loam; reddish brown (5YR 4/4) moist; moderate medium prismatic parting to weak medium subangular blocky; very hard, friable; sand grains coated with oriented clay; slightly effervescent; clear wavy boundary.

Btk1--54 to 68 cm; reddish brown (5YR 5/4) clay loam; reddish brown (5YR 4/4) moist; moderate medium prismatic parting to weak fine medium subangular blocky structure; very hard, friable; sand grains coated with oriented clay; few carbonate filaments; slightly effervescent; clear wavy boundary.

Btk2--68 to 78 cm; reddish brown (5YR 5/4) clay loam; reddish brown (5YR 4/4) moist; moderate medium prismatic parting to weak fine medium subangular blocky structure; very hard, friable; sand grains coated with oriented clay; few carbonate filaments and nodules; some parts are slightly effervescent and others are stongly effervescent; clear wavy boundary.

Btk3--78 to 97 cm; reddish brown (4YR 5.5/4) clay loam; reddish brown (4YR 4/4) moist; weak fine subangular blocky; very hard, friable; sand grains coated with oriented clay; common carbonate filaments and few nodules; strongly effervescent; clear wavy boundary.

K1t--97 to 105 cm; light reddish brown (5YR 6.5/4) clay; reddish brown (5YR 5/4) moist; lesser amount 5YR 9/4 and 5/4, dry; weak fine and very fine subangular blocky structure; hard and very hard, friable; dry common carbonate filaments and nodules; strongly effervescent; clear wavy boundary.

K21--105 to 118 cm; pink (5YR 7/3) clay; reddish brown (5YR 5.5/4) moist; lesser amount 5YR 9/4, dry; weak very fine subangular blocky structure; hard, friable; violently effervescent.

S90NM-013-008 *** PRIMARY CHARACTERIZATION DATA *** PRINT DATE 11/29/91

Soil series: STELLAR FINE, MIXED, THERMIC USTOLLIC HAPLARGID

NSSL - PROJECT 90P 78, DONA ANA CO.
- PEDON 90P 499, SAMPLES 90P2782-2796
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

-1- -2- -3- -4- -5- -6- -7- -8- -9- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY CO3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS(MM) WEIGHT 2 -5	5 -20	20 -75	>2MM .1- 75	>2MM WT PCT OF WHOLE SOIL
			<- - - - - - - - - - PCT OF <2MM (3A1) - - - - - - - - - - ->												<- PCT OF <75MM(3B1)->				
90P2782S	0- 4	A	21.0	29.3	49.7			19.6	9.7	24.0	19.8	4.7	1.0	0.2	--	--	--	26	--
90P2783S	4- 14	EA	17.1	25.6	57.3			14.7	10.9	26.2	22.6	6.0	1.9	0.6	--	--	--	31	--
90P2784S	14- 22	E	25.9	43.8	30.3			31.5	12.3	17.2	8.8	2.4	1.2	0.7	--	--	--	13	--
90P2785S	22- 29	EB	36.1	37.0	26.9			29.2	7.8	11.9	9.8	3.0	1.6	0.6	2	TR	--	17	2
90P2786S	29- 39	BT1	35.1	29.9	35.0			22.7	7.2	16.7	12.1	3.8	1.8	0.6	3	--	--	21	3
90P2787S	39- 54	BT2	34.7	32.9	32.4		8.9	23.6	9.3	16.7	10.7	2.8	1.4	0.8	5	--	--	20	5
90P2788S	54- 68	BTK1	31.8	35.6	32.6		1.6	24.4	11.2	15.8	10.5	2.8	1.3	2.2	3	TR	--	19	3
90P2789S	68- 78	BTK2	32.7	35.0	32.3		0.6	25.0	12.0	16.4	10.7	3.0	1.4	0.8	2	--	--	18	2
90P2790S	78- 97	BTK3	37.8	26.4	35.8		2.5	16.5	9.9	17.2	11.9	3.8	2.0	0.9	1	TR	--	19	1
90P2791S	97-105	K1T	41.8	30.1	28.1		9.3	20.9	9.2	12.8	9.7	3.2	1.6	0.8	2	TR	--	17	2
90P2792S	105-118	K21	40.9	35.9	23.2		12.9	25.5	10.4	11.4	7.9	2.3	1.1	0.5	4	TR	--	15	4
															--	--	--		--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B3a <2MM	EXTR P 6S3 PPM	TOTAL S 6R3a	DITH-CIT EXTRACTABLE FE 6C2b	AL 6G7a	MN 6D2a	CEC 8D1	RATIO/CLAY 15 BAR 8D1	ATTERBERG LL 4F1	LIMITS PI 4F	FIELD MOIST 4A3a	BULK DENSITY 1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
	PCT		PPM	<- PERCENT	OF	<2MM -->				PCT	<0.4MM	<- -	G/CC	- - ->	CM/CM	<- - -	-PCT OF	<2MM	- ->	CM/CM
0- 4	2.21							1.16	0.52										11.0	
4- 14	0.96							1.14	0.54				1.46	1.54	0.018			17.5	9.2	0.12
14- 22	1.03							1.14	0.51				1.42	1.49	0.002			21.9	13.1	0.13
22- 29	0.66							0.86	0.42										15.0	
29- 39	0.48							0.79	0.40				1.56	1.72	0.033			18.9	14.1	0.07
39- 54	0.43							0.70	0.39				1.57	1.61	0.008			19.4	13.7	0.09
54- 68	0.30							0.78	0.41										12.9	
68- 78	0.26							0.64	0.39				1.46	1.70	0.051			18.3	12.6	0.08
78- 97	0.22							0.58	0.37				1.52	1.91	0.078			19.9	14.1	0.09
97-105	0.20							0.48	0.33										13.9	
105-118	0.19							0.41	0.29				1.48	1.60	0.026			21.1	11.9	0.13

AVERAGES, DEPTH 29- 79: PCT CLAY 33 PCT .1-75MM 19

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA 5B5a 6N2a	MG 5B5a 6O2d	NA 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES 6H5a	ACIDITY	CEC SUM CATS 5A3a	CEC NH4-OAC 5A8b	EXCH NA 5B5b PCT	SAR 5E	BASE SATURATION SUM 5C3	BASE SATURATION NH4OAC 5C1	CARBONATE AS CACO3 <2MM 6E1g	CARBONATE AS CACO3 <20MM 8E1	CASO4 AS GYPSUM <2MM 6F1a	CASO4 AS GYPSUM <20MM 6F4	PH SAT PASTE 8C1b	PH CACL2 .01M 8C1f 1:2	PH H2O 8C1f 1:1
	<- - - - - - - - - -MEQ / 100 G - - - - - - - - - ->								PCT		<- -PCT- >		<- -PCT ->		<- -PCT ->				
0- 4		3.9	0.1	3.1		8.9		24.3	TR			100	1				7.5	7.4	7.8
4- 14		2.8	0.1	2.3		1.8		19.5	TR			100	1					7.6	8.1
14- 22	31.3	3.7	0.1	3.1	38.2	1.3	39.5	29.5	TR		97	100	TR					7.5	8.3
22- 29	26.8	4.2	TR	3.0	34.0	2.1	36.1	31.0	TR		94	100	--					7.4	8.1
29- 39		4.4	0.1	2.7		1.5		27.7	TR			100	1					7.4	7.8
39- 54		5.1	0.1	2.6				24.2	1		100	100	1					7.6	8.1
54- 68		5.3	--	2.4				22.1	--		100	100	2					7.8	8.5
68- 78		5.6	--	2.2				20.8	--		100	100	4					7.8	8.3
78- 97		7.4	--	2.2				21.9	--		100	100	6					7.8	8.4
97-105		7.8	--	1.9				20.1	--		100	100	21					7.9	8.5
105-118		7.5	--	1.5				16.9	--		100	100	30					5.2	5.7

DEPTH (CM)	WATER EXTRACTED FROM SATURATED PASTE CA 6N1b	MG 6O1b	NA 6P1b	K 6Q1b	CO3 6I1b	HCO3 6J1b	CL 6K1c	SO4 6L1c	NO3 6M1c	H2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A3a
	<- - - - - - - - - -MEQ / LITER - - - - - - - - - ->									<- -PCT ->		MMHOS /CM
0- 4	10.6	2.2		1.5	--	11.2	0.7	1.7	--	55.7	TR	1.20
4- 14												0.22
14- 22												0.21
22- 29												0.17
29- 39												0.18
39- 54												0.19
54- 68												0.18
68- 78												0.18
78- 97												0.18
97-105												0.19
105-118												0.18

MMHOS/CM OF 1:2 WATER EXTRACT (8I) & EXCH NA AS EXTRACTABLE NA FOR LAYERS 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,

ANALYSES: S= ALL ON SIEVED <2mm BASIS

long periods of available water at the deeper depths (60, 90, and 120 cm). The soil water data are shown in figures 338-357.

Soil Water and Precipitation. The gypsum resistance blocks were installed at the 10, 25, and 40-cm soil depth on August 1, 1957 and at the 60, 90, and 120-cm depths on July 29, 1959 within a livestock exclosure at Stuart Rain Gauge. This rain gauge was established in 1926. The annual precipitation for 1957 was 334 mm (fig. 338). The soil water at 10 cm was >-1.5 MPa August 1-September 12 and October 9-December 31, 1957. The moisture control section, 25-cm depth, had soil water >-1.5 MPa August 1-September 7 and October 10, 1957-May 3, 1958 (figs. 338, 339). There was soil water >-1.5 MPa at the 40-cm depth August 7-8, August 12-15, and October 11-December 31, 1957 (fig. 338).

Annual precipitation for 1958 was 321 mm but soil water at 10 cm was <-1.5 MPa April 25-July 29 (fig. 339). Precipitation of 61 mm occurred on July 28. The 25-cm depth had soil water >-1.5 MPa July 30-August 18, September 15-16, and October 16-November 7, 1958 in addition to that observed in the winter and early spring (fig. 339).

The precipitation in 1959 was above average but 58% occurred in August. The 25-cm depth had soil water >-1.5 MPa July 29-September 29 (fig. 340).

The 1960 precipitation was 182 mm and the soil water at 25 cm was >-1.5 MPa only July 9-24 and August 12-25 (fig. 341). Precipitation of 32 mm was recorded on December 11, 1960 and 1961-63 had above average precipitation (figs. 341-344). There was water >-1.5 MPa at the 25-cm soil depth February 6-May 11, 1961 (fig. 342); August 14-September 4; September 9-30; November 13-30; December 12, 1961-May 6, 1962 (figs. 342, 343); July 9-August 16; September 27-October 25; December 7, 1962-March 13, 1963 (figs. 343, 344); July 7-August 4; and August 23-September 30, 1963.

Annual precipitation for the next three years, 1964-66 was <200 mm (figs. 345-347). The matric potential of the soil water at 25 cm was >-1.5 MPa September 12-November 8, 1964 (fig. 345); January 9-April 11, 1965 (fig. 346); September 9-October 20; December 12, 1965-May 11, 1966 (figs. 346, 347); August 3-27; and September 6-28, 1966.

The annual precipitation for both 1967 and 1968 was above average. The soil water at 25 cm was >-1.5 MPa June 19, 1967-July 28 (fig. 348); August 7, 1967-May 11, 1968 (figs. 348, 349); and August 1-September 11, 1968.

Annual precipitation in 1969 was 234 mm (fig. 350). There was soil water >-1.5 MPa at the 25-cm depth February 1-April 11; July 9-August 3; and September 3-October 3, 1969. Precipitation in 1970 was only 112 mm (fig. 351) but 23 mm on October 2, 1969, and subsequent significant amounts in December 1969 and March 1970 resulted in soil water >-1.5 MPa at 25 cm October 24, 1969-May 10, 1970 (figs. 350, 351). In addition, soil water was >-1.5 MPa at 25 cm July 26-August 25 and October 3-November 9, 1970 (fig. 351).

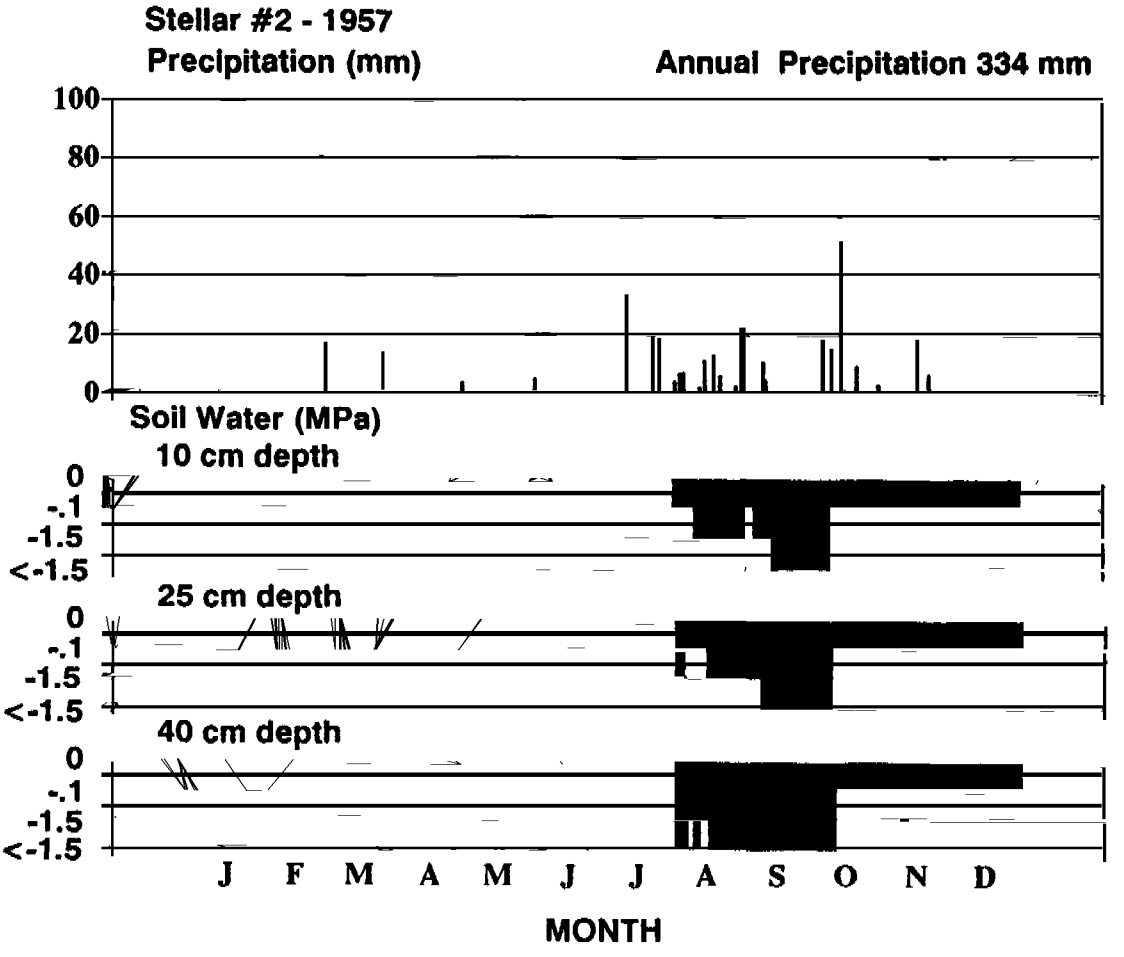


Figure 338. Annual (334 mm) and daily (mm) precipitation for 1957, and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 1-December 31, 1957 at the Stellar #2 site.

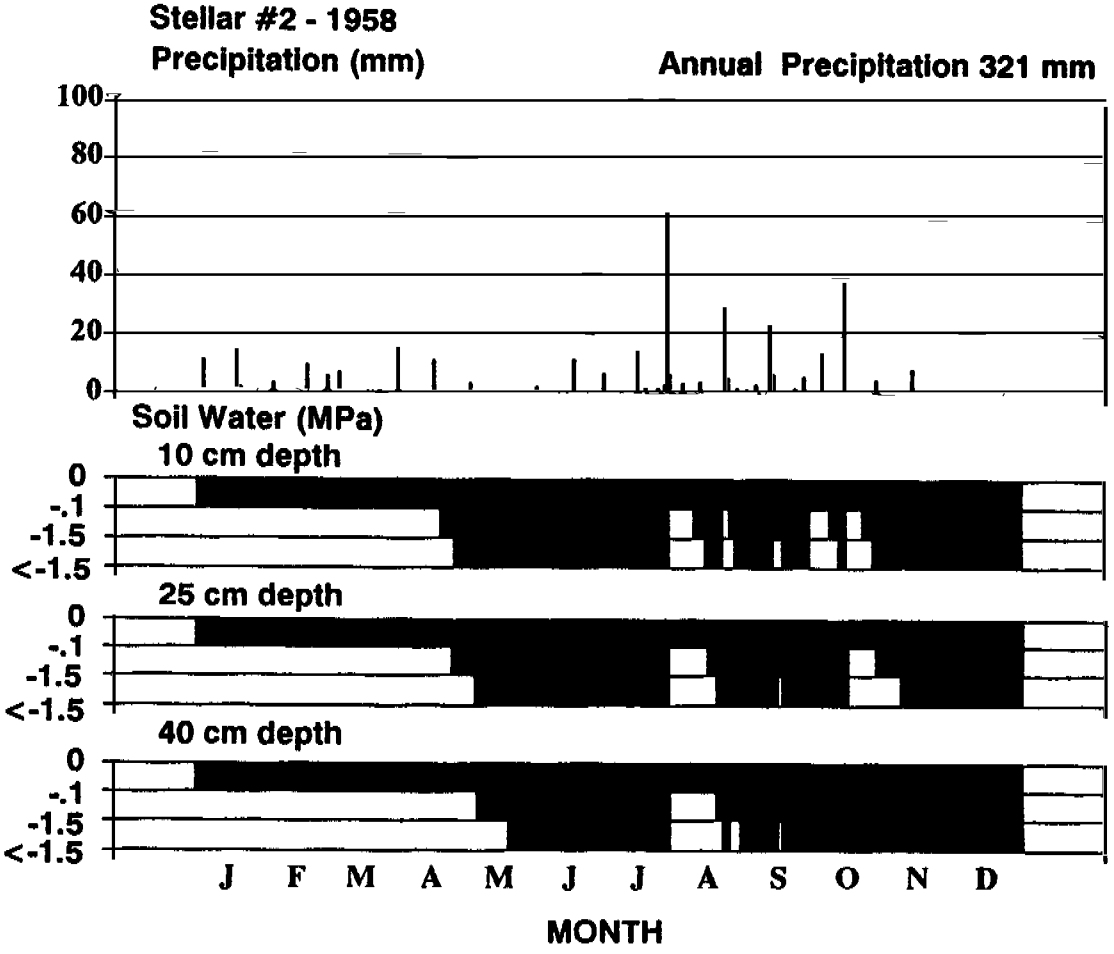


Figure 339. Annual precipitation (321 mm), daily precipitation (mm), and the matric potential of th soil water (MPa) at depths of 10, 25, and 40 cm for 1958 at the Stellar #2 site.

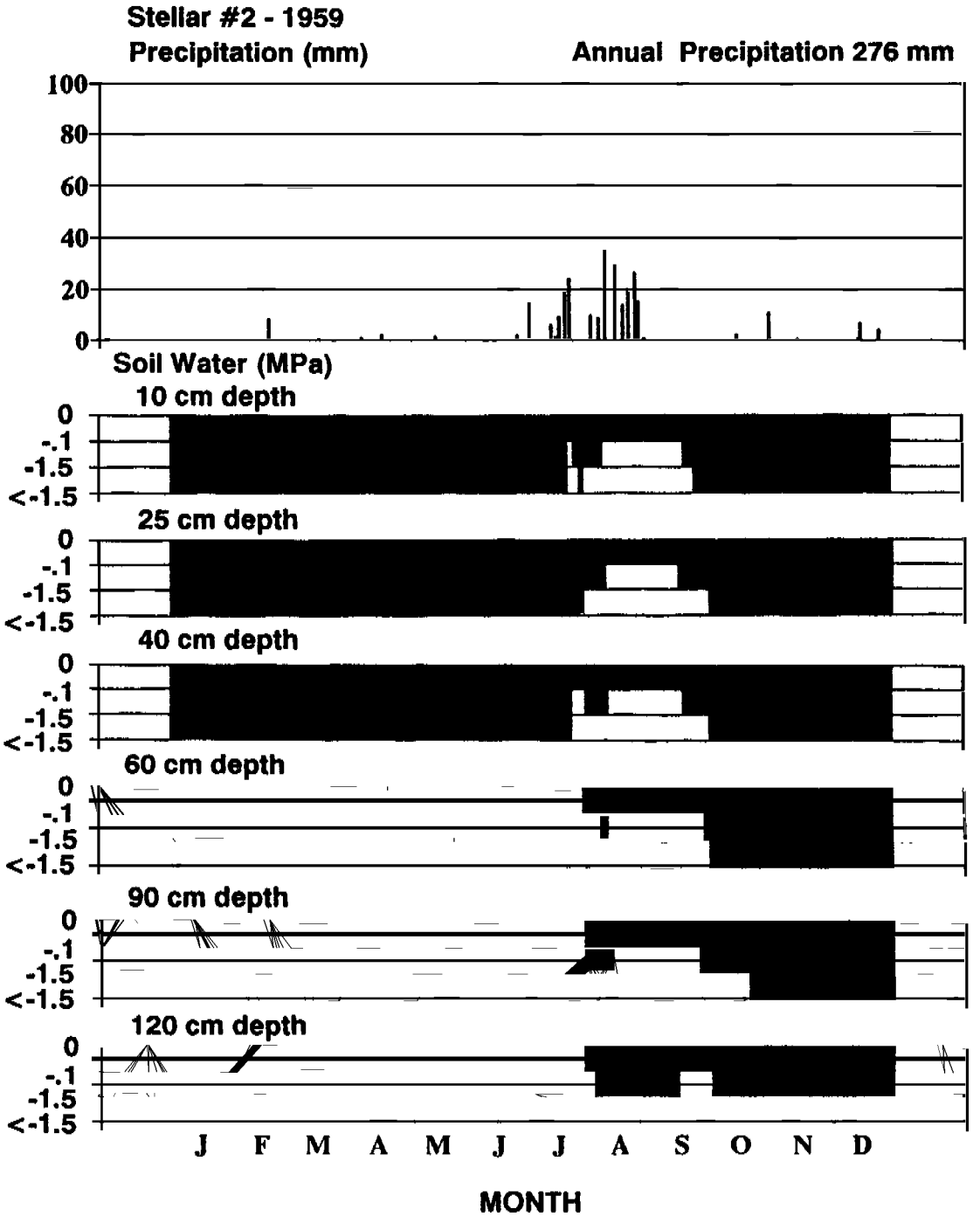


Figure 340. Annual precipitation (276 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm at the Stellar #2 site for 1959. Also shown is the soil water for depths of 60, 90, and 120 cm July 29-December 31, 1959.

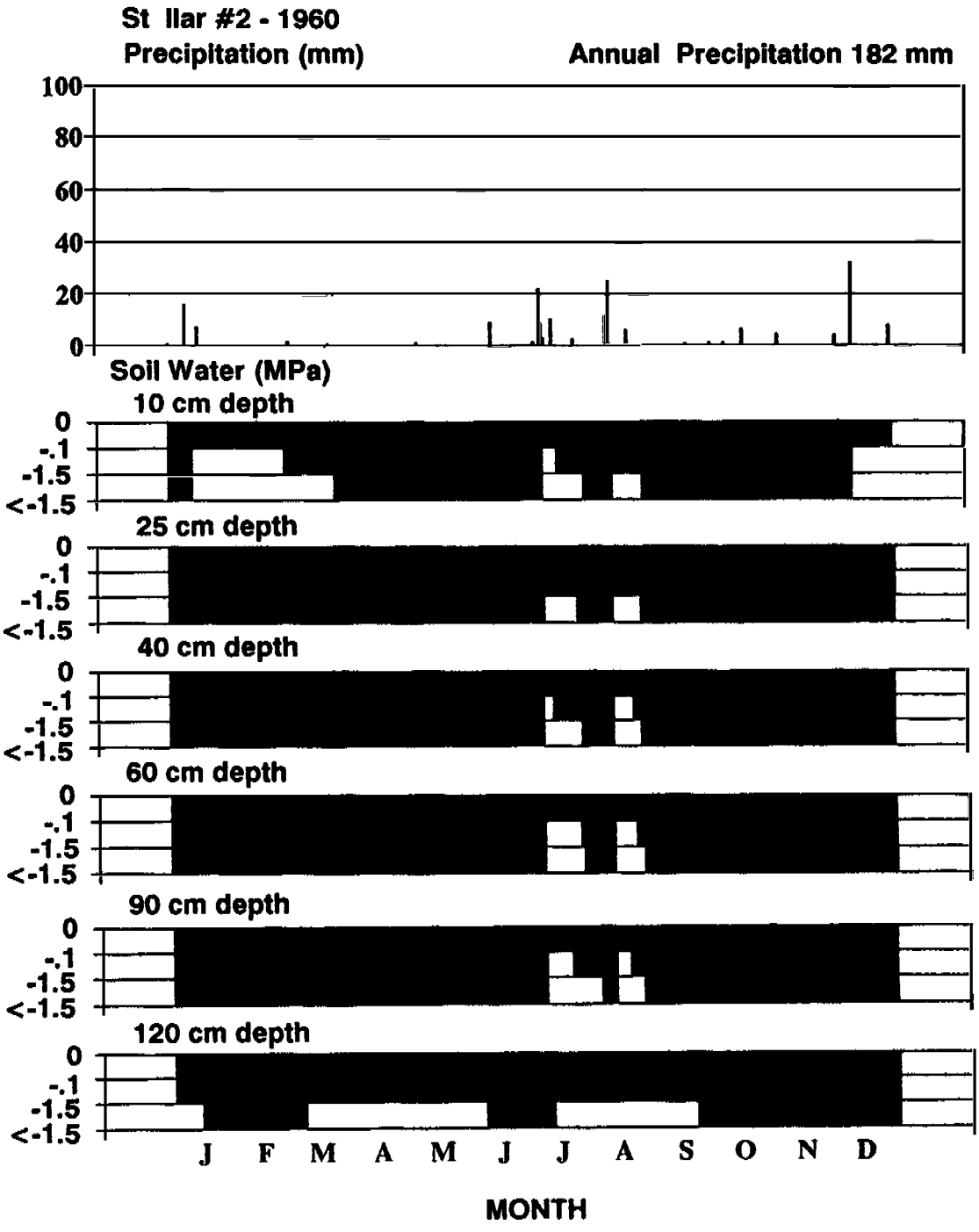


Figure 341. Annual precipitation (182 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1960.

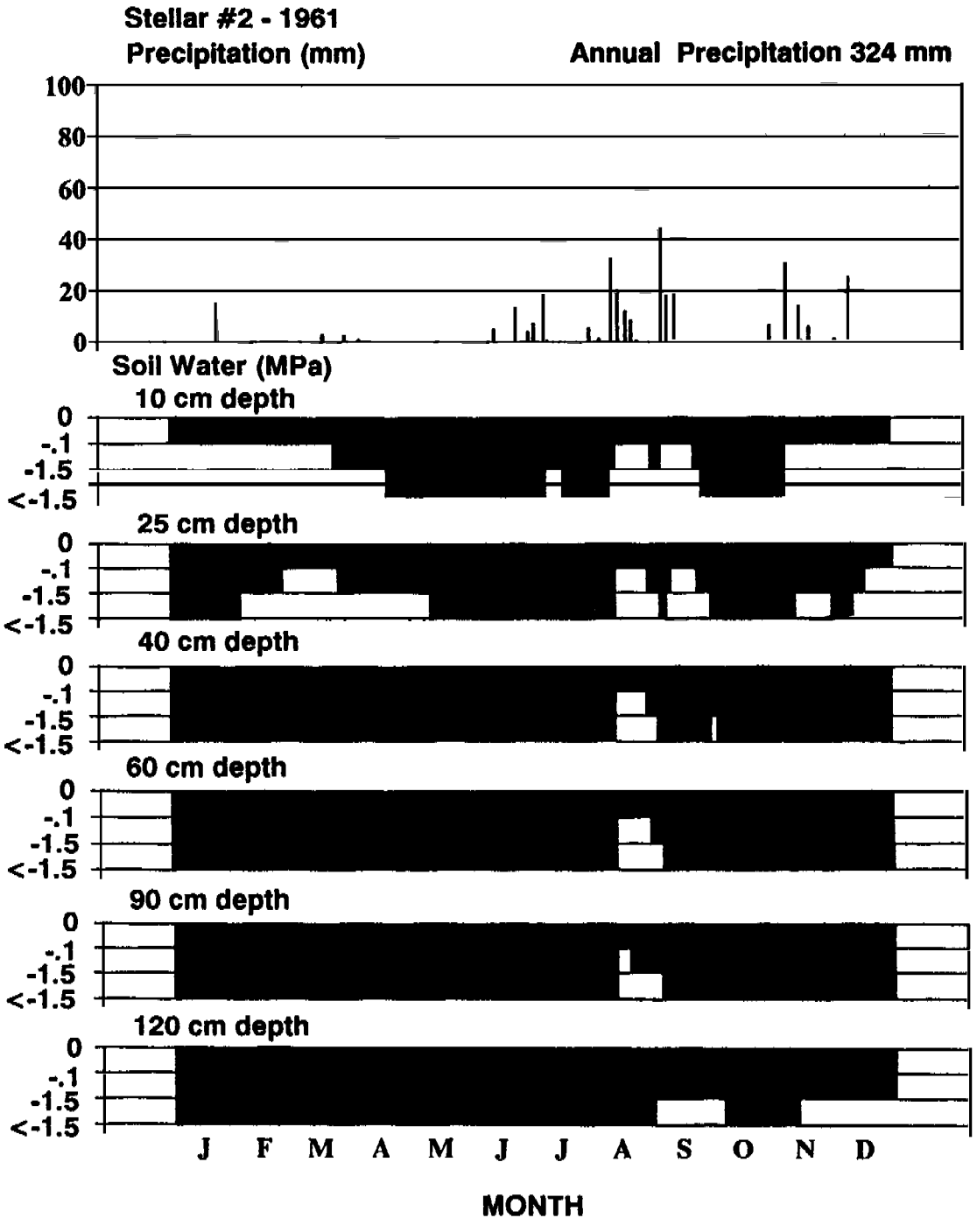


Figure 342. Annual precipitation (324 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1961.

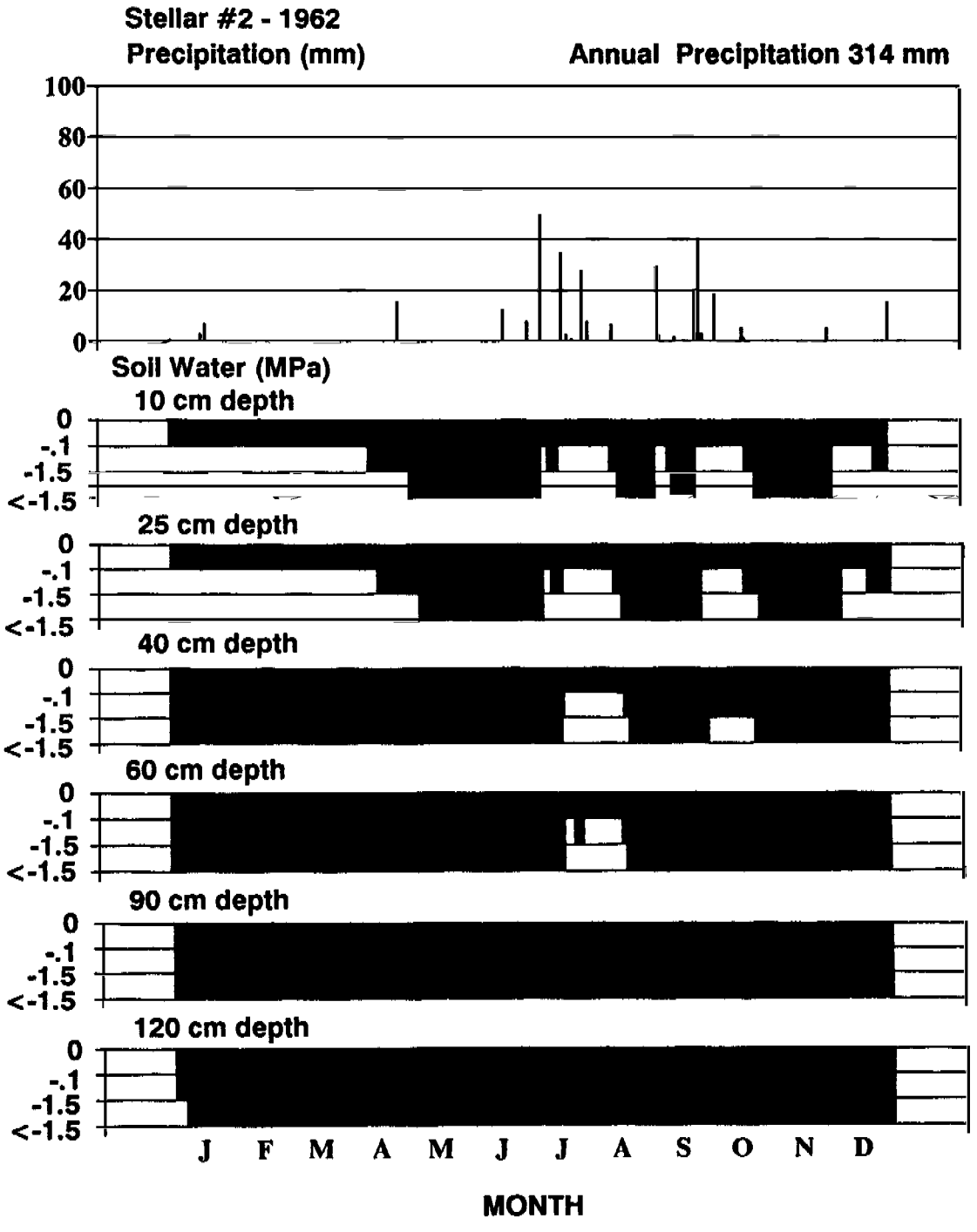


Figure 343. Annual precipitation (314 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1962.

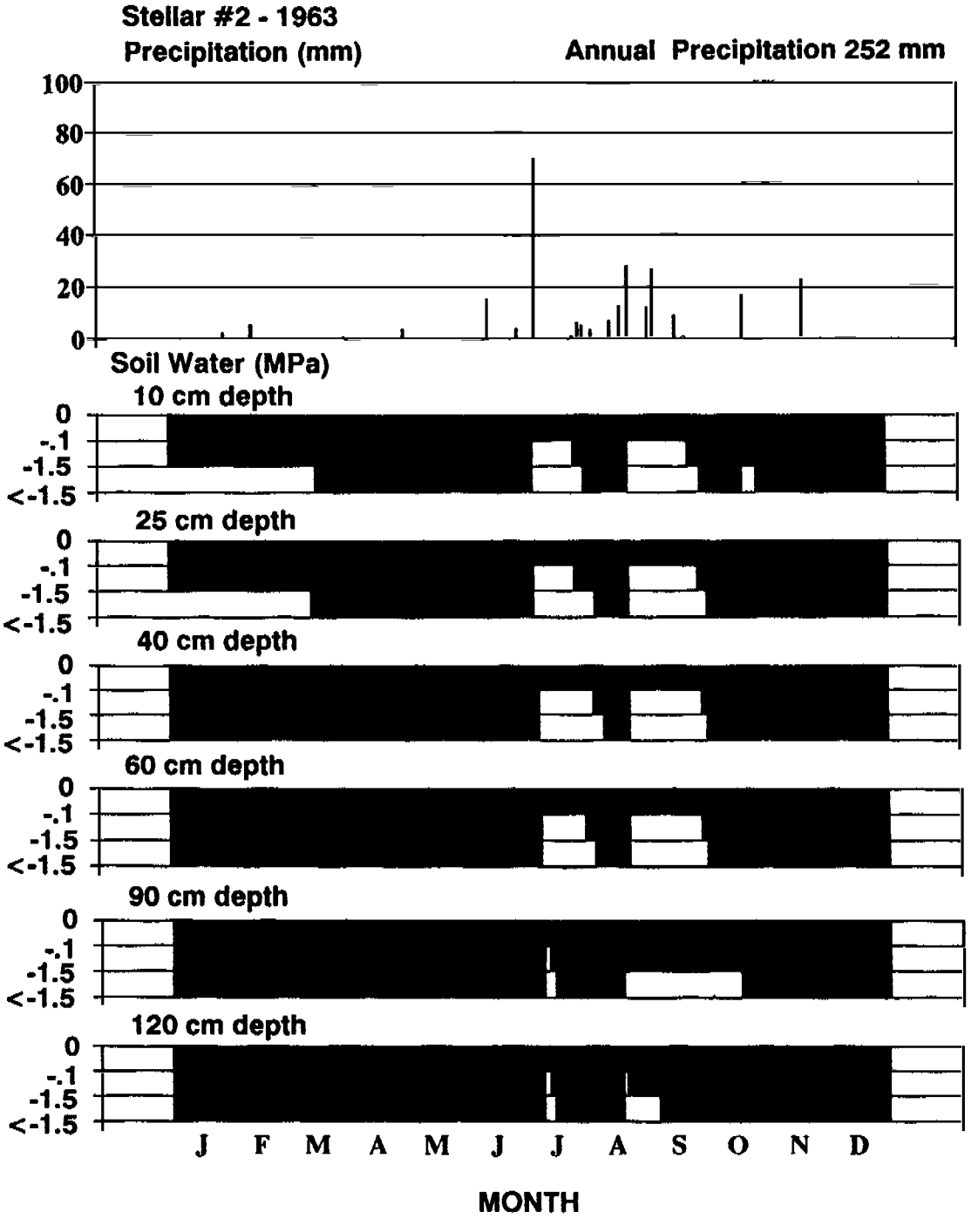


Figure 344. Annual precipitation (252 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1963.

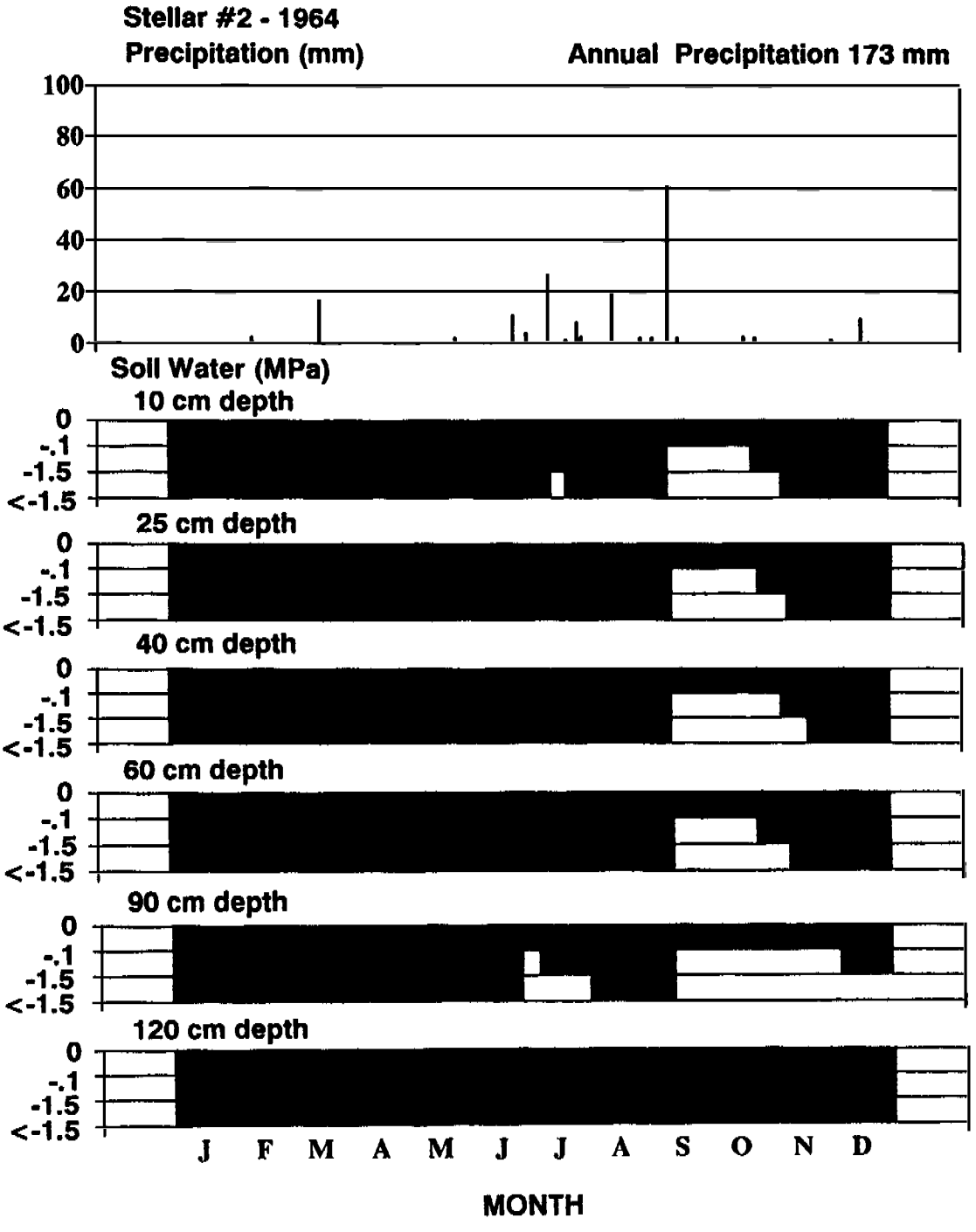


Figure 345. Annual precipitation (173 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1964.

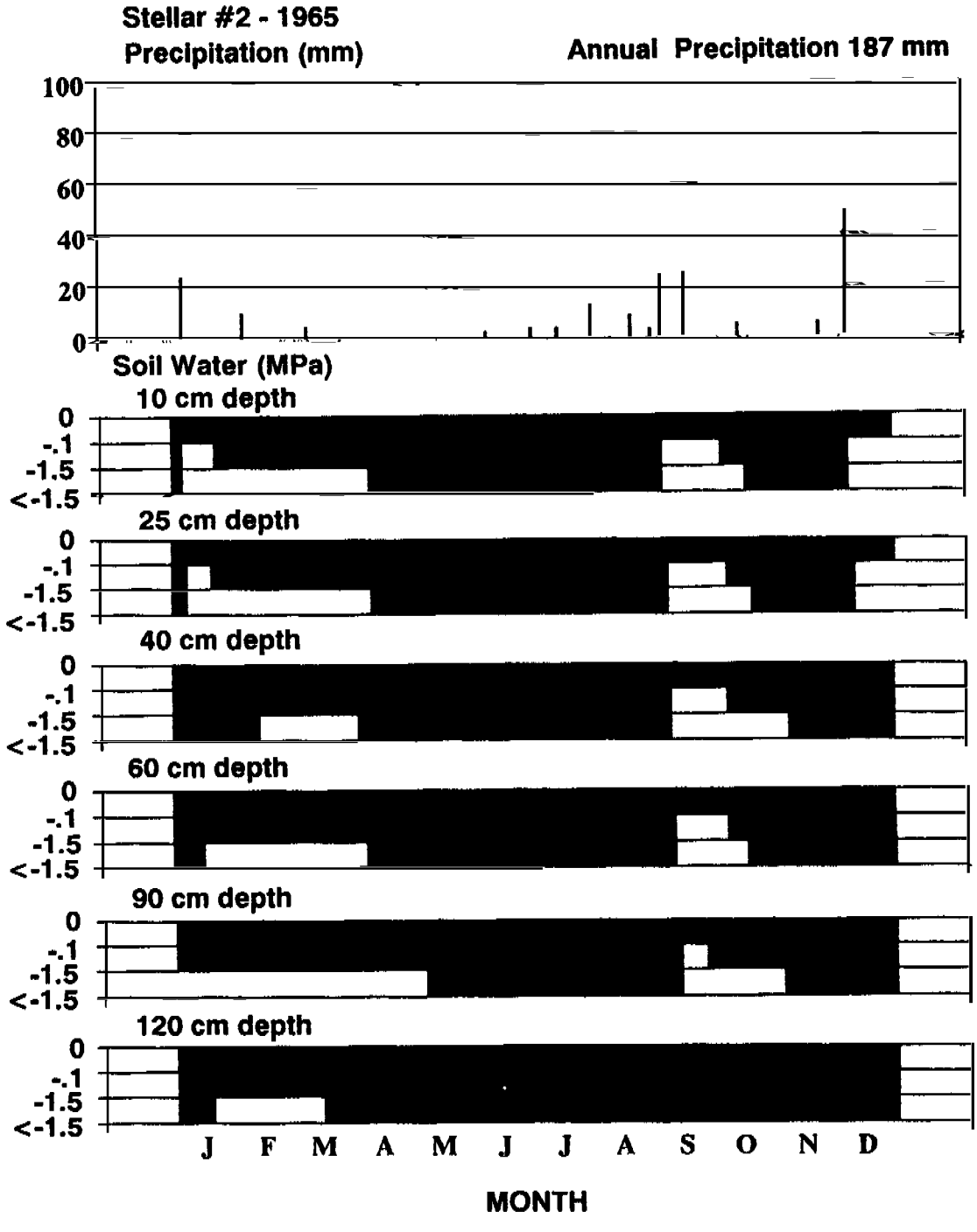


Figure 346. Annual precipitation (187 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1965.

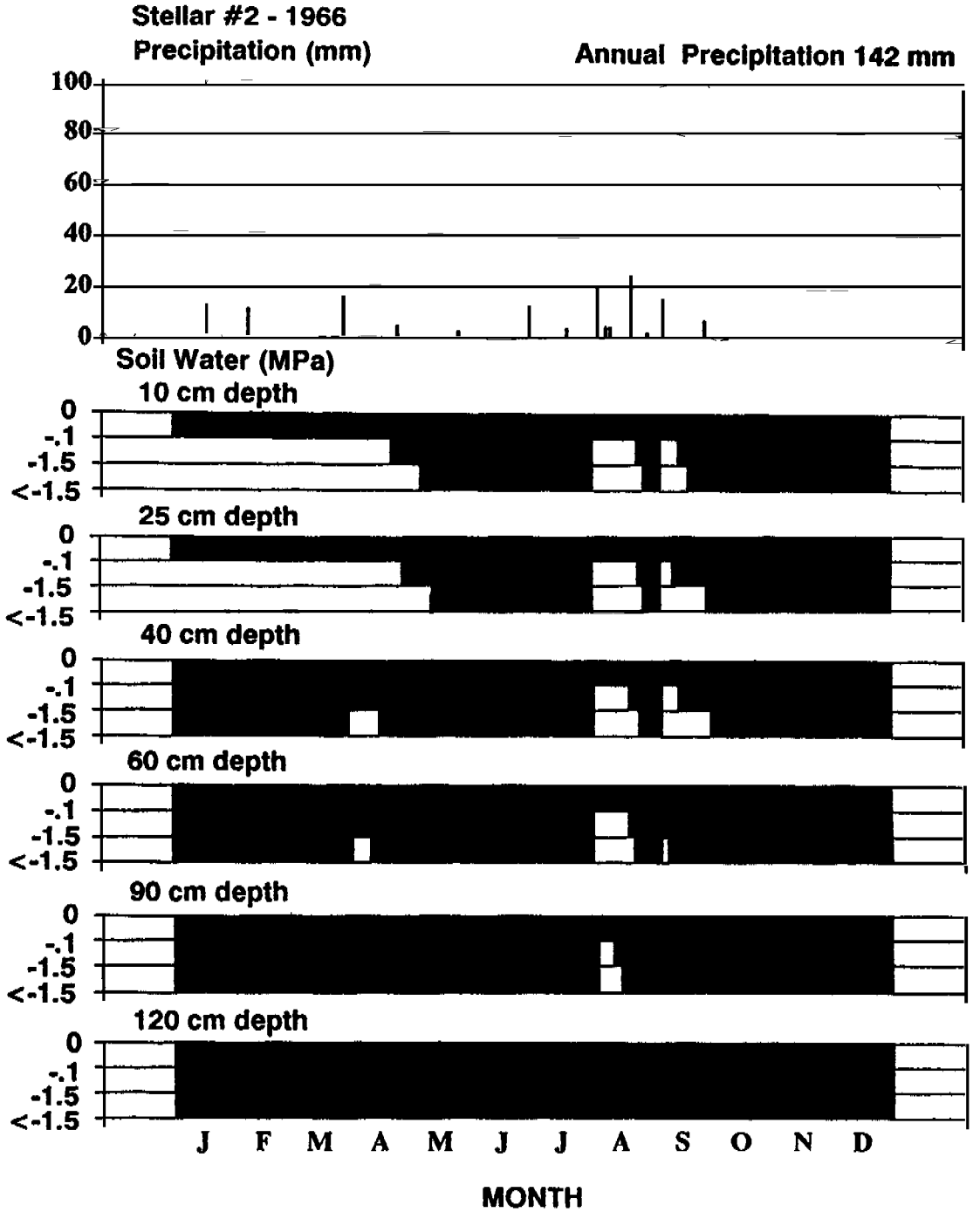
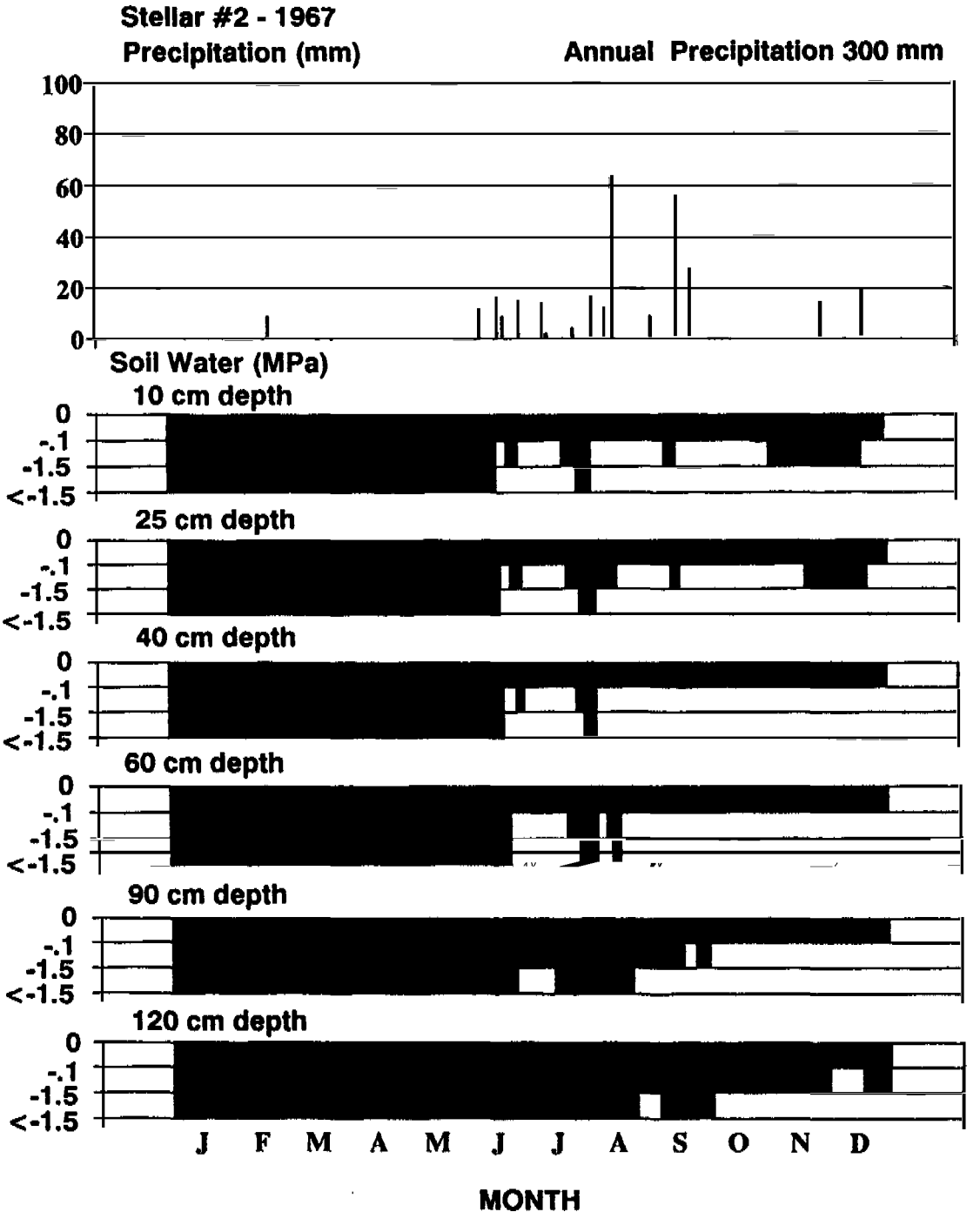


Figure 347. Annual precipitation (142 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1966.



Figures 348. Annual precipitation (300 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1967.

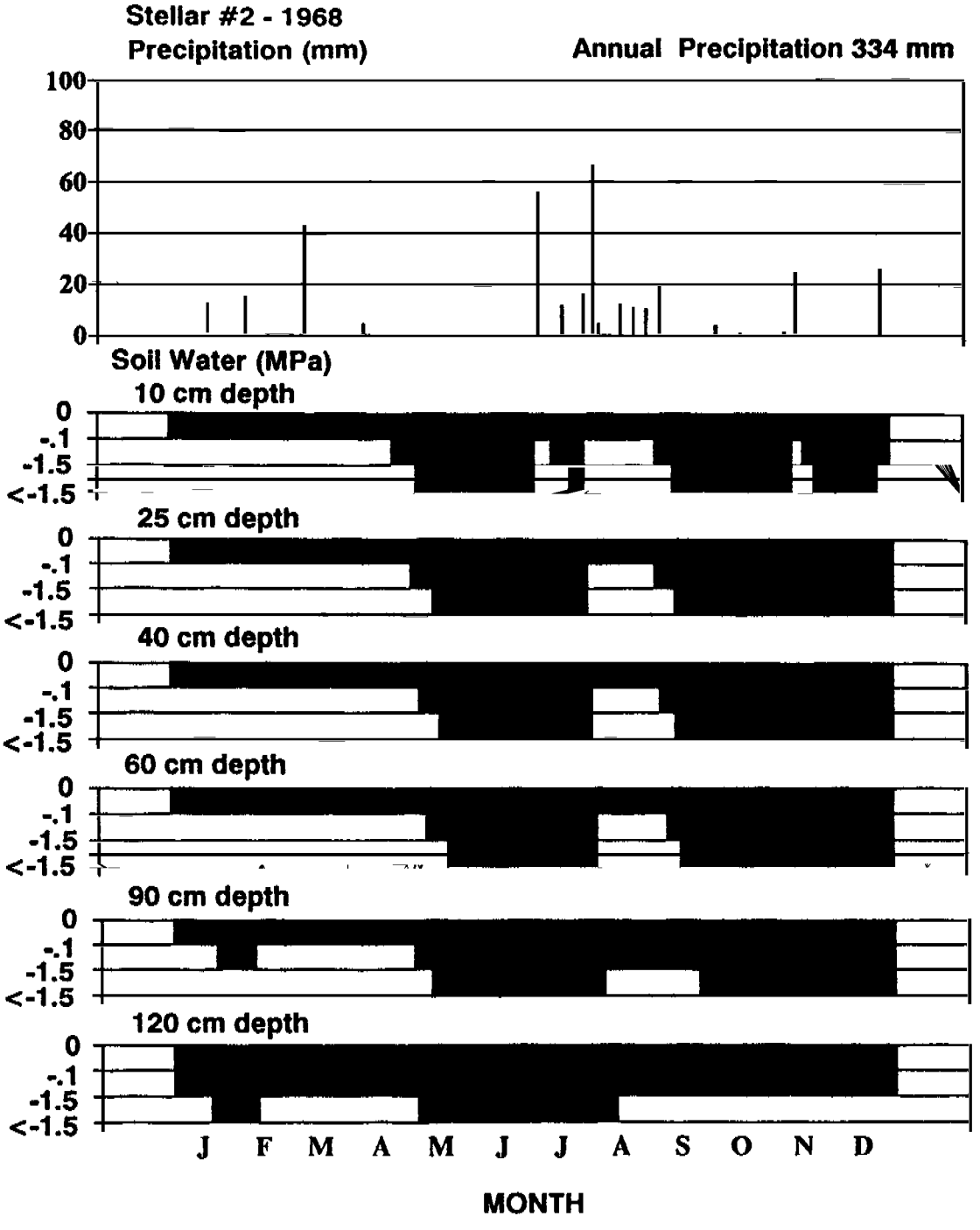


Figure 349. Annual precipitation (334 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1968.

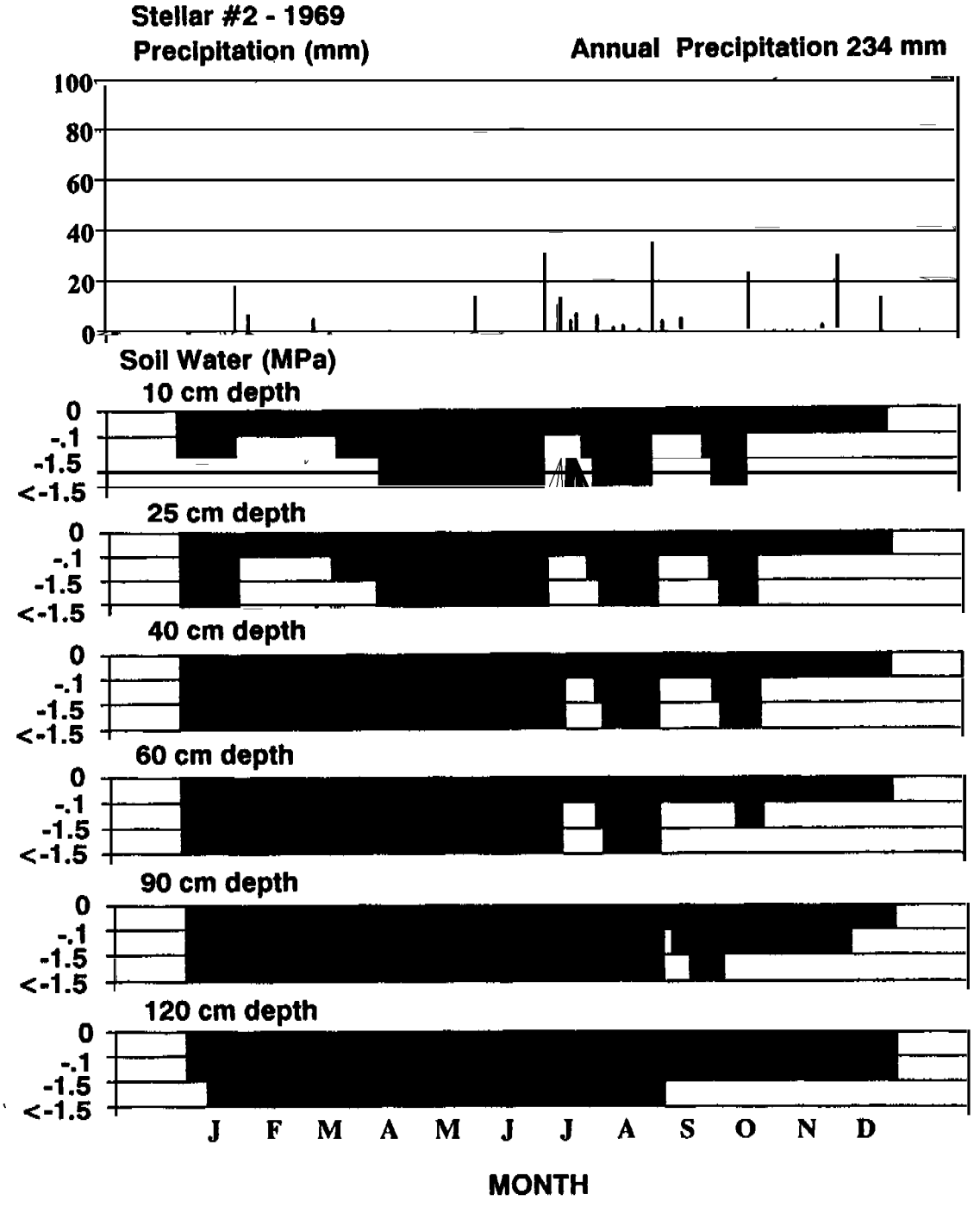


Figure 350. Annual precipitation (234 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1969.

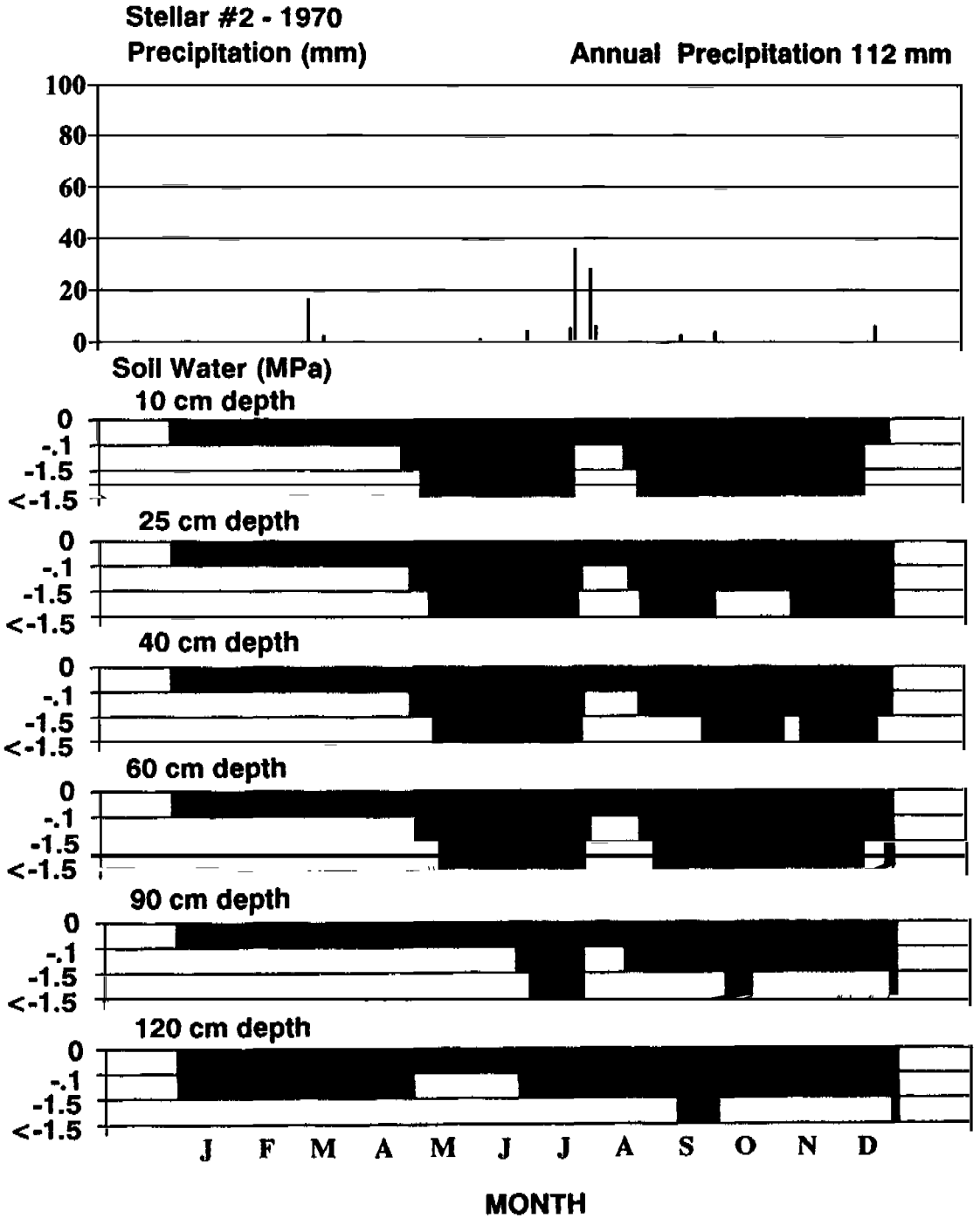


Figure 351. Annual precipitation (112 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1970.

Precipitation was above average each year 1971-76 (figs. 352-357). Matric potential of the soil water at 25 cm was >-1.5 MPa August 19-September 26, 1971 (fig. 352); October 26, 1971-May 14, 1972 (figs. 352, 353); and July 13-23, 1972. No soil water data were available August 8-December 31, 1972. Soil water >-1.5 MPa at 25 cm was observed January 1, 1973-May 10 (fig. 354); July 20-August 25, 1973; July 15-September 3, 1974 (fig. 355); September 15, 1974-June 12, 1975 (figs. 355, 356); July 15, 1975-July 2, 1976 (figs. 356, 357); and August 28-November 12, 1976.

Annual precipitation for 1957-76 was below average for five years, about average for one year, and above average for 14 years. The probability of the matric potential of the soil water >-1.5 MPa at the 25-cm depth averaged 57.2% for December-April, 16.6% for May and June, 48.3% for July-September, and 42.6% for October and November (fig. 358).

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, 10 of 20 years had soil water <-1.5 MPa more than half the time at a depth of 10 cm; 11 of 20 years at 25 cm; 13 of 20 years at 40 cm; 12 of 18 years at 60 cm; 10 of 18 years at 90 cm; and 9 of 18 years at a soil depth of 120 cm. Six of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 7 of 20 years at 25 cm; 11 of 20 years at 40 cm; 8 of 18 years at 60 and 120 cm; and 7 of 18 years at a depth of 90 cm. For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 16 of 18 years and >30 consecutive days in the four months after June 21, 14 of 18 years when the soil water data were complete for the entire year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was observed in both years and the 30-day criterion was observed in 1957.

Site Veatch-Stellar 3 (VS3)

Site VS3 (figs. 226, 359-362, table 13) is in the Fertilizer Plot Exclosure of the Jornada Experimental Range. In contrast to other sites (where the gypsum blocks are set in one kind of soil), at site VS3, the blocks are set in two different kinds of soil, Stellar and Veatch. Illustrative pedons of each (figs. 359-362) were described and classified (table 13). The Veatch pedon is 3 m south of the south fence of the exclosure; the Stellar pedon is about 3 1/2 m east of the east fence of the exclosure. Perennial vegetation on the Veatch and most Stellar soils is a dense stand of tobosa. Average annual production for 1958-61 was 3,000 kg/ha (Herbel, 1963). Some Stellar soils (including the studied pedon) have burrograss vegetation.

Soils. Both of the studied soils have formed in fan-piedmont sediments derived from monzonite, rhyolite, andesite, and latite, and are on the Jornada II surface of late-Pleistocene age. Both soils are also underlain by buried Haplargids of Jornada I age (figs. 225, 253, 359, 361, tables 1, 2, 13). Slope is 0.5% to the east.

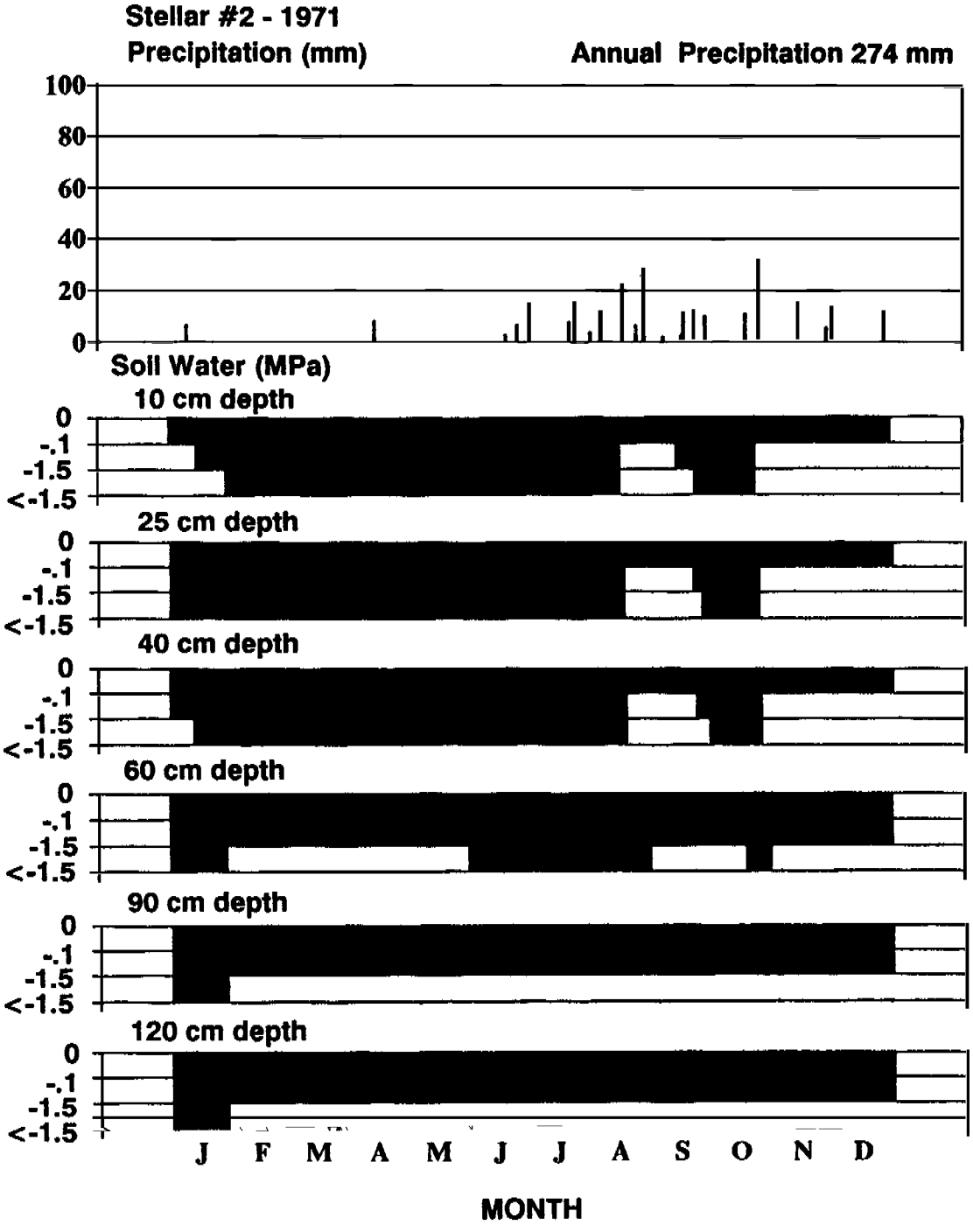


Figure 352. Annual precipitation (274 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1971.

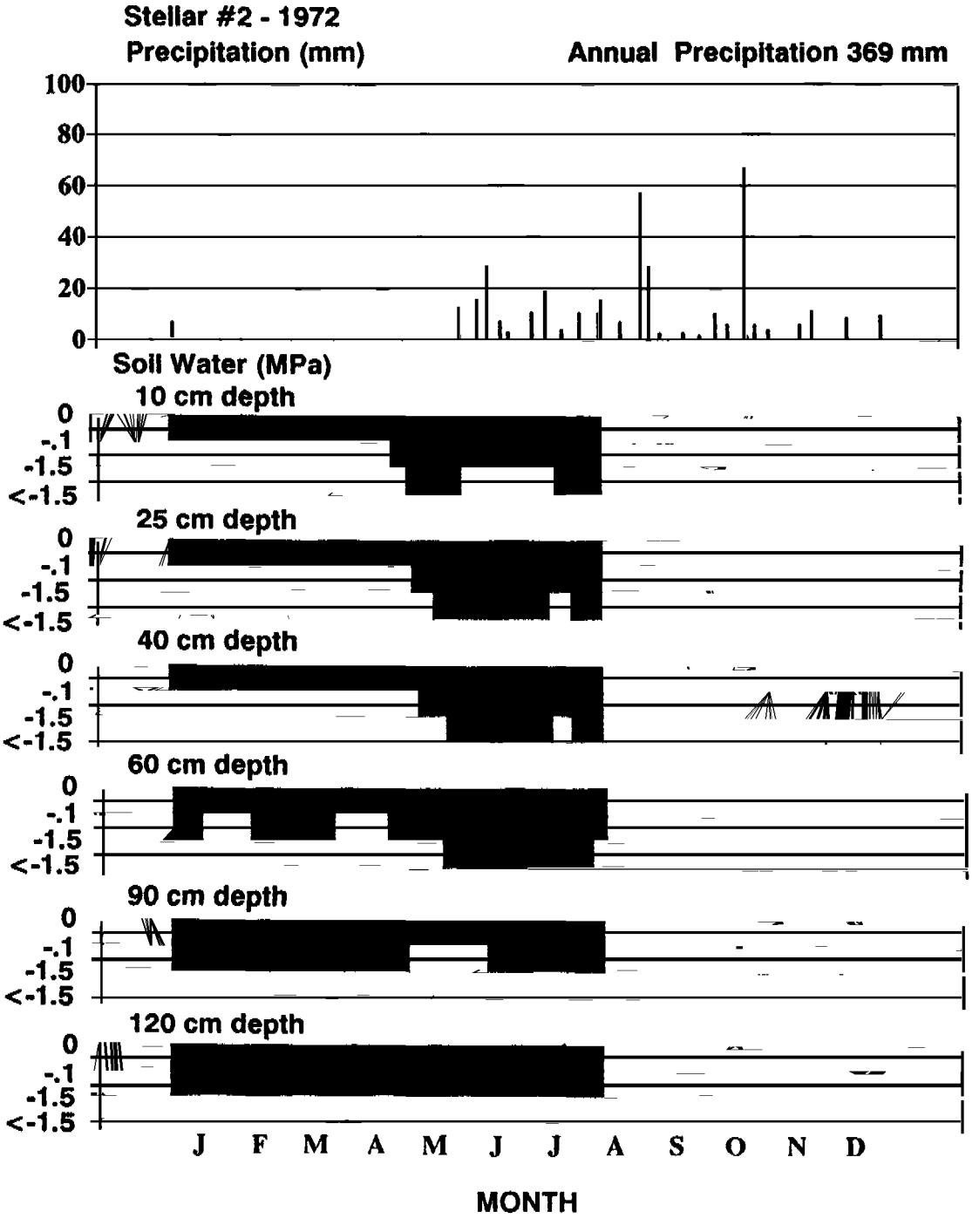


Figure 353. Annual (369 mm) and daily (mm) precipitation for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm January 1-August 7, 1972 at the Stellar #2 site.

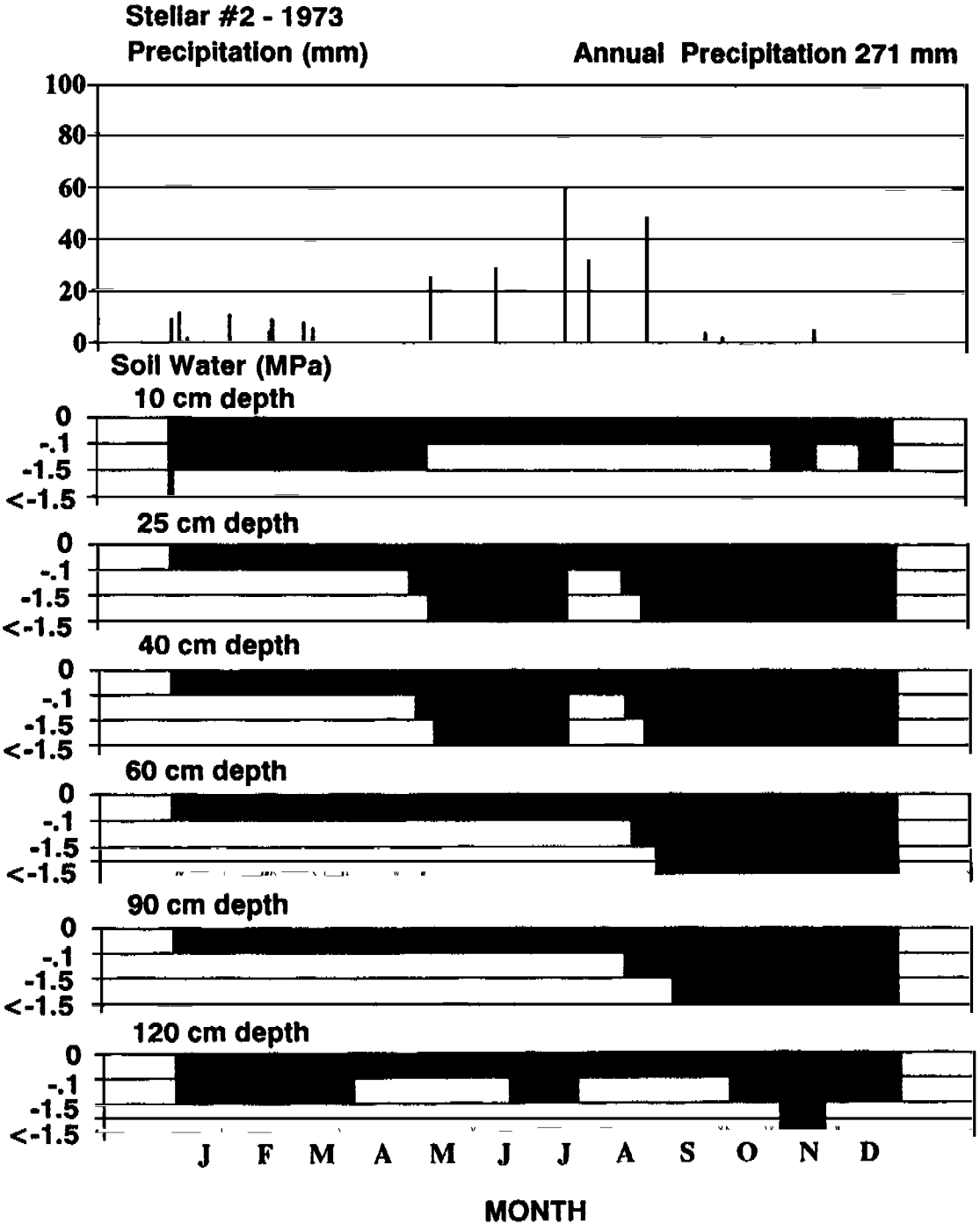


Figure 354. Annual precipitation (271 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1973.

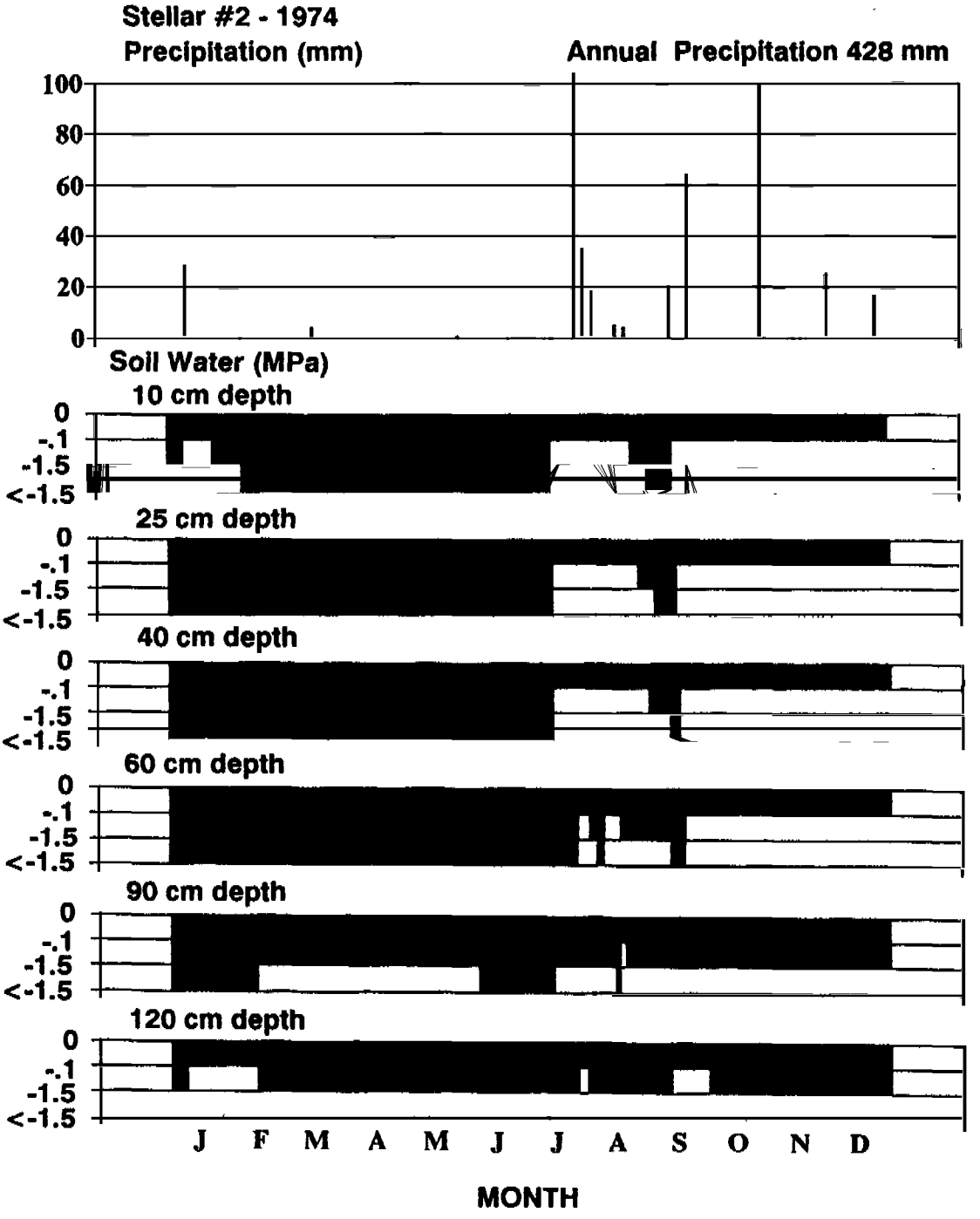


Figure 355. Annual precipitation (428 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1974.

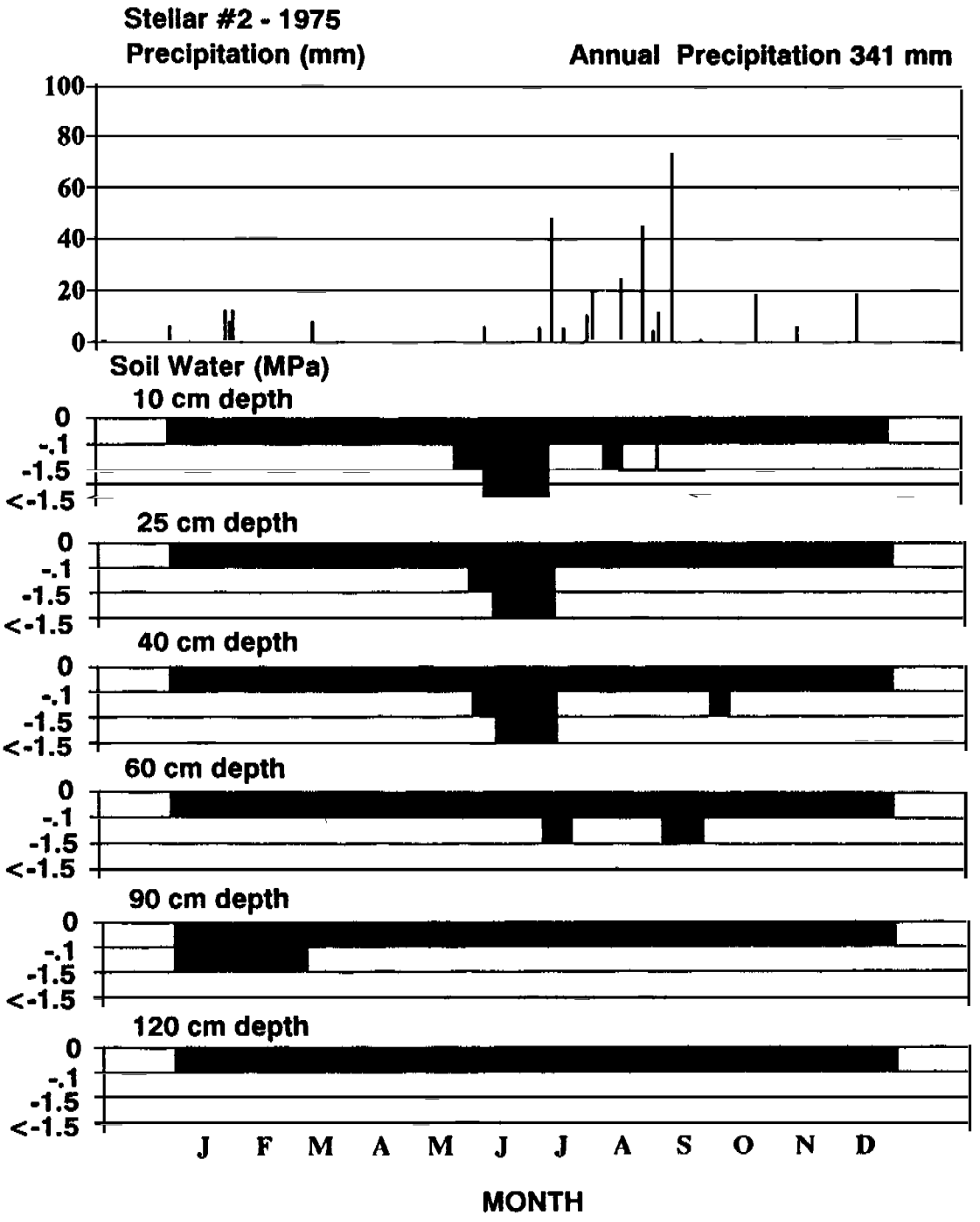


Figure 356. Annual precipitation (341 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1975.

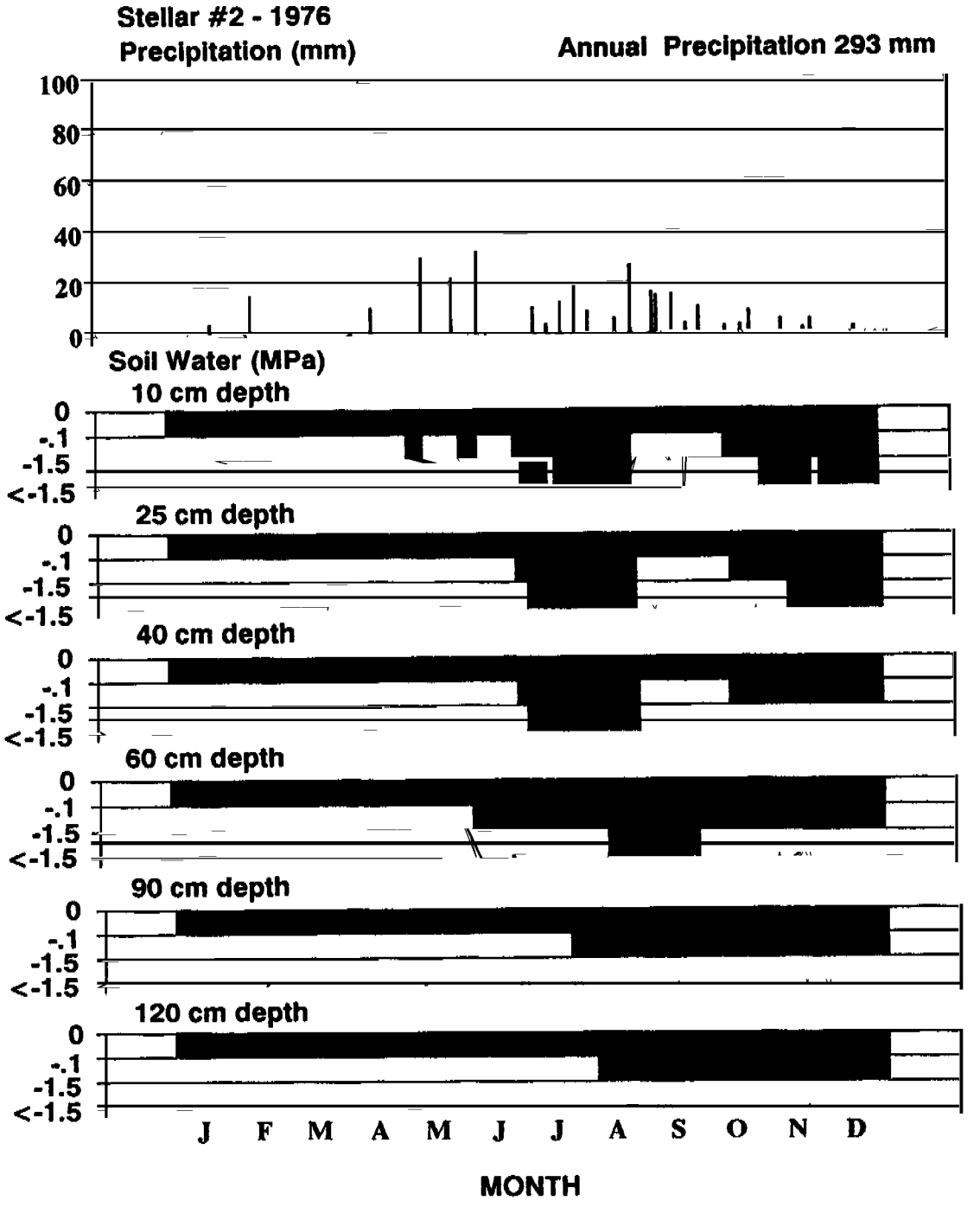


Figure 357. Annual precipitation (293 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site for 1976.

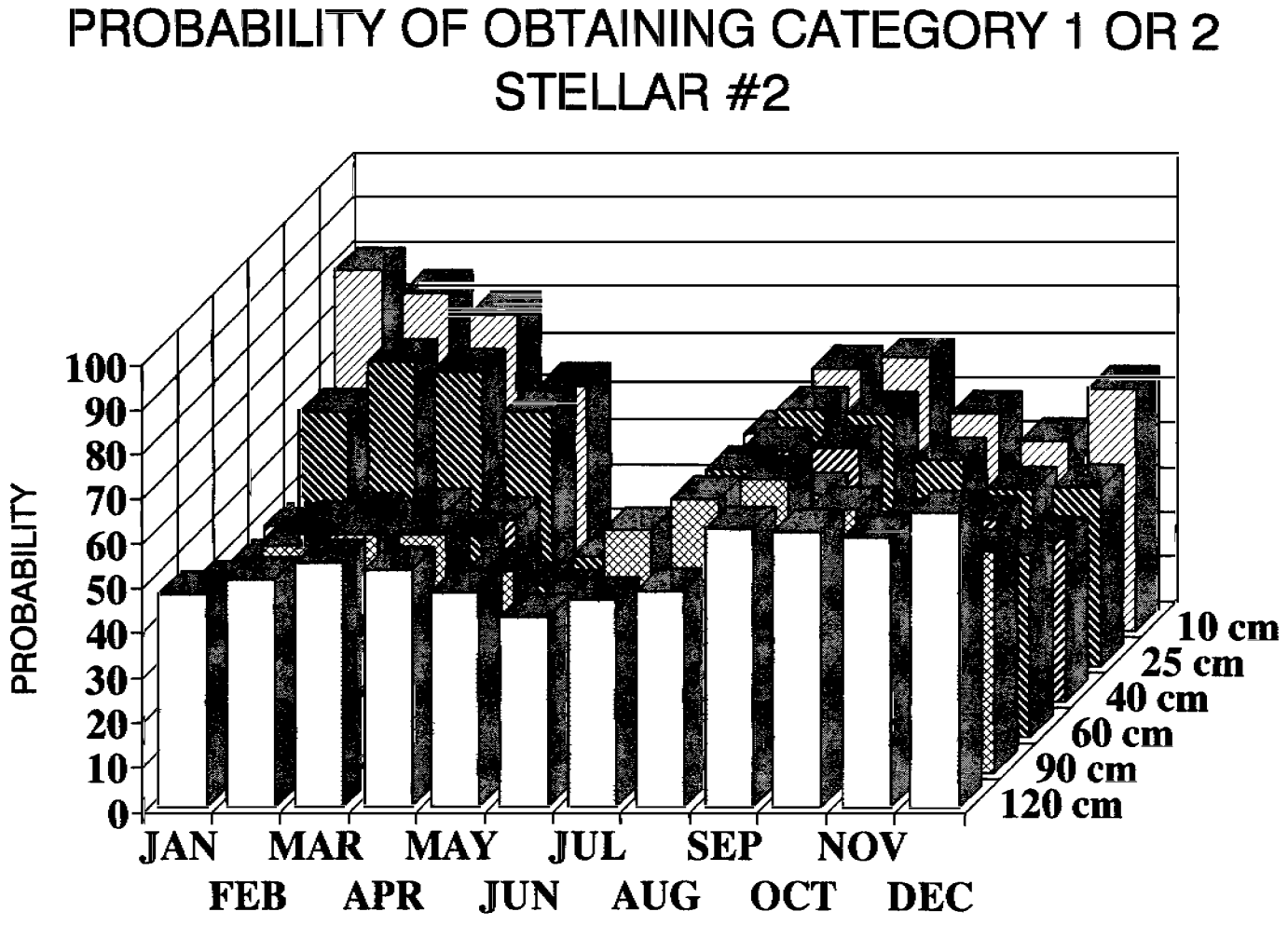


Figure 358. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #2 site.

Table 13. Characteristics of Ustollic Haplargids at site VS3.

Alluvium	Horizon	Depth cm	Hue	Value/chroma Dry	Moist	Structure	Consistence Dry	Moist	Eff. with HCl	Textural class
Veatch										
Jornada II	E	0-7	10YR	7/2	4.5/2	1fgr-lmsbk,cpl	sh,h	vfr fr	es	1
	BAt	7-15	7.5YR	6/4	5/4	lmsbk	vh,ef	fi	es	cl,c
	Bt1	15-43	7.5YR	5/4	4/4	2m,csbk	eh	vfi	es	c
	Bt2	43-75	7.5YR	5/4	4/4	2cpl,2cw lmsbk	eh	vfi	es	c
	K1t	75-90	7.5YR	8/4	6/4	lmsbk	vh	fi	es	c
			7.5YR	5/4	4/4	1cpl,1cw				
	K2	90-112	7.5YR	8/2	6/4	lmsbk	h	fi	es	cl
			7.5YR	6/4	5/4					
	Bky	112-133	7.5YR	6/4	5/4	lmpr-1,2,f,msbk	h	fi	es	cl
Jornada I	BAtkyb	133-152	7.5YR	6/4	5/4					
			5YR	5/4	4/4	1msbk	h	fi	es	cl
	Btkyb	152-163	5YR	5/4	4/4	1f,msbk	h	fi	es,nc	cl
Stellar										
Jornada II	E	0-8	10YR	6/2	4/3	1msbk, 1mcpl	sh	vfr	e,nc	cl
	Bt	8-25	6YR	6/4	4/4	1pr-2fmsbk	h,vh	fi	nc	cl
	Btk1	25-43	6YR	6.5/4	4.5/4	1mpr-2f,mbk	vh	fi	es	cl
	Btk2	43-61	5YR	5.5/4	4/4	1fpr-1f,msbk	h	fi	es	cl
	Btk3	61-81	5YR	5/4	4/4	2mpr-1msbk	vh	fi	es	cl
	K2	81-117	7.5YR	6.5/4	5.5/4	1f,msbk	h,vh	fi	es	cl
			7.5YR	9/2	8/4					
Jornada I	Bkb	117-140	7.5YR	6/4	5/4	1cpr-1msbk	h	fi	es	cl
	Btkb	140-168	7.5YR	6/4	5/4	1cpr-1msbk	h	fi	ew	cl

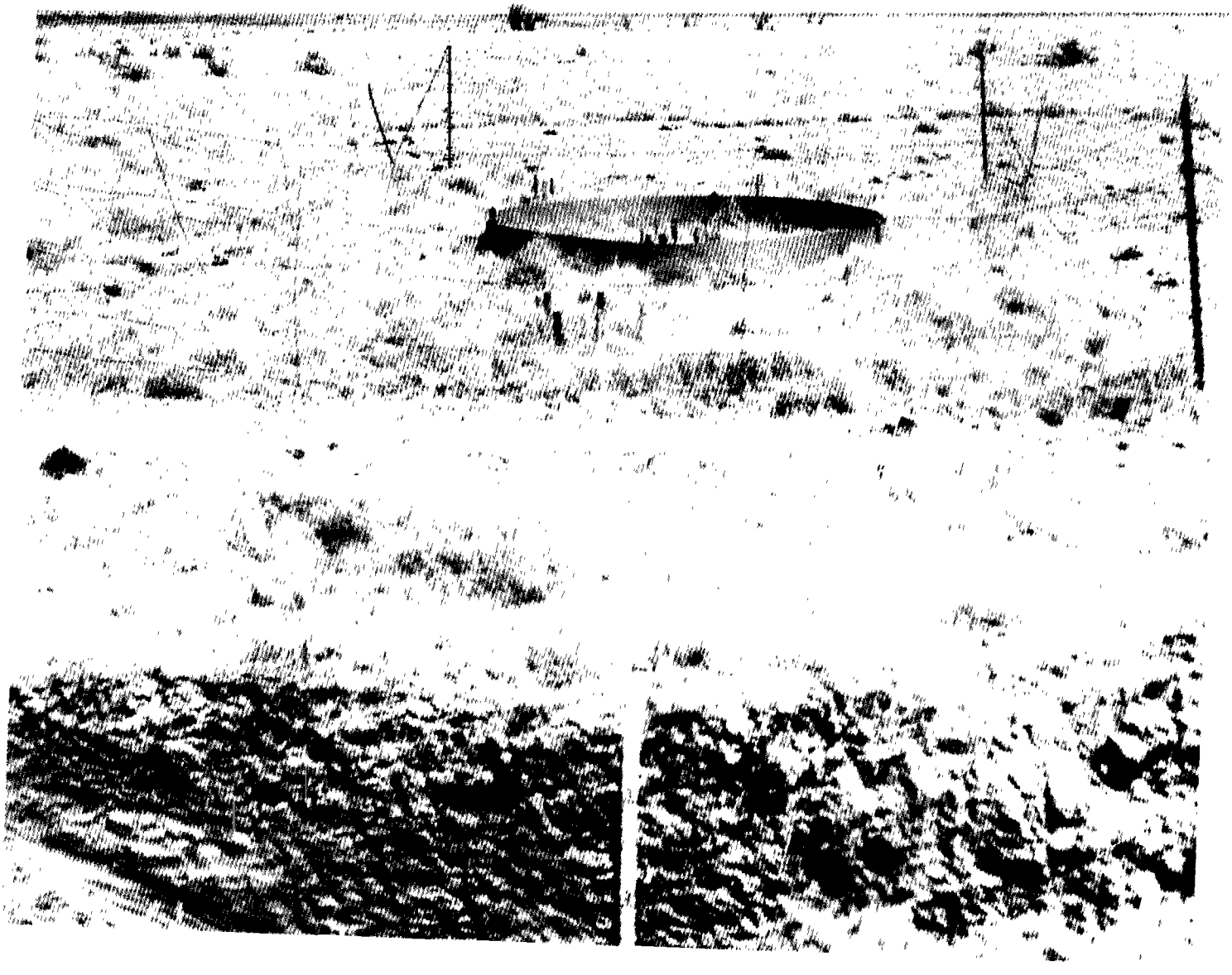


Figure 359. Landscape of the fan-piedmont toeslope at Site VS3 (fig. 226) and the Ustollic Haplargid Veatch, in the Fertilizer Plot exclosure in the Jornada Experimental Range. Stakes and wires to soil water blocks are both inside and outside the large metal cylinder (see text discussion). Photographed in May 1971.

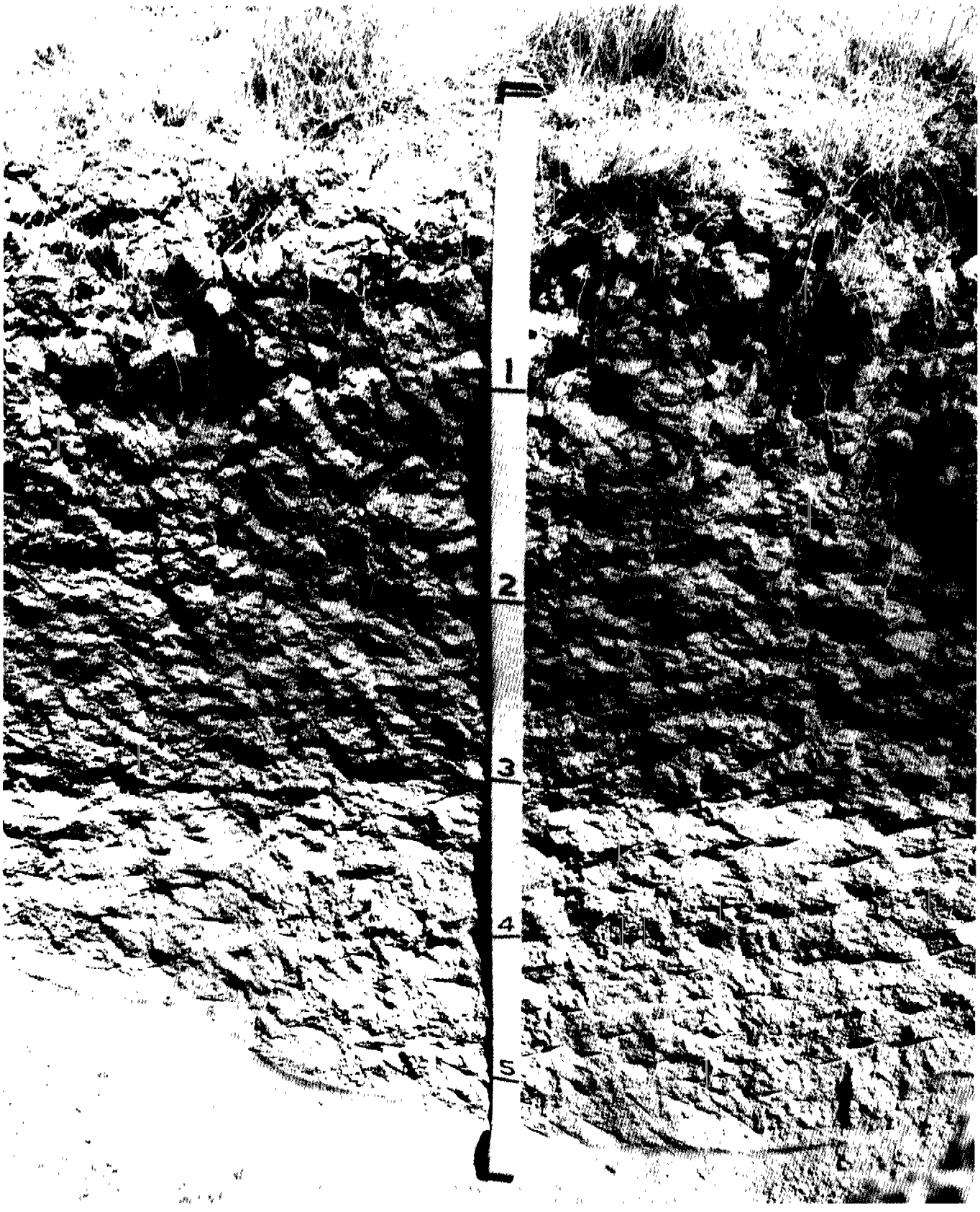


Figure 360. Profile of the Ustollic Haplargid Veatch. The Bt and K1 horizons contain plates that are pressure-generated morphological forms (see text discussion). A clear smooth boundary separates the K1 from the K2 horizon at a depth of about 3 ft. Scale is in feet.

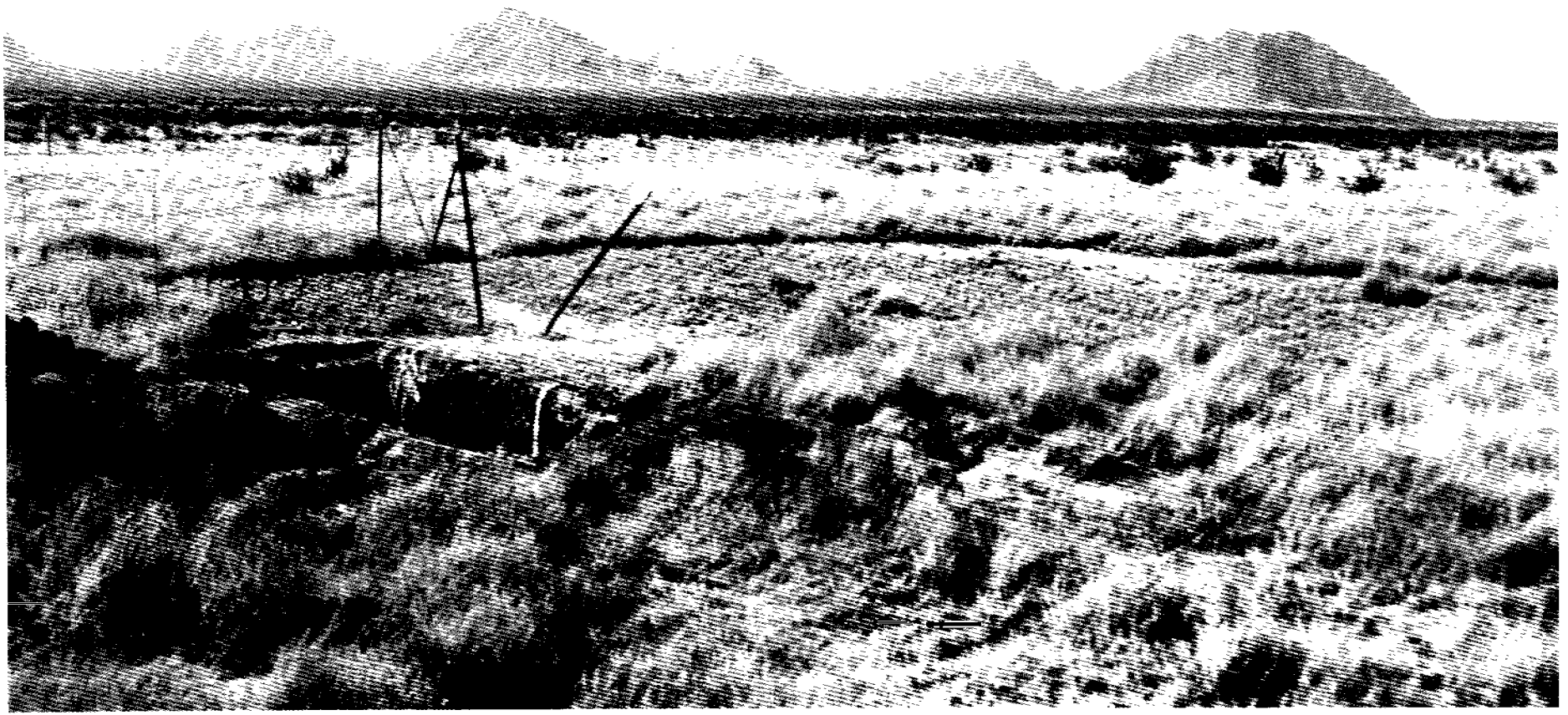


Figure 361. Landscape of the fan-piedmont toeslope at site VS3 (fig. 226) and the Ustollic Haplargid Stellar, in the burrograss area at the Fertilizer Plot exclosure on the Jornada Experimental Range. The stakes inside the exclosure at left lead to the soil water blocks in the Stellar soil. The Dona Ana Mountains are on the skyline. Photographed December 1970.

Figure 362. Profile of the Ustollic Haplargid Stellar. In contrast to the plates and wedges in Veatch (fig. 360), the Bt horizon in Stellar is dominated by prismatic and blocky structure. Scale is in feet.

Site VS3 occurs on the fan-piedmont toeslopes just west of the basin floor (fig. 225). While fan-toeslopes, such as this site, may contribute some runoff water to the basin floor from a high-intensity storm, they also receive considerable run-in from the adjacent steeper slopes (fig. 225). There are no distinct drainageways at this site but in places, as at the Veatch site, there is a microrelief of small depressions and holes. Just upslope from the soil water blocks is a network of small circular and linear depressions. One of the linear depressions is about 5 m long, 20-30 cm deep, and 50-75 cm wide; it occurs along the contour and would catch moisture moving downslope. This linear depression has branches 3-5 m long, one of which leads directly towards the water blocks in Veatch and ends only about 1 m away from the blocks. In places, small holes extend from the depressions into the Bt horizon.

Five sets of water blocks are at site VS3 (figs. 359, 361), three sets are in Stellar pedons and two are in Veatch pedons. Two of the sets in Stellar pedons and both sets in the Veatch pedons have tobosa vegetation. The other set of blocks is in burrograss.

Diagnostic horizons for both Stellar and Veatch are an ochric epipedon, an argillic horizon, and a calcic horizon. Both pedons also have substantial clay, but their Bt horizons differ considerably in morphology (table 13), as discussed in the following sections.

Veatch

The Bt2 horizon, and to a lesser extent the K1 horizon, of the Veatch pedon have morphological features not found in the Stellar pedon, discussed later. These are the distinctive wedges and plates that are characteristic of Vertisols. In addition slickensides, another feature characteristic of Vertisols, occur in the Bt2 horizon of Veatch. These morphological features are thought to mark an initial stage of the morphological transition from Haplargids to Vertisols. Development of the Veatch soils has not yet reached the intergrade stage of Soil Taxonomy, because they do not have the deep wide cracks of the Vertic Haplargids. Although the study trench was dug during a long dry period, such cracks were not present in Veatch. Cracks did form during this dry period after the pit was dug, but at 50 cm they were only 1-2 mm wide, and at 25 cm were only 5 mm wide.

Initial formation of the plates, wedges, and slickensides in Veatch is thought to have begun when clay accumulation in the Bt horizon reached a critical level. Apparently, shrinking and swelling associated with wet-dry cycles initiated the formation of small cracks at the surface, which are common in fine-textured soils. Subsequent wetting down the cracks led to the formation of the small depressions and holes in upper horizons. By means of these holes, moisture penetrates quickly and deeply into parts of the soil. B cause parts of the soil below and adjacent to the holes are wetted before other parts, the wetted parts swell,

causing movement against adjacent unwetted parts. This movement, which may be lateral, vertical, or at an angle between the two, apparently causes the formation of wedges, plates, and slickensides (see page 375, Soil Survey Staff, 1975, for details of formation of these features in Vertisols). The foregoing relations of microrelief and soil morphology help to explain the relatively deep and frequent wetting of Veatch compared to Stellar, discussed in the following section.

Stellar

The soil surface, morphology, and soil water data for Stellar (table 13) differ considerably from those of Veatch, which is deeply wetted by way of the depressions and small holes leading to cracks in the Bt horizon. In contrast, the depressions and holes are not present in Stellar soils, and moistening of Stellar is accomplished by wetting through the soil matrix from the soil surface downward. Also contrasting with Veatch, soil water decreases regularly from the top down (figs. 363-435). The regular occurrence of the mostly noncalcareous 5-25 cm zone and the underlying calcareous Bt2 horizon in Stellar reflects this regular pattern of soil water. Instead of the wedges, plates, and slickensides in the Bt horizon of Veatch, the Bt horizon of Stellar has prisms that part to subangular blocky (table 13). The moisture data and morphology of this soil and of the Holocene soil at site H, together with morphological comparison of soils of Holocene and Pleistocene age elsewhere in the Desert Project (Gile et al. 1981), indicate that the 5-25 cm zone is kept largely free of carbonates under the present climate, and that carbonate is presently accumulating primarily in the Bt2 and underlying subhorizons of the Bt horizon, with lesser accumulation below the Bt horizon.

The calcareous state of the upper 5 cm of the E horizon is a feature of many soils in and adjacent to the basin floor. Carbonate in the upper part of the E horizon has apparently been emplaced by carbonate-laden soil water and by incorporation of carbonate in the dustfall. More carbonate has accumulated at the soil surface than can be moved down into the soil by present soil moisture.

Soil Water, Precipitation, and Yields. In this section we will discuss two Stellar soils (#3), one dominated by tobosa and one dominated by burrograss, and two Veatch soils (Veatch (S) and Veatch) within a sheet metal cylinder. The gypsum resistance blocks were installed in two replications at depths of 10, 25, and 40 cm July 28, 1958 and at soil depths of 60, 90, and 120 cm on July 29, 1959 within the livestock exclosure on an area dominated by tobosa (Stellar #3) at Fertilizer. The fertilizer study was discussed by Herbel (1963). None of the gypsum blocks were placed on fertilized plots. Also on July 29, 1959, blocks were installed at depths of 10, 25, 40, 60, 90, and 120 cm on a patch of land dominated by burrograss, about 5 m wide, adjacent to the area

dominated by tobosa. Two sets of blocks were also installed at the six soil depths the latter part of July within a sheet metal cylinder that was buried 15 cm to exclude surface runoff. These latter two sets of blocks were in Veatch soils, Veatch (S) and Veatch. The depressions and holes provided additional soil water below the 15-cm depth to these Veatch sites. These Veatch sites were dominated by tobosa. Daily precipitation was recorded at Stuart Rain Gauge (Stellar #2), 0.3 km north of Fertilizer.

The matric potential of the soil water at 10 cm at Stellar #3 dominated by tobosa was >-1.5 MPa July 29-September 3, 1958 (fig. 363), September 11-17, and September 27-November 13, 1958. The moisture control section, 25-cm soil depth, had water >-1.5 MPa July 29-August 31, 1958, and October 14-December 11, 1958. There was soil water >-1.5 MPa at 40 cm July 28-September 1, 1958 (fig. 363). The tobosa on 15, 30.5-cm x 1.5-m quadrats was clipped to ground level each fall 1958-66. The average production of tobosa in 1958 was 2319 kg/ha (s.e.=87 kg/ha).

The precipitation for 1959 at Stuart Rain Gauge was 276 mm. The soil water at 25 cm at Stellar #3 dominated by tobosa was >-1.5 MPa July 20-August 2 and August 8-September 20 (fig. 364). Tobosa yields were 3125 kg/ha (s.e.=351 kg/ha). At 25 cm, the Stellar site dominated by burrograss had soil water >-1.5 MPa July 29-September 14 (fig. 365), Veatch (S) had soil water >-1.5 MPa July 31-September 30 (fig. 366), and Veatch had water >-1.5 MPa July 27-September 30, 1959 (fig. 367).

The annual precipitation for 1960 was 182 mm (figs. 368-371). Stellar #3 dominated by tobosa had water >-1.5 MPa at 25 cm July 8-August 2 and August 11-September 3 (fig. 368). Tobosa produced 1668 kg/ha (s.e.=224 kg/ha). At the 25-cm depth, Stellar #3 dominated by burrograss had water >-1.5 MPa July 8-29 (fig. 369), Veatch (S) had soil water >-1.5 MPa July 8-August 3 and August 12-September 3 (fig. 370), and Veatch had water >-1.5 MPa July 8-August 7 and August 12-September 10 (fig. 371).

Annual precipitation at Stuart Rain Gauge was 324 mm in 1961 (figs. 372-375). Stellar #3 dominated by tobosa at fertilizer had soil water >-1.5 MPa at the 25-cm depth January 25-April 16, July 2-25, and August 12-October 31 (fig. 372). Tobosa yielded 4907 kg/ha (s.e.=322 kg/ha). At the 25-cm depth, the area dominated by burrograss (Stellar #3) had soil water >-1.5 MPa August 12-October 18, 1961 (fig. 373); Veatch (S) had soil water >-1.5 MPa March 13-26, July 1-28, and August 13-December 31 (fig. 374); and Veatch had soil water >-1.5 MPa February 1-April 16, July 1-30, and August 12-December 31, 1961 (fig. 375).

Annual precipitation for 1962 was 314 mm (figs. 376-379). The tobosa area (Stellar #3) had soil water >-1.5 MPa at 25 cm November 9, 1961-May 16, 1962 (figs. 372, 376) and July 8-August 26. Tobosa produced 2330 kg/ha (s.e.=109 kg/ha). At 25 cm, the soil water was >-1.5 MPa at Stellar #3 (dominated by burrograss) November 11, 1961-April 24, 1962, July 8-August 9, and September 24-October 29, 1962 (figs. 373, 377); the soil water was >-1.5 MPa at Veatch (S) January 1-May 19, 1962, July 19-August 29,

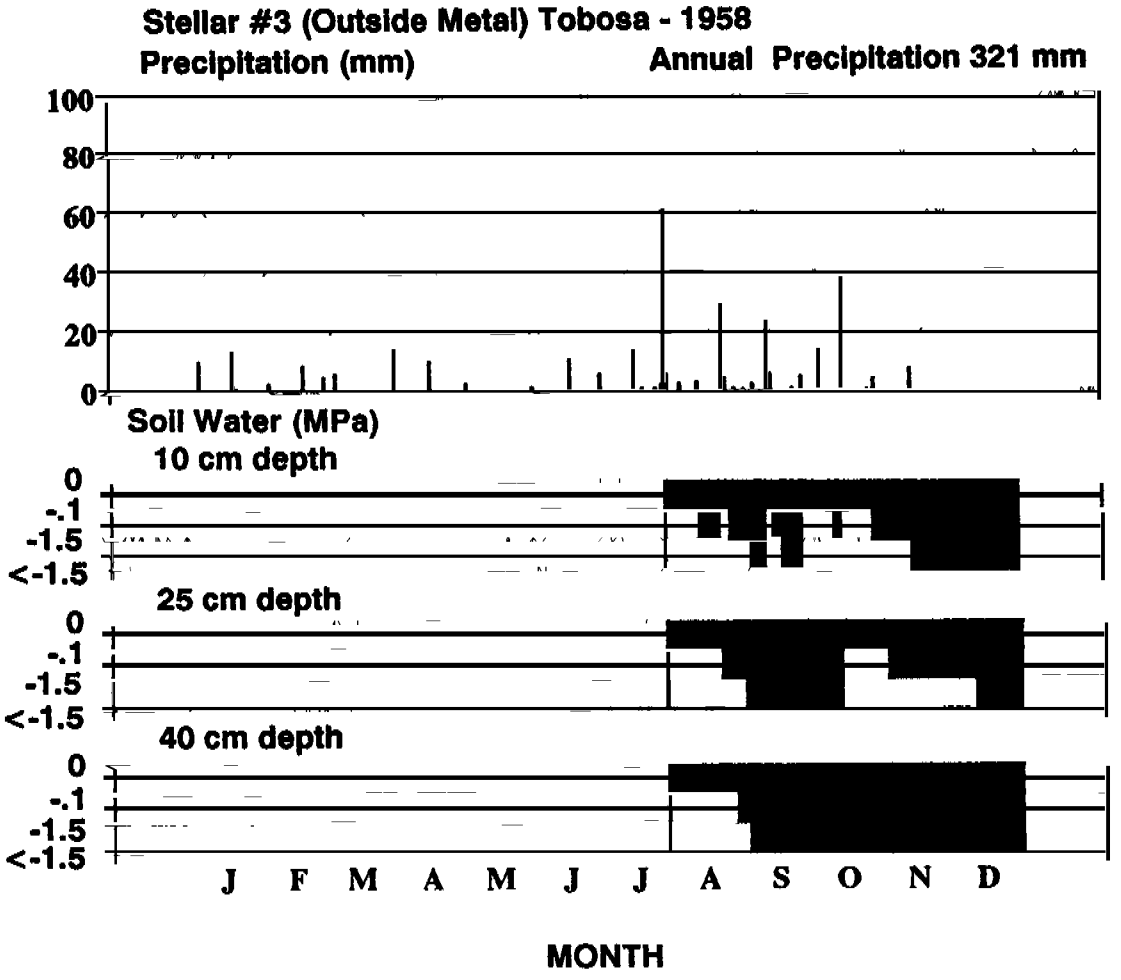


Figure 363. Annual (321 mm) and daily (mm) precipitation for 1958 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for July 28-December 31, 1958 at the Stellar #3 site dominated by tobosa.

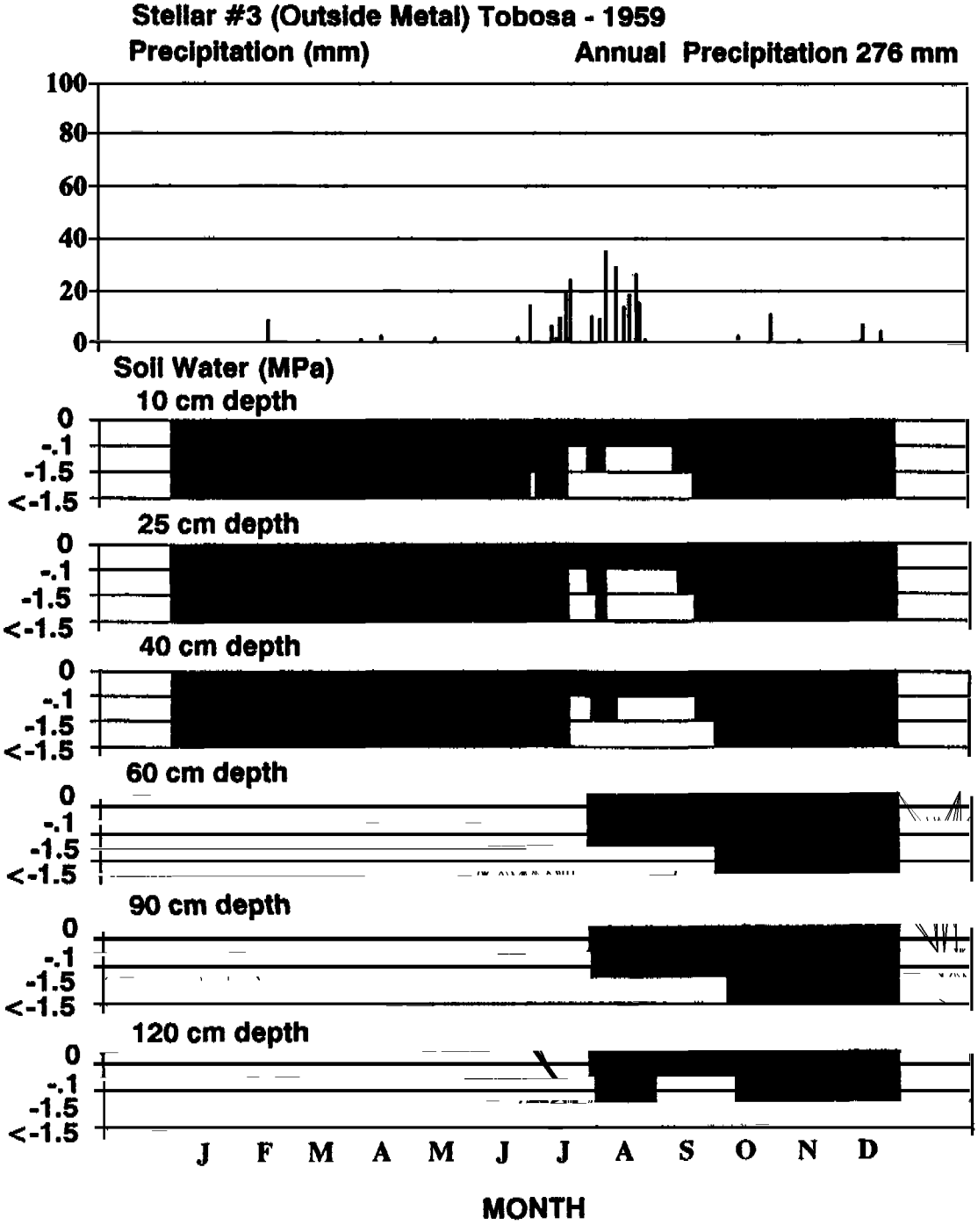


Figure 364. Annual (276 mm) and daily (mm) precipitation for 1959 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for 1959 at the Stellar #3 site dominated by tobosa. Also shown is the soil water for depths of 60, 90, and 120 cm July 29-December 31, 1959.

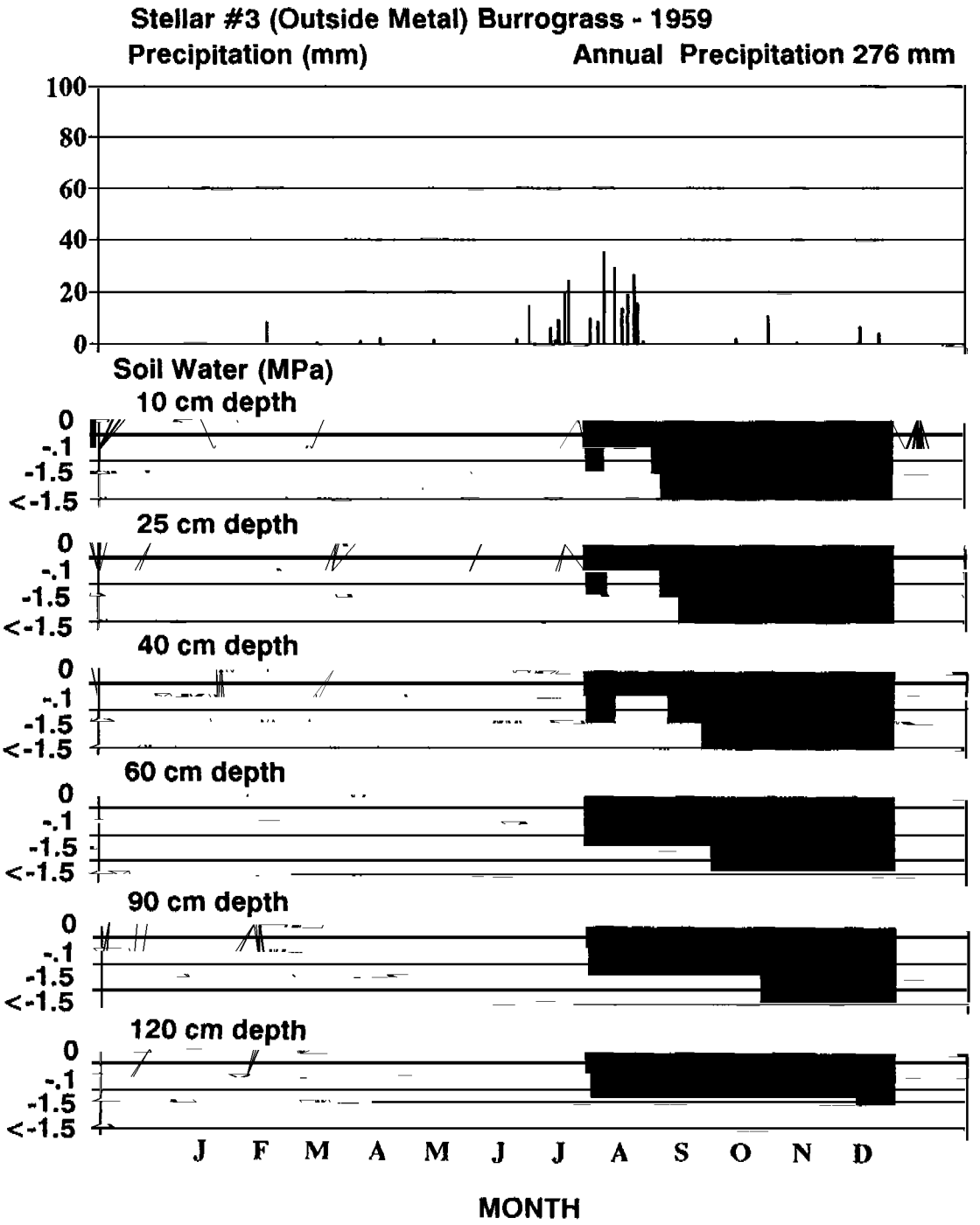


Figure 365. Annual (276 mm) and daily (mm) precipitation for 1959 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for July 29-December 31, 1959 at the Stellar #3 site dominated by burrograss.

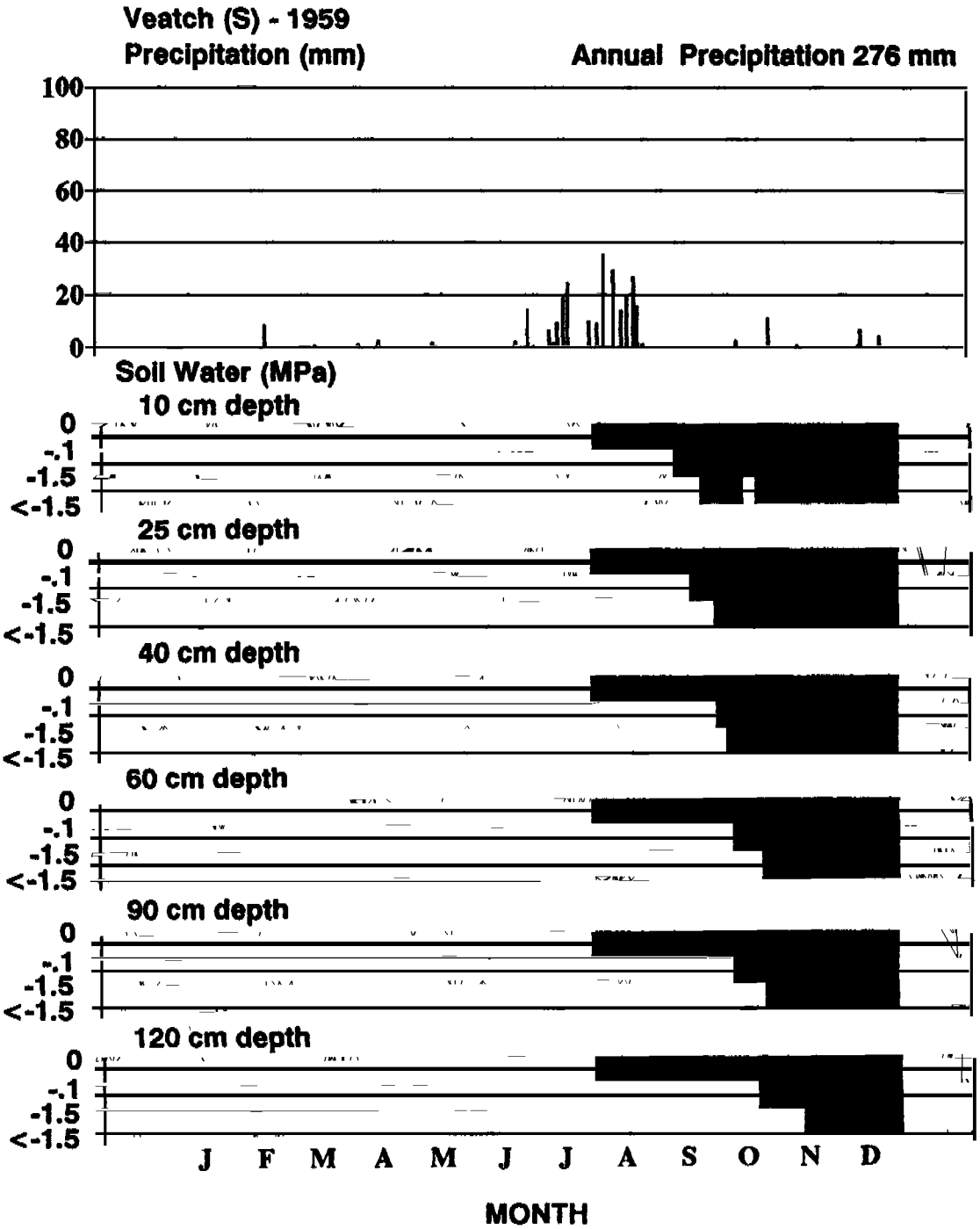


Figure 366. Annual (276 mm) and daily (mm) precipitation for 1959 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for July 31-December 31, 1959 at the Veatch (S) site.

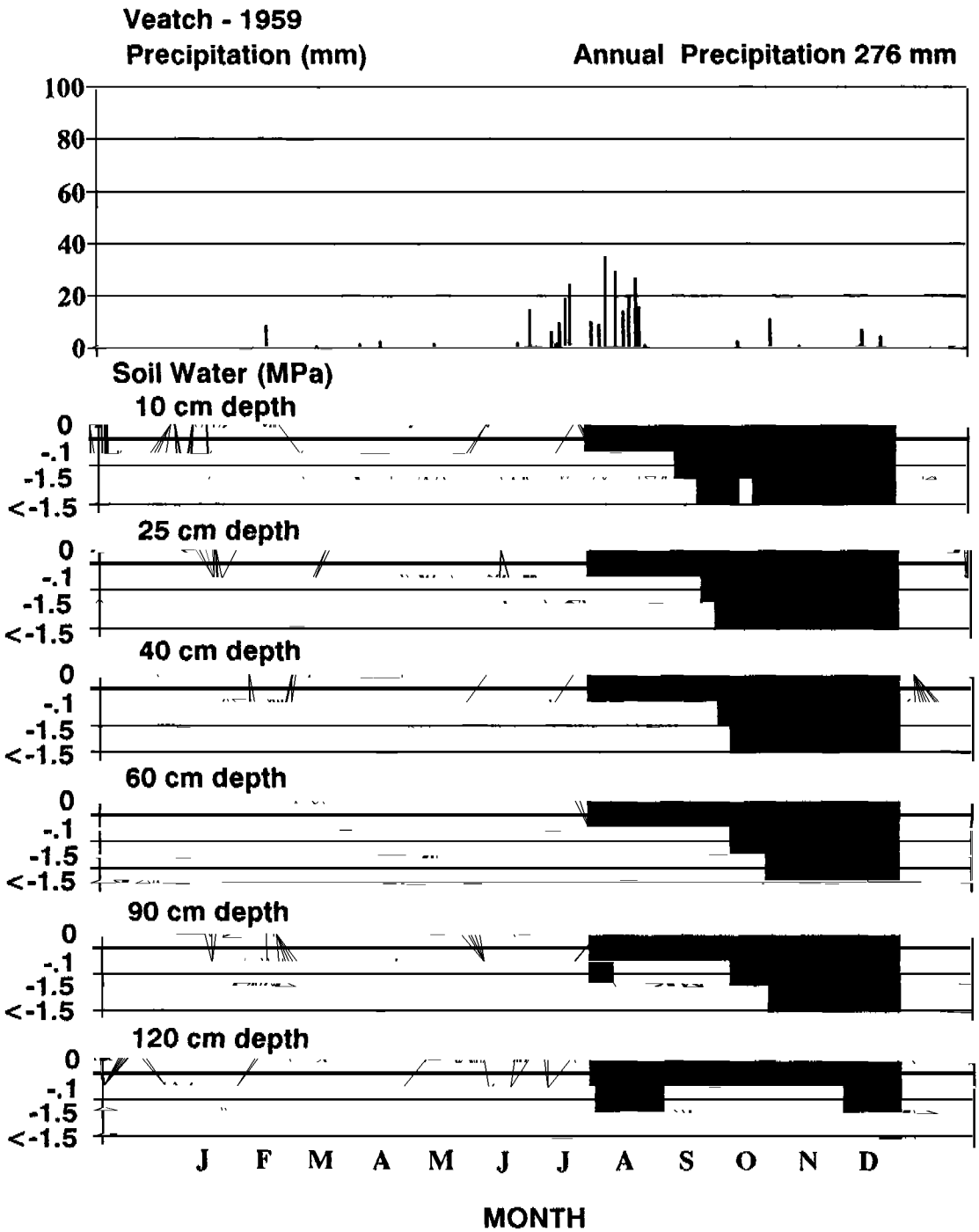


Figure 367. Annual (276 mm) and daily (mm) precipitation for 1959 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for July 27-December 31, 1959 at the Veatch site.

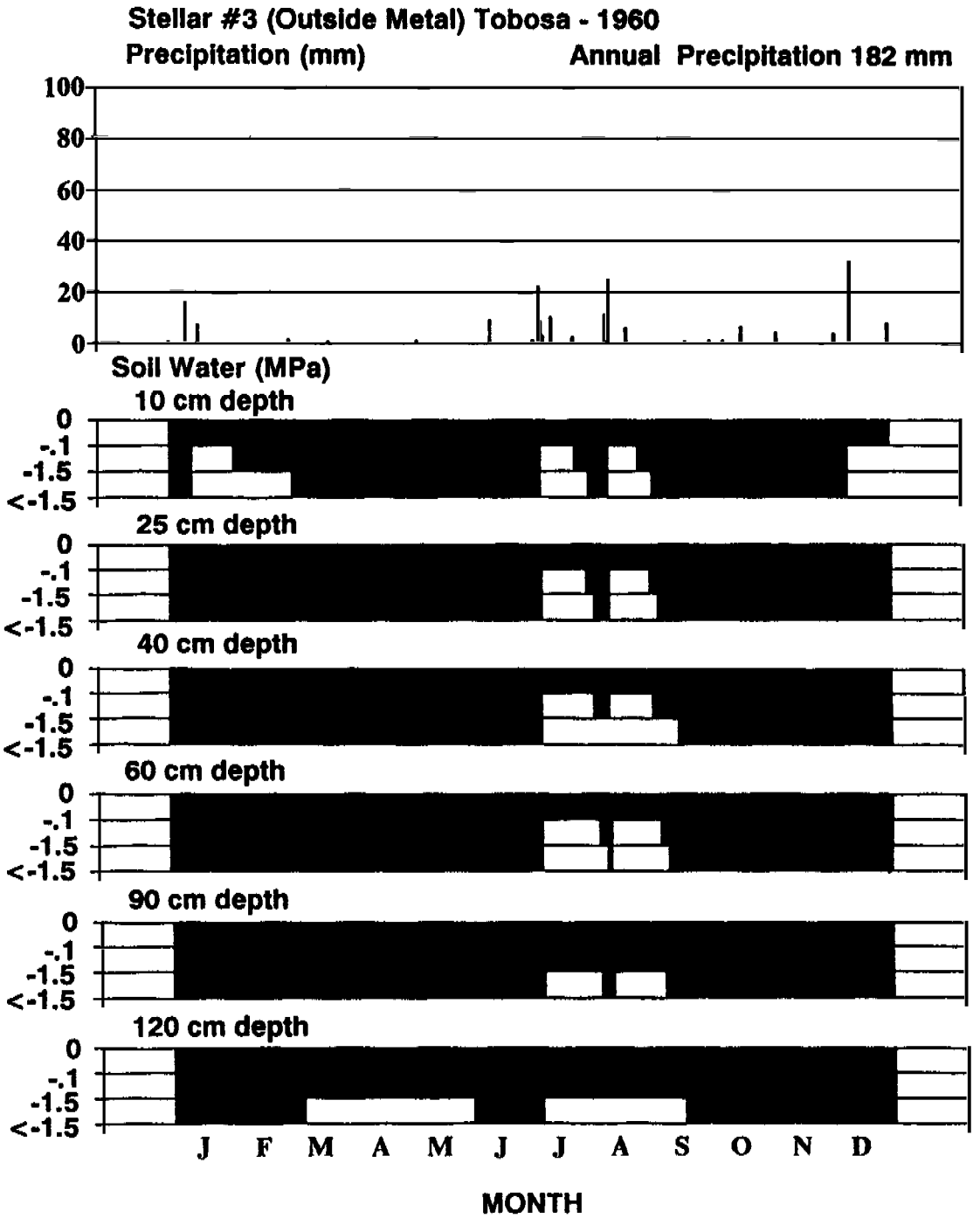


Figure 368. Annual (182 mm) and daily (mm) precipitation for 1960 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1960 at the Stellar #3 site dominated by tobosa.

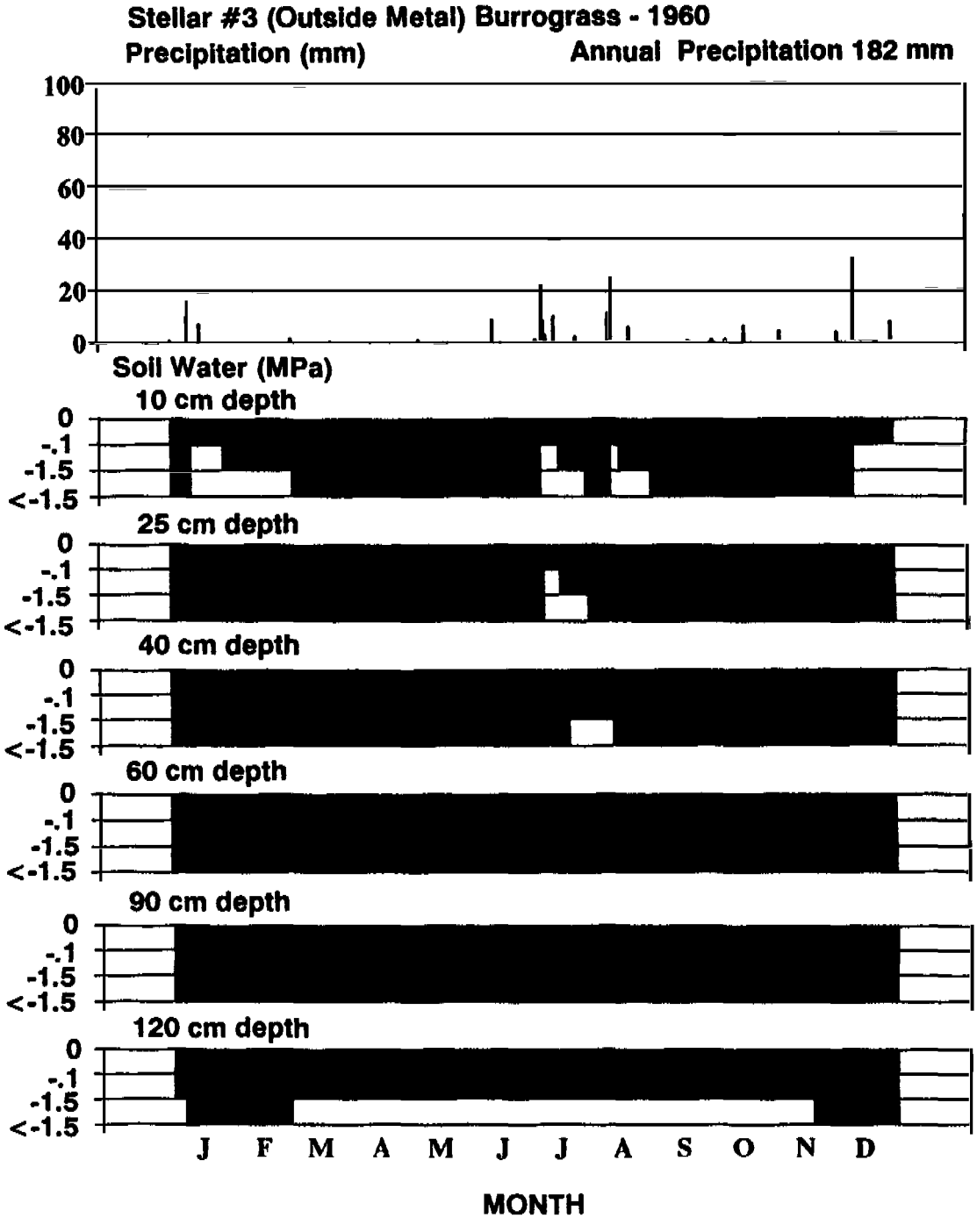


Figure 369. Annual (182 mm) and daily (mm) precipitation for 1960 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1960 at the Stellar #3 site dominated by burrograss.

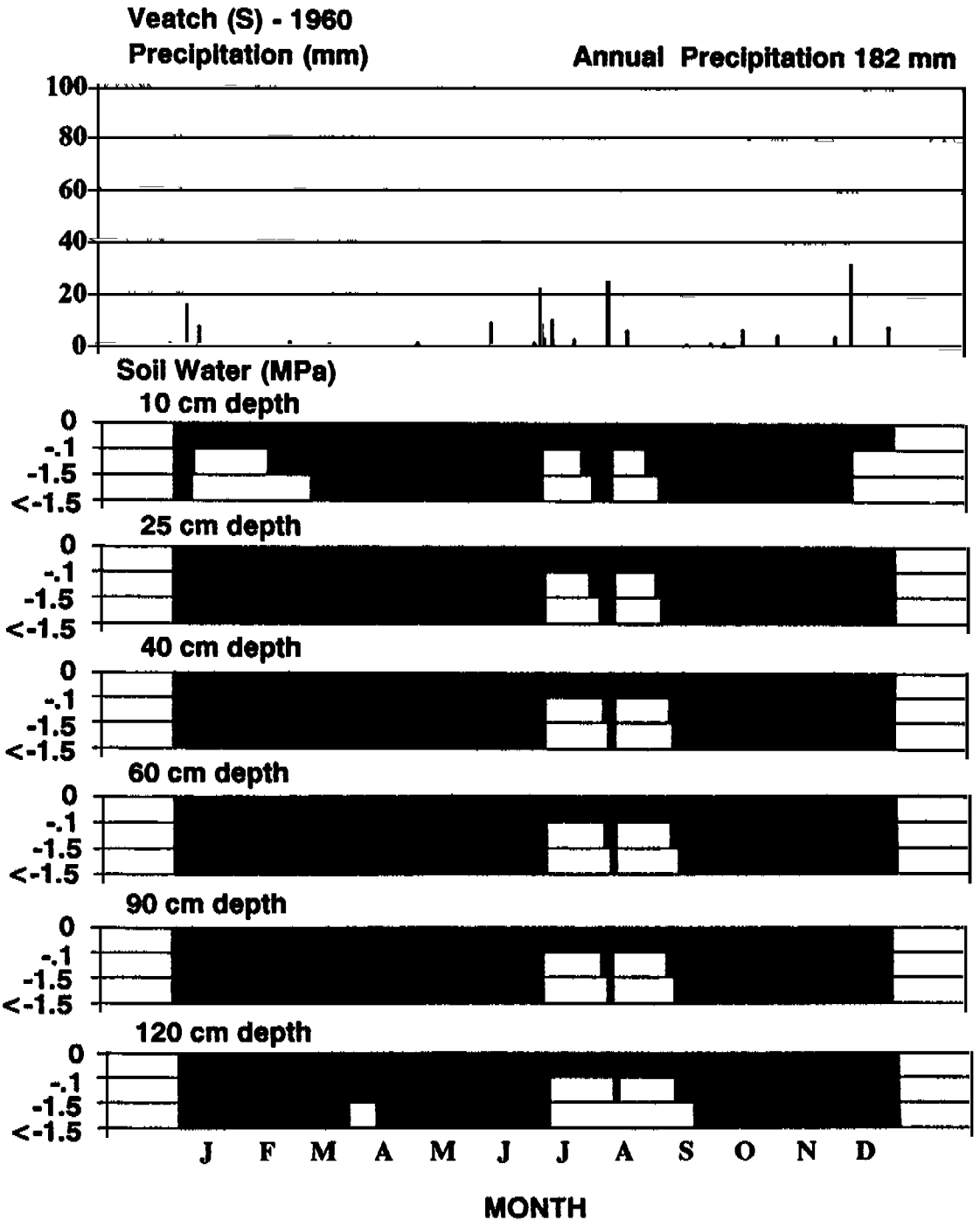


Figure 370. Annual (182 mm) and daily (mm) precipitation for 1960 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1960 at the Veatch (S) site.

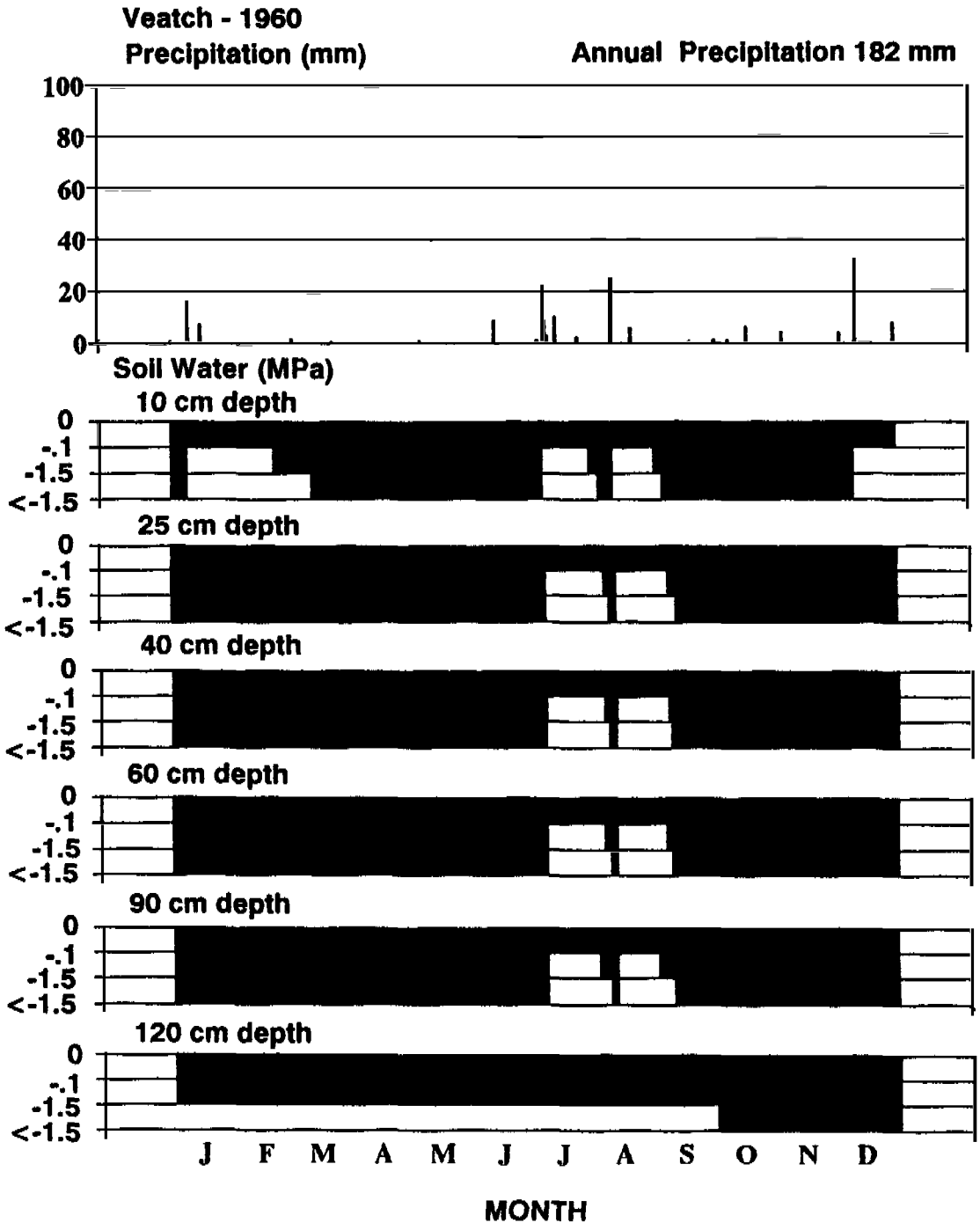


Figure 371. Annual (182 mm) and daily (mm) precipitation for 1960 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1960 at the Veatch site.

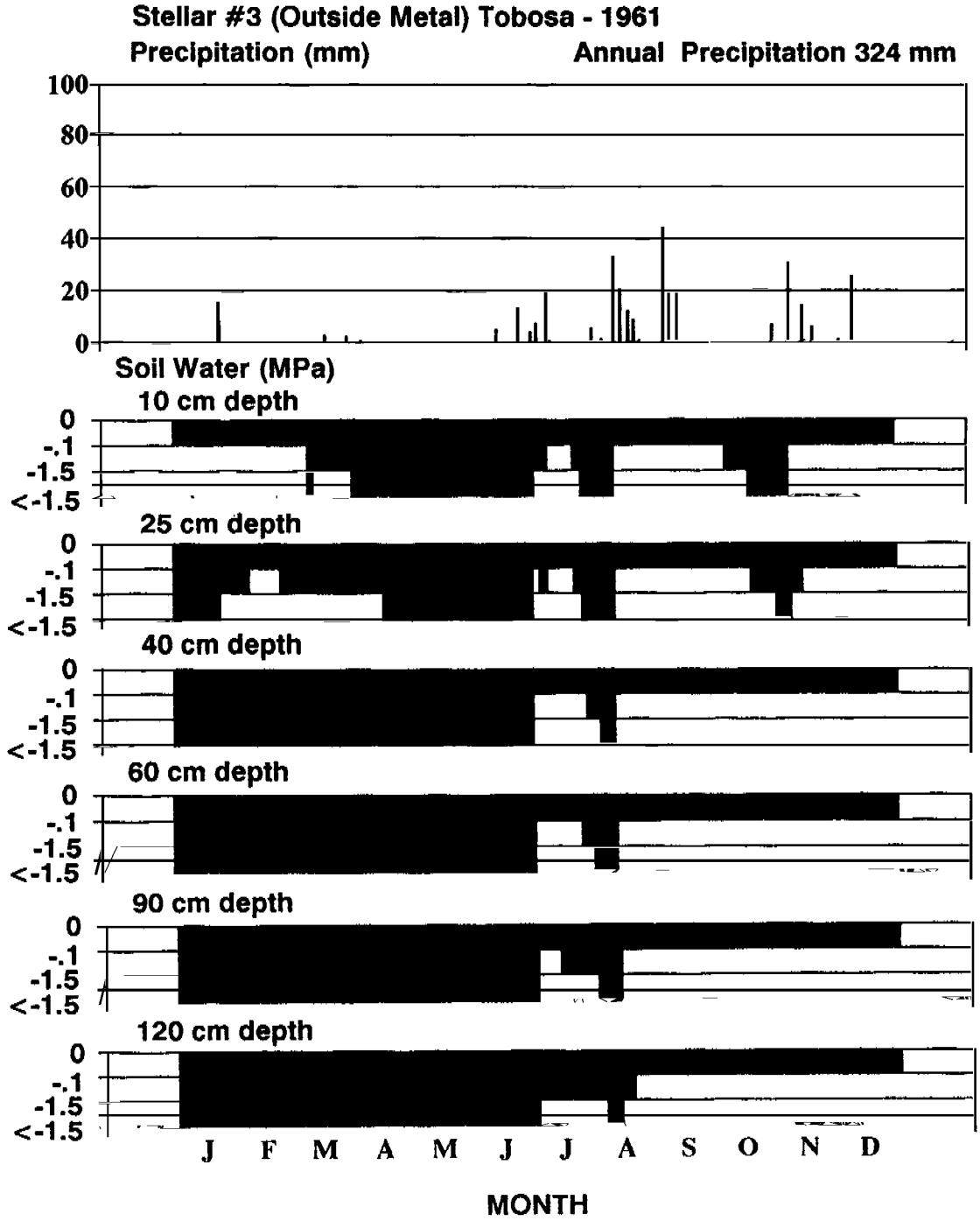


Figure 372. Annual (324 mm) and daily (mm) precipitation for 1961 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1961 at the Stellar #3 site dominated by tobosa.

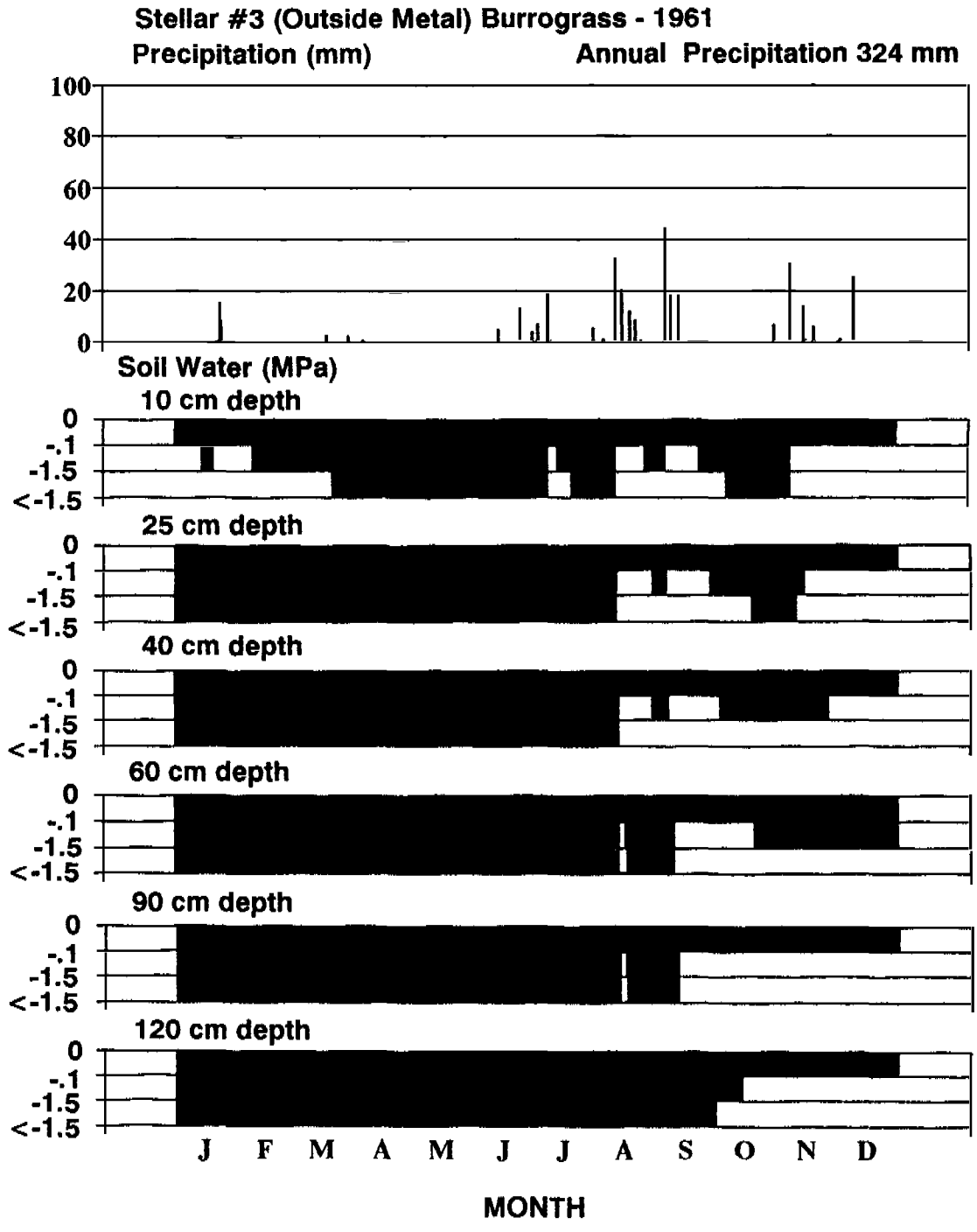


Figure 373. Annual (324 mm) and daily (mm) precipitation for 1961 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1961 at the Stellar #3 site dominated by burrograss.

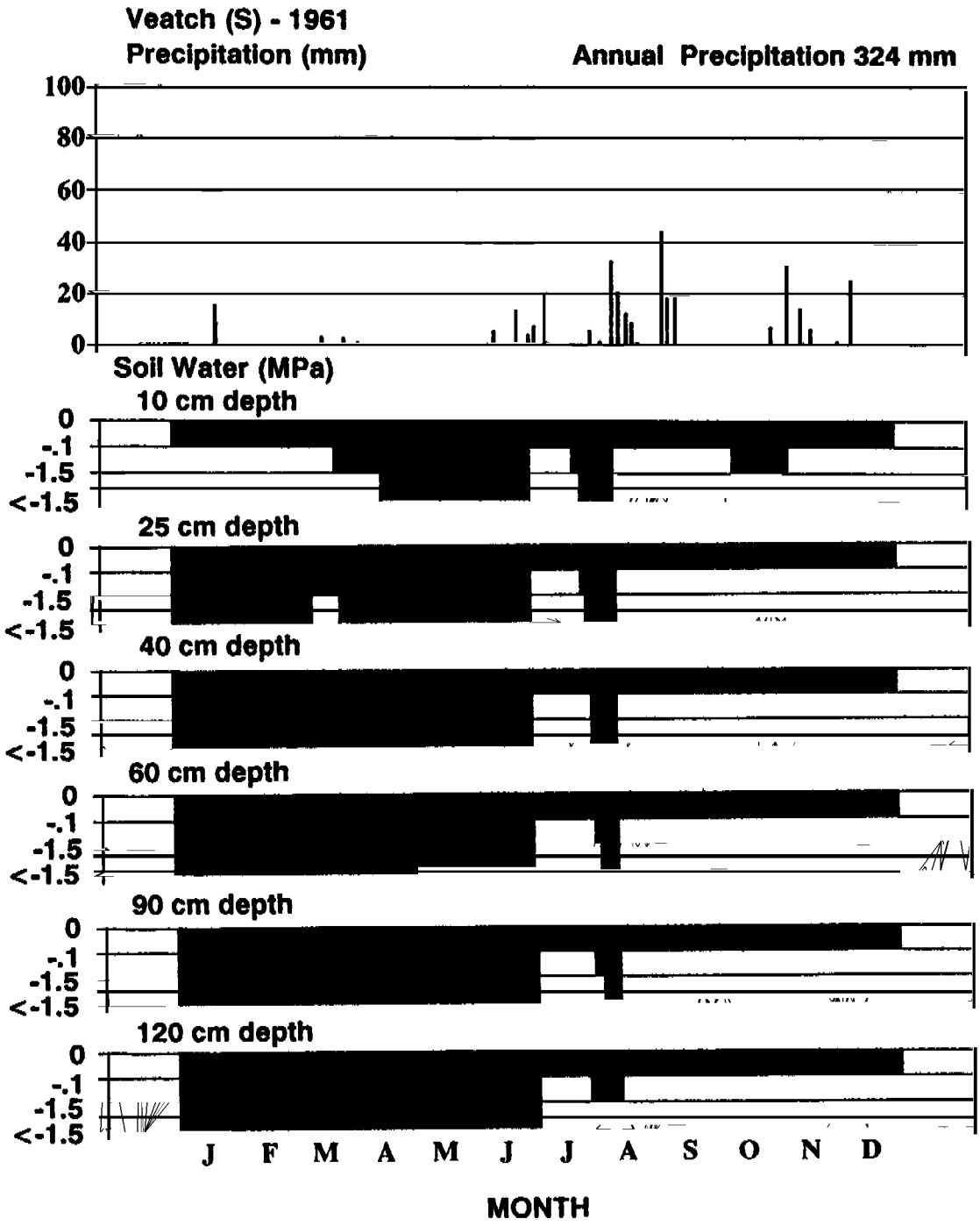


Figure 374. Annual (324 mm) and daily (mm) precipitation for 1961 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1961 at the Veatch (S) site.

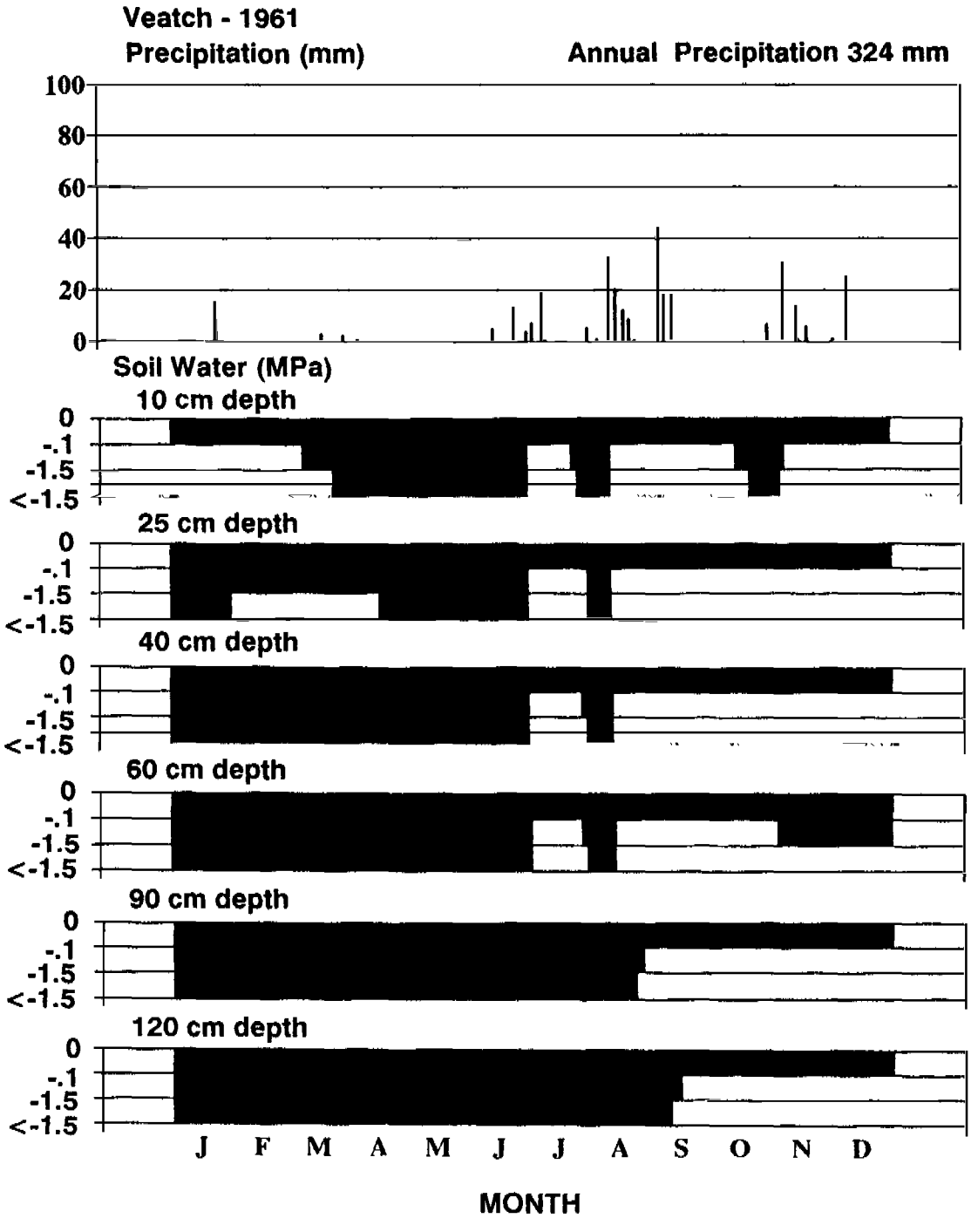


Figure 375. Annual (324 mm) and daily (mm) precipitation for 1961 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1961 at the Veatch site.

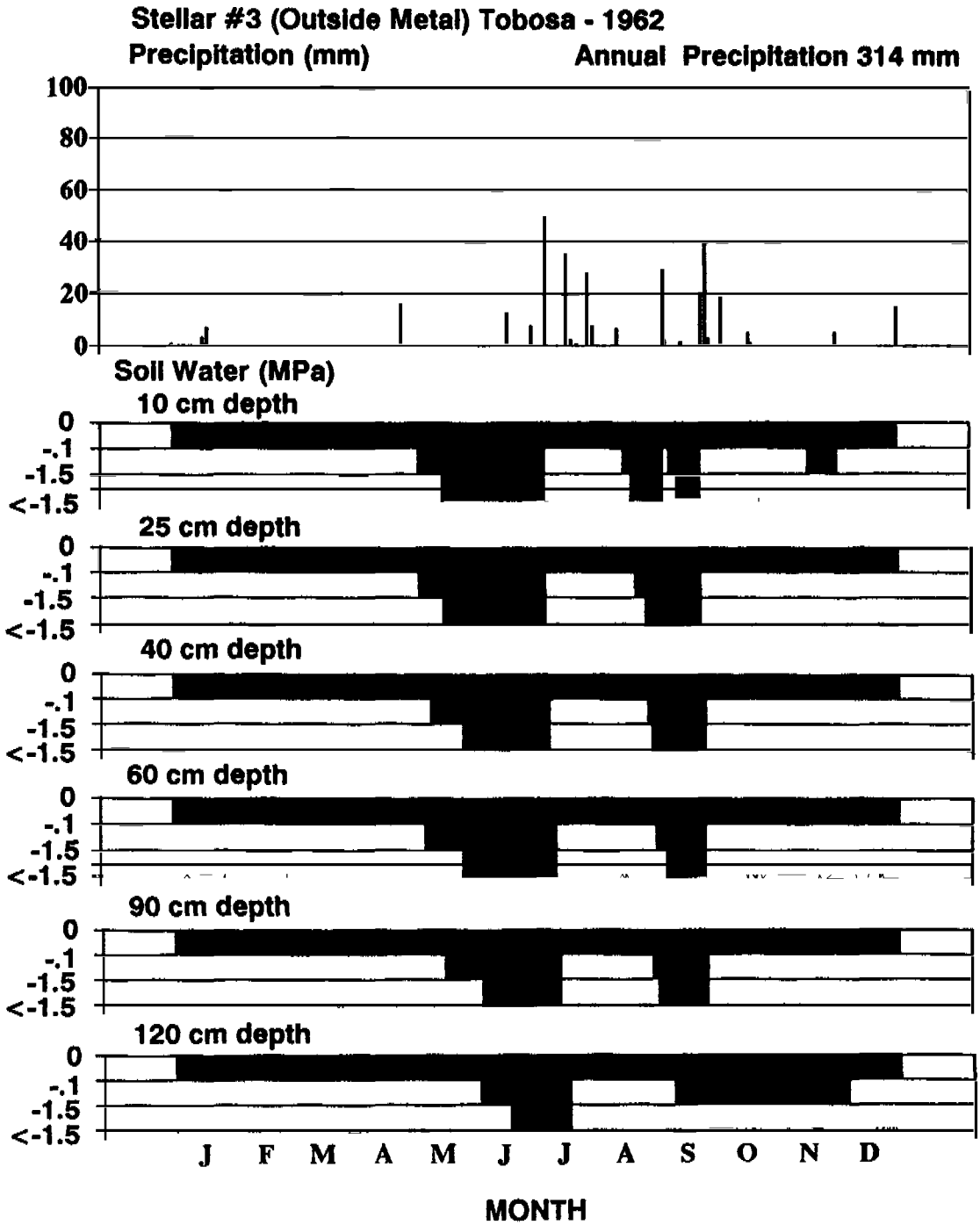


Figure 376. Annual (314 mm) and daily (mm) precipitation for 1962 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1962 at the Stellar #3 site dominated by tobosa.

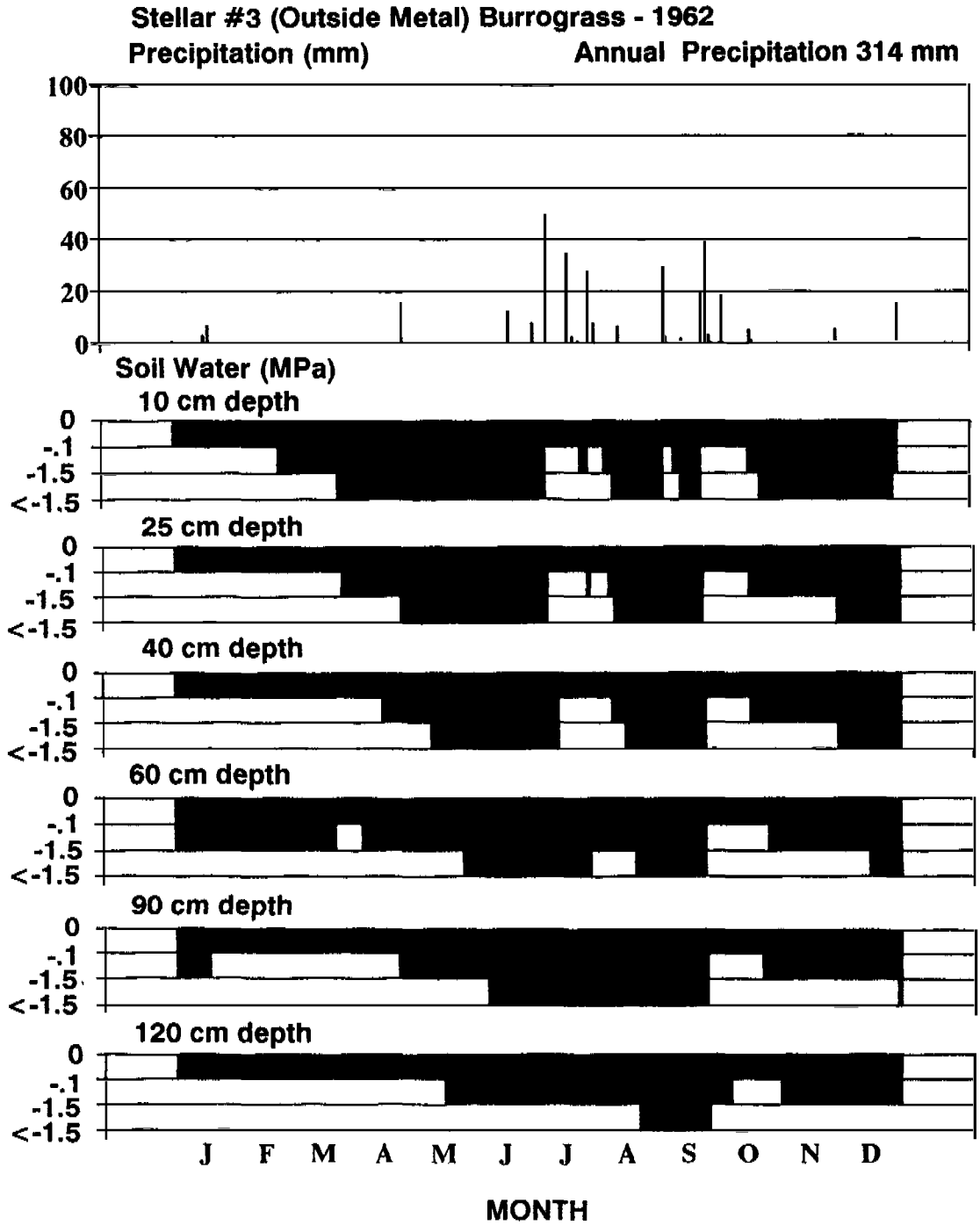


Figure 377. Annual (314 mm) and daily (mm) precipitation for 1962 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1962 at the Stellar #3 site dominated by burrograss.

and September 27-December 31 (fig. 378); and Veatch had soil water >-1.5 MPa at 25 cm January 1-May 27, July 10-August 28, and September 25-December 31, 1962 (fig. 379).

The 1963 precipitation at Stuart Rain Gauge was 252 mm (figs. 380-383). The Stellar #3 tobosa area had soil water >-1.5 MPa at 25 cm September 24, 1962-May 7, 1963 (figs. 376, 380); July 6-August 6; and August 22-October 9, 1963. Tobosa production in 1963 was 2230 kg/ha (s.e.=99 kg/ha). The soil water at 25 cm was >-1.5 MPa at Stellar #3 burrograss July 6-21 and August 23-September 2 (fig. 381); at Veatch (S) January 1-May 8, 1963 and July 7-December 31 (fig. 382); and at Veatch January 1-May 25, July 7-August 11, and August 23-December 7, 1963 (fig. 383).

Annual precipitation for 1964 was 173 mm (figs. 384-387). Stellar #3 dominated by tobosa had soil water >-1.5 MPa at the 25-cm depth September 10-December 31 (fig. 384). Annual yield of tobosa was 646 kg/ha (s.e.=42 kg/ha). At the 25-cm depth, Stellar #3 dominated by burrograss had water >-1.5 MPa September 11-October 11 (fig. 385), Veatch (S) had water >-1.5 MPa for the entire year (fig. 386), and Veatch had soil water >-1.5 MPa August 15-December 31, 1964 (fig. 387).

The 1965 precipitation was 187 mm (figs. 388-391). The soil water for Stellar #3 dominated by tobosa at 25 cm was >-1.5 MPa January 1-May 10 (fig. 388) and September 6-November 9. Tobosa yields were 569 kg/ha (s.e.=43 kg/ha). At 25 cm, Stellar #3 dominated by burrograss had soil water >-1.5 MPa September 18-30 (fig. 389), Veatch (S) had water >-1.5 MPa January 1-August 8 and September 7-December 31 (fig. 390), and Veatch had soil water >-1.5 MPa January 1-May 6 and September 7-December 31, 1965 (fig. 391).

Annual precipitation for 1966 was 142 mm (figs. 392-395). Stellar #3 tobosa had water >-1.5 MPa at the 25-cm depth January 18-April 22 and August 3-September 30 (fig. 392). Tobosa yields were 4061 kg/ha (s.e.=114 kg/ha). At the 25-cm depth, Stellar #3 burrograss had water >-1.5 MPa August 3-28 and September 6-12 (fig. 393); Veatch (S) had soil water >-1.5 MPa January 1-May 23, July 1-14, August 3-21, and September 6-28 (fig. 394); and Veatch January 1-May 16, August 3-29, and September 6-21, 1966 (fig. 395).

The 1967 precipitation at Stuart Rain Gauge was 300 mm (figs. 396-399). The soil water at 25 cm was >-1.5 MPa at Stellar #3 tobosa August 16-December 31 (fig. 396); at Stellar #3 burrograss August 16-September 13 and September 17-October 16 (fig. 397); at Veatch (S) June 22-December 31 (fig. 398); and Veatch June 29-July 26 and August 17-December 31 (fig. 399).

Annual precipitation for 1968 was 334 mm (figs. 400-403). The water at the 25-cm soil depth was >-1.5 MPa at Stellar #3 dominated by tobosa January 1-May 20 and August 2-31 (fig. 400); Stellar #3 burrograss February 8-April 6 and August 2-19 (fig. 401); at Veatch (S) January 1-May 20 and July 6-December 31 (fig. 402); and Veatch January 1-May 24 and July 6-September 23, 1968 (fig. 403).

The annual precipitation for 1969 was 234 mm (figs. 404-407). Soil water at 25 cm was >-1.5 MPa at Stellar #3 tobosa September 2-October 6 and October 21-December 31 (fig. 404); Stellar #3

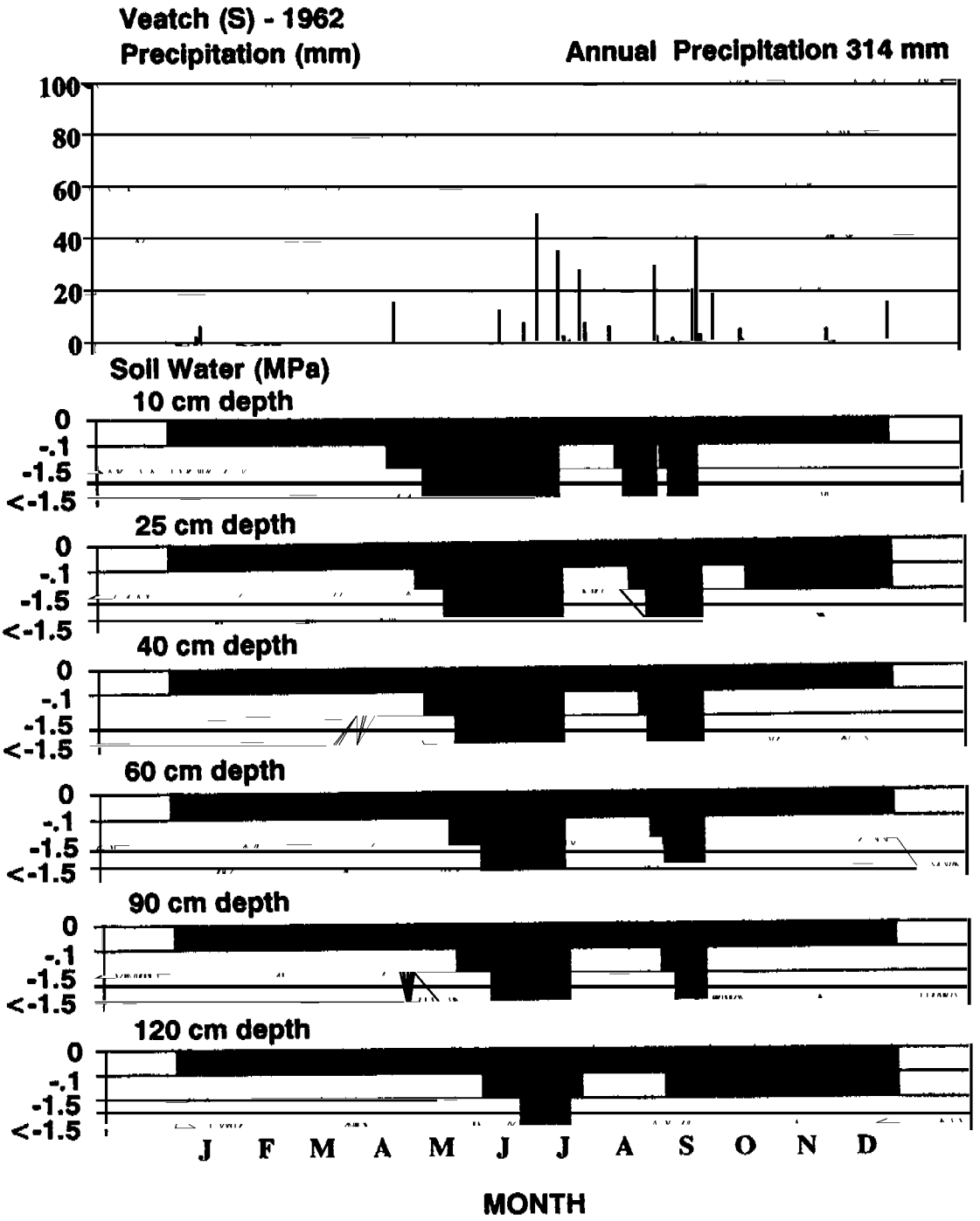


Figure 378. Annual (314 mm) and daily (mm) precipitation for 1962 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1962 at the Veatch (S) site.

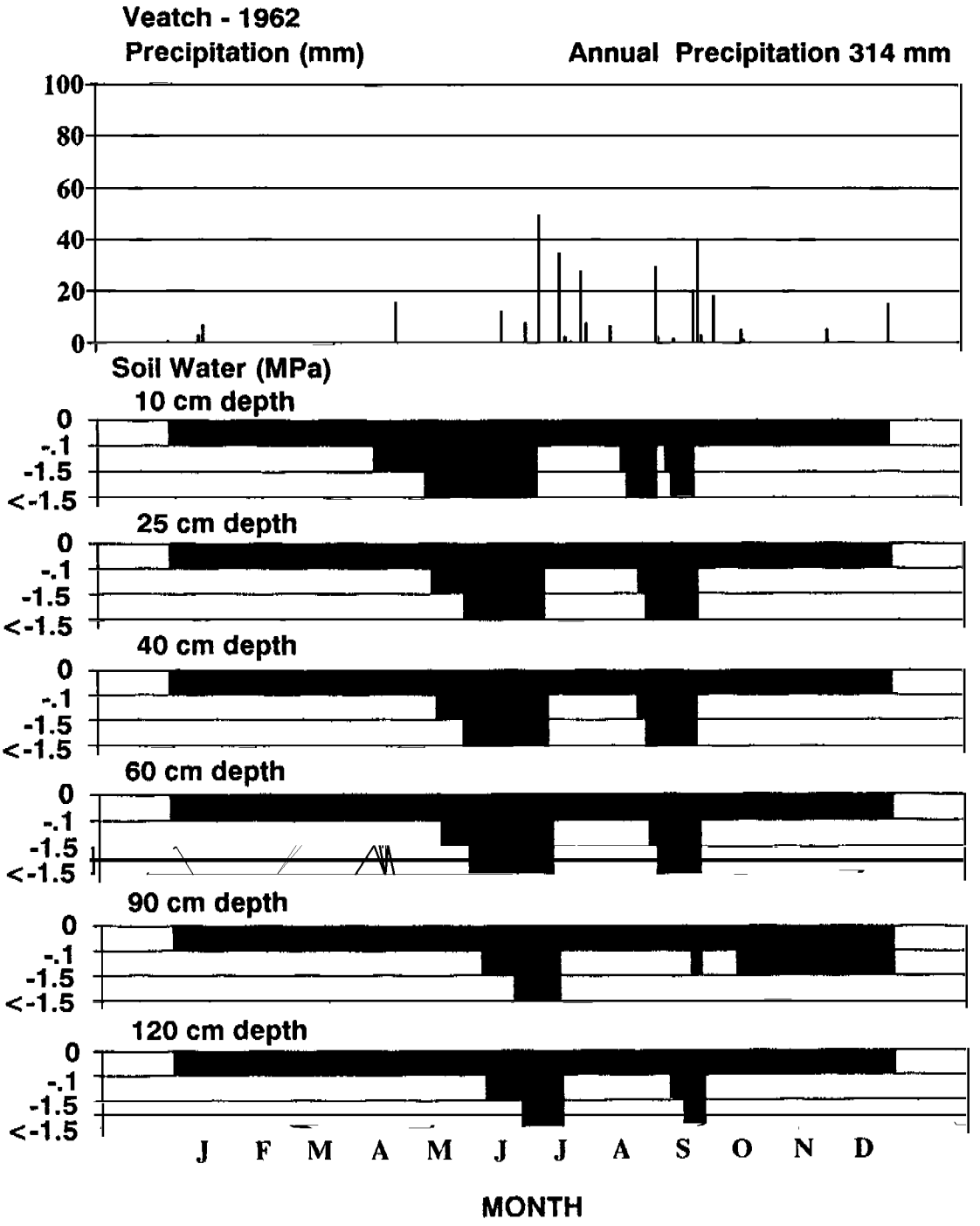


Figure 379. Annual (314 mm) and daily (mm) precipitation for 1962 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1962 at the Veatch site.

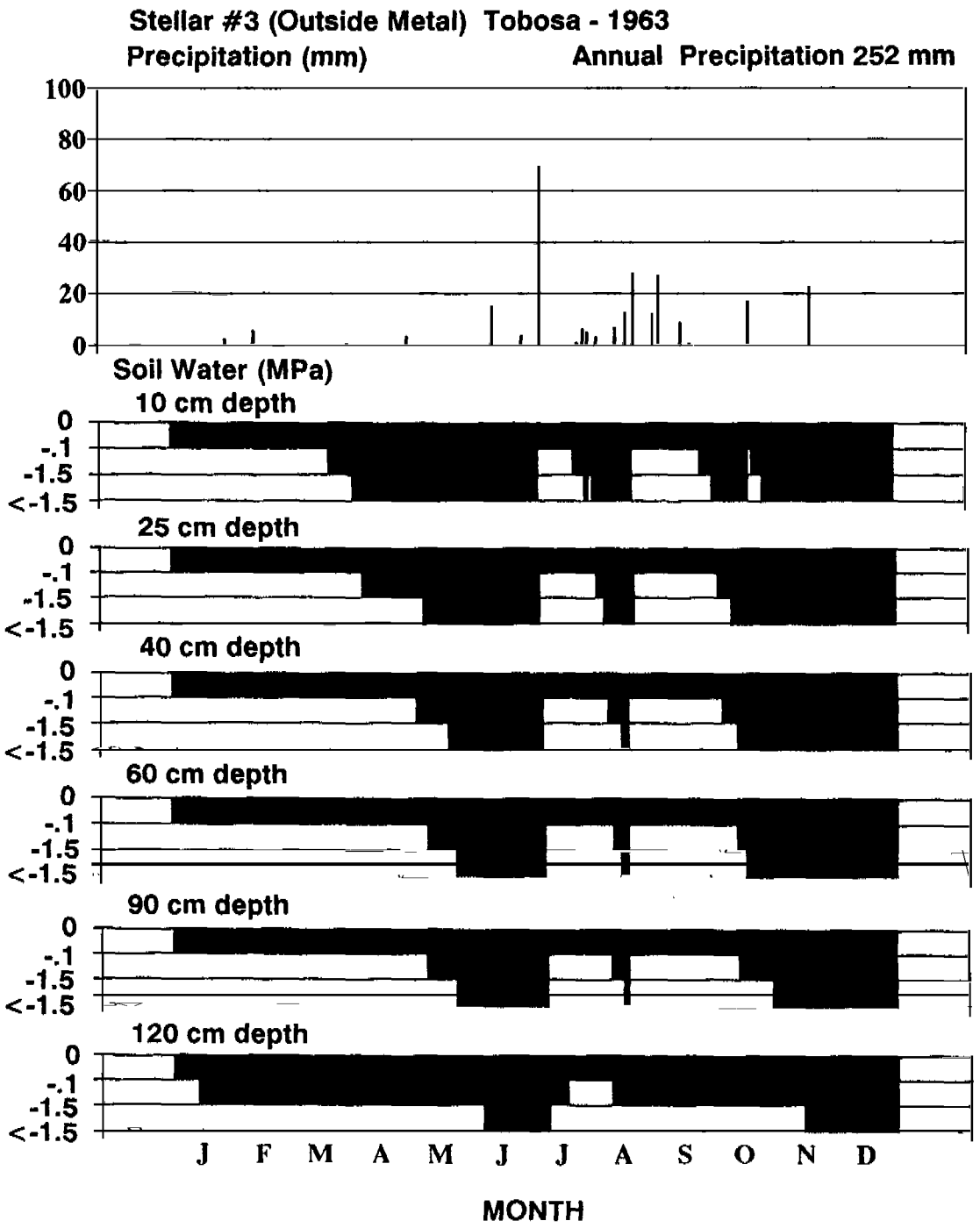


Figure 380. Annual (252 mm) and daily (mm) precipitation for 1963 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1963 at the Stellar #3 site dominated by tobosa.

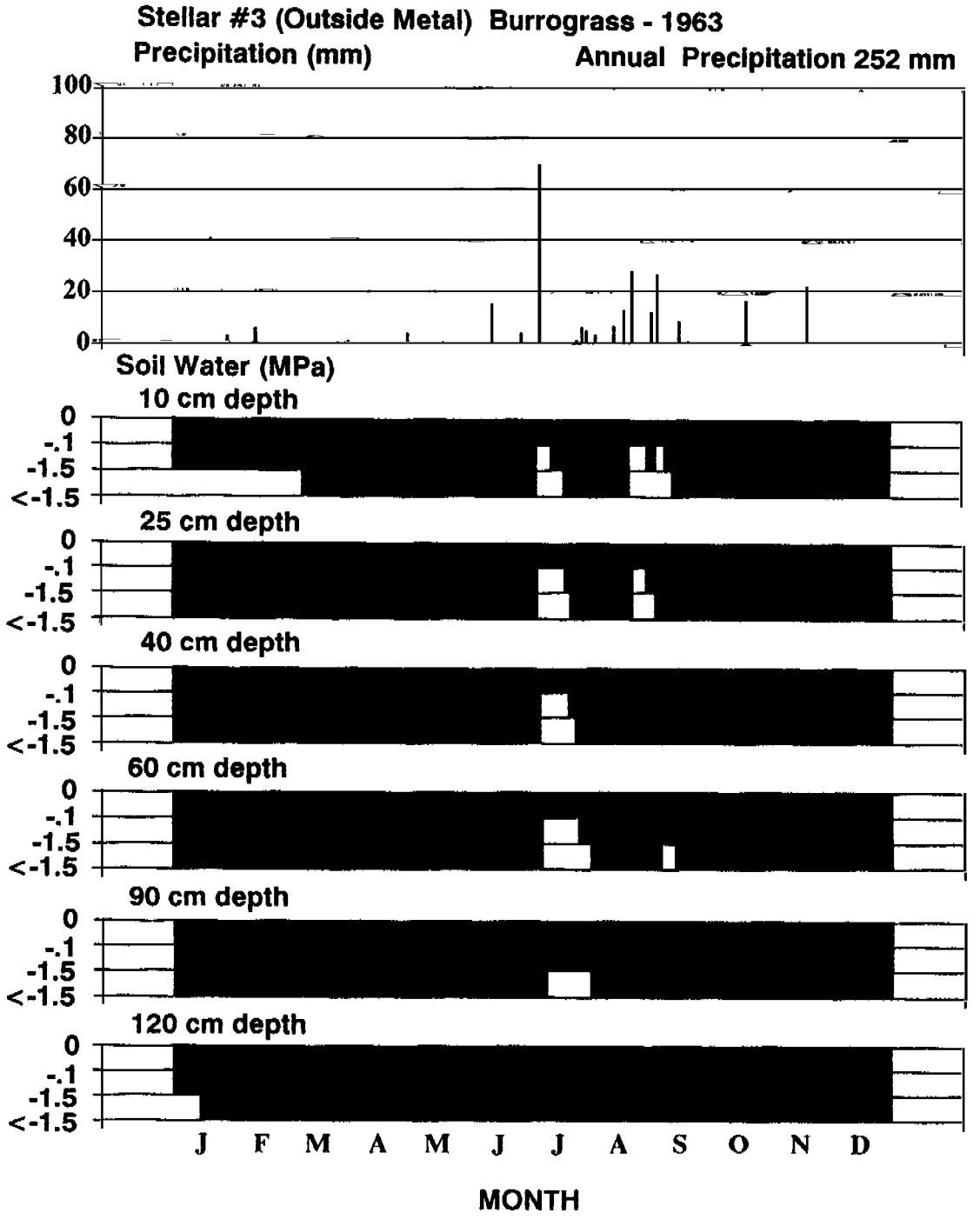


Figure 381. Annual (252 mm) and daily (mm) precipitation for 1963 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1963 at the Stellar #3 site dominated by burrograss.

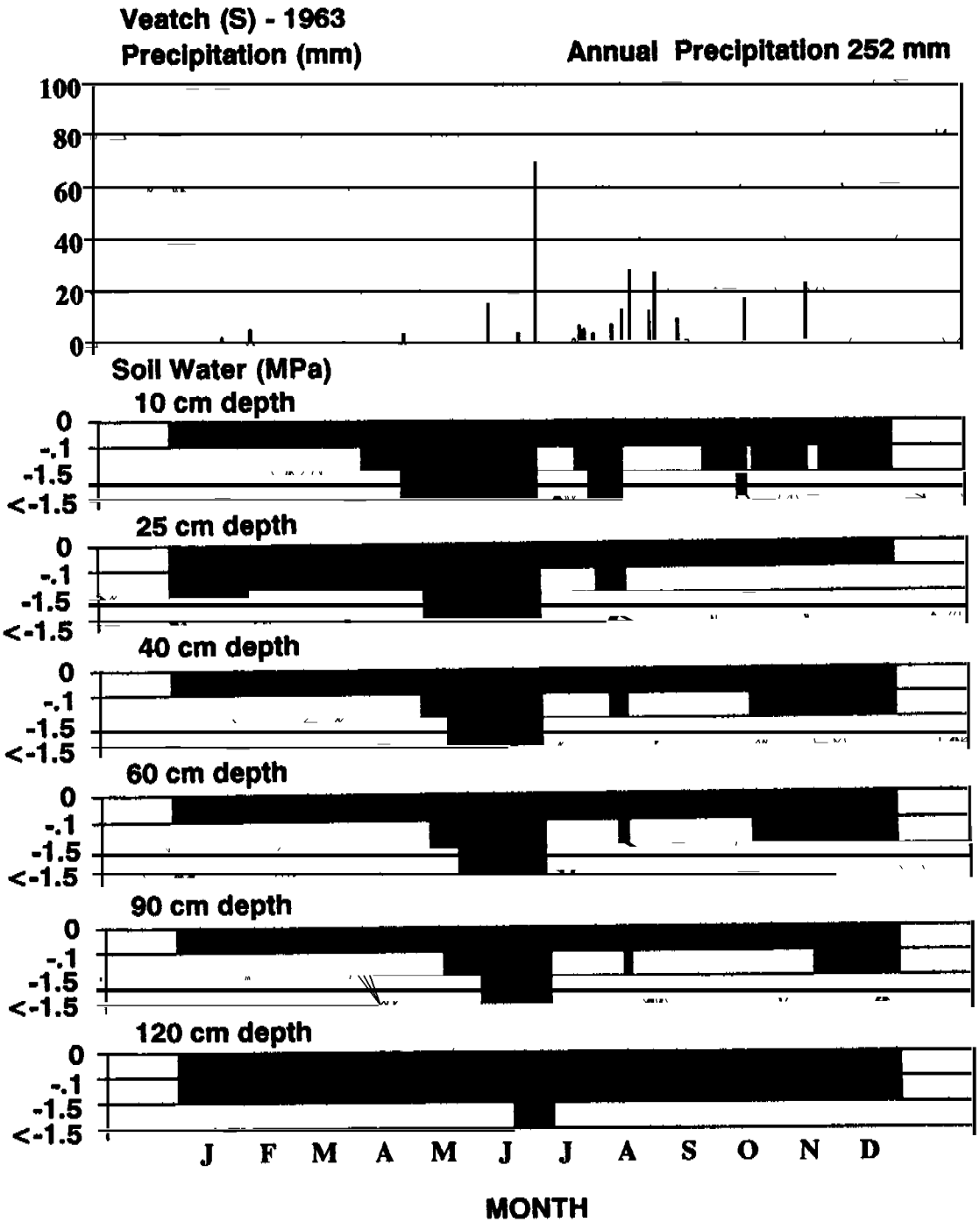


Figure 382. Annual (252 mm) and daily (mm) precipitation for 1963 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1963 at the Veatch (S) site.

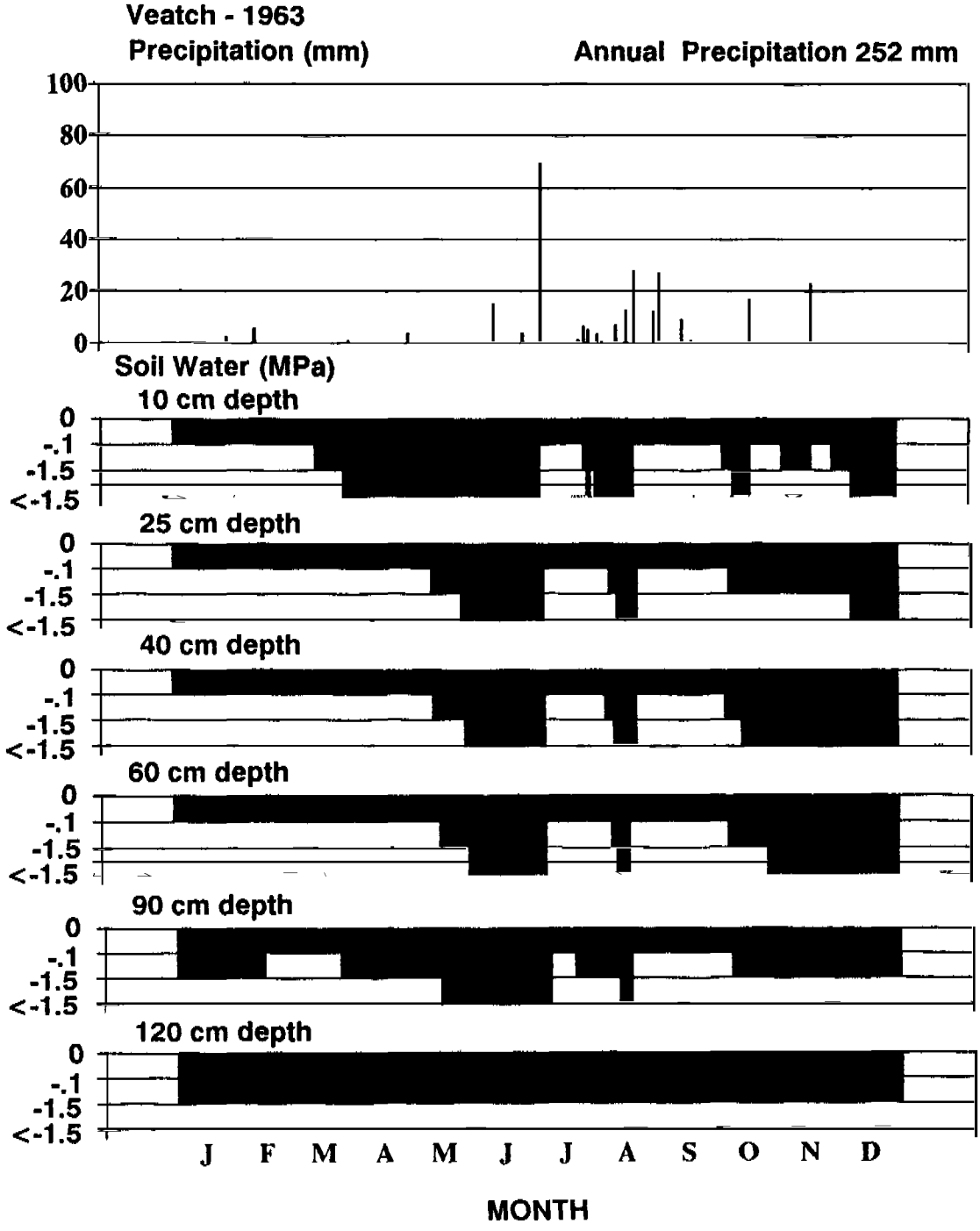


Figure 383. Annual (252 mm) and daily (mm) precipitation for 1963 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1963 at the Veatch site.

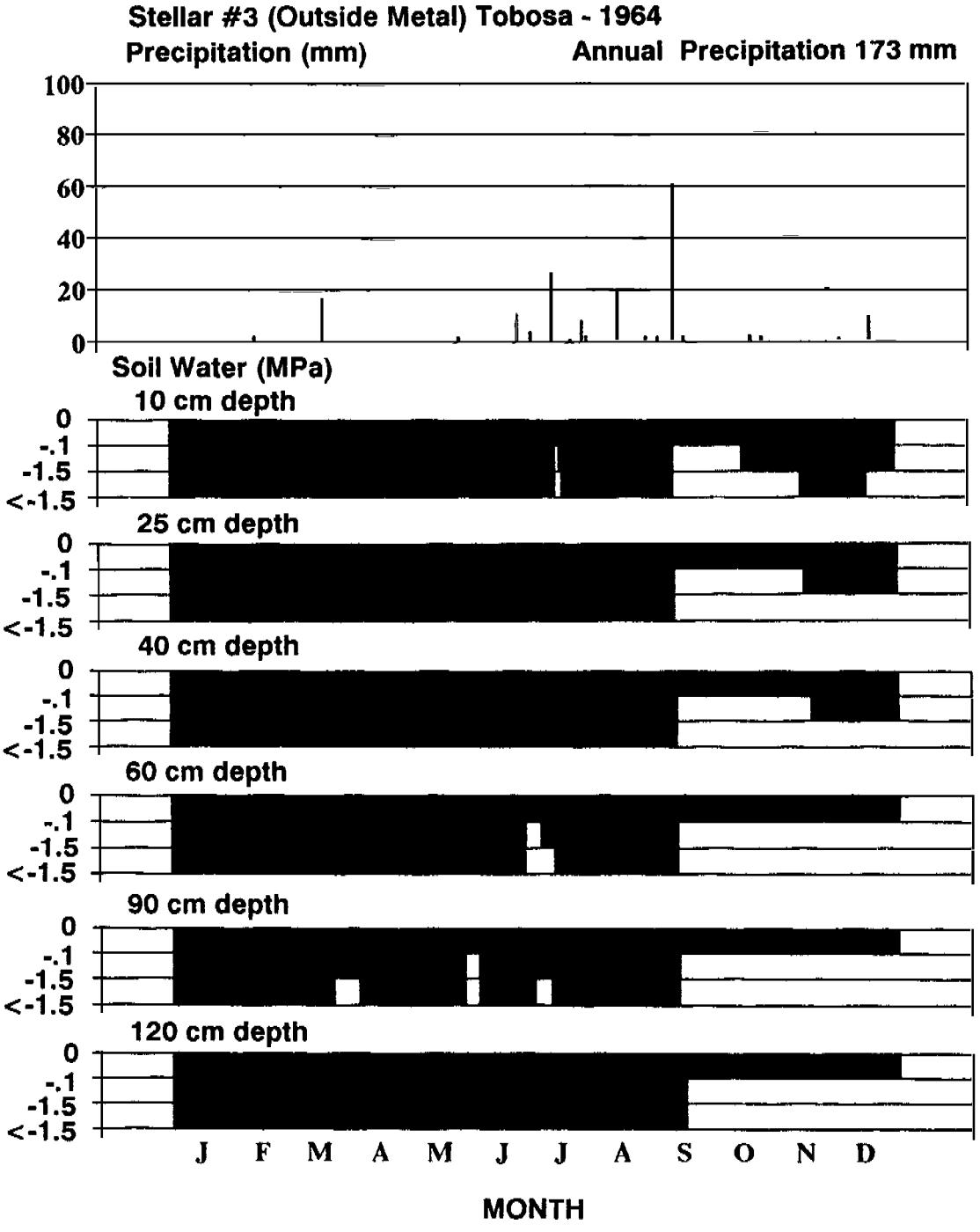


Figure 384. Annual (173 mm) and daily (mm) precipitation for 1964 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1964 at the Stellar #3 site dominated by tobosa.

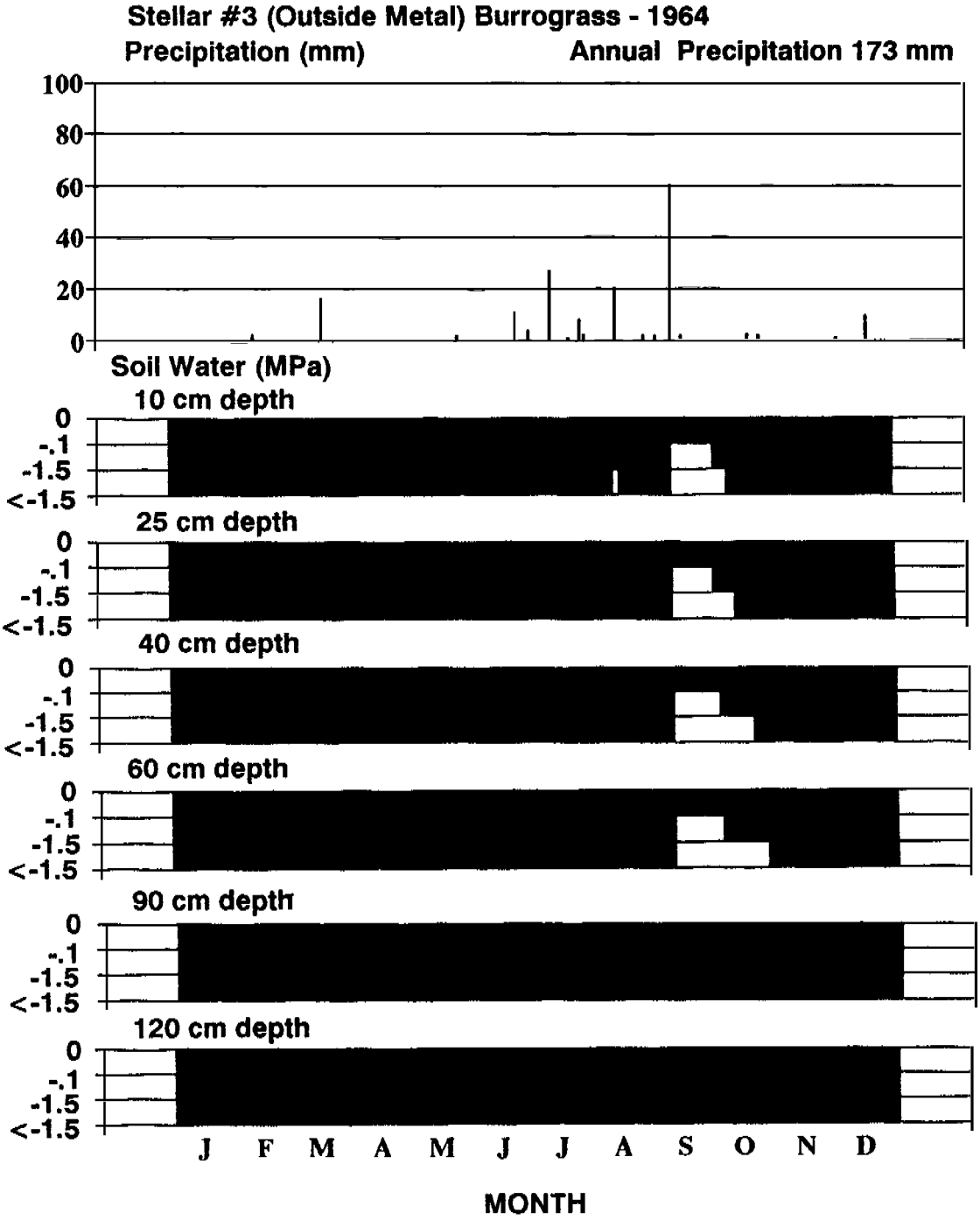


Figure 385. Annual (173 mm) and daily (mm) precipitation for 1964 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1964 at the Stellar #3 site dominated by burrograss.

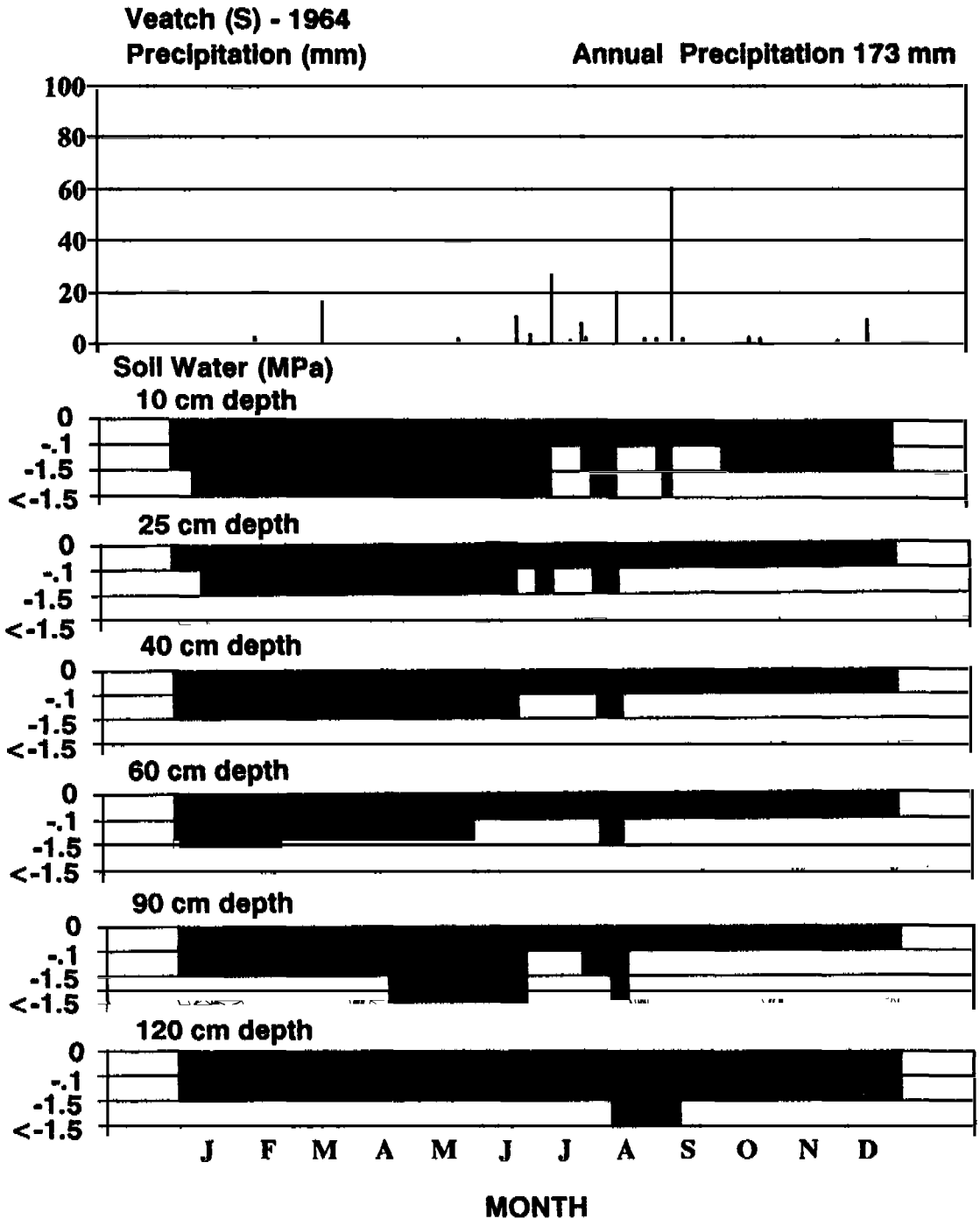


Figure 386. Annual (173 mm) and daily (mm) precipitation for 1964 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1964 at the Veatch (S) site.

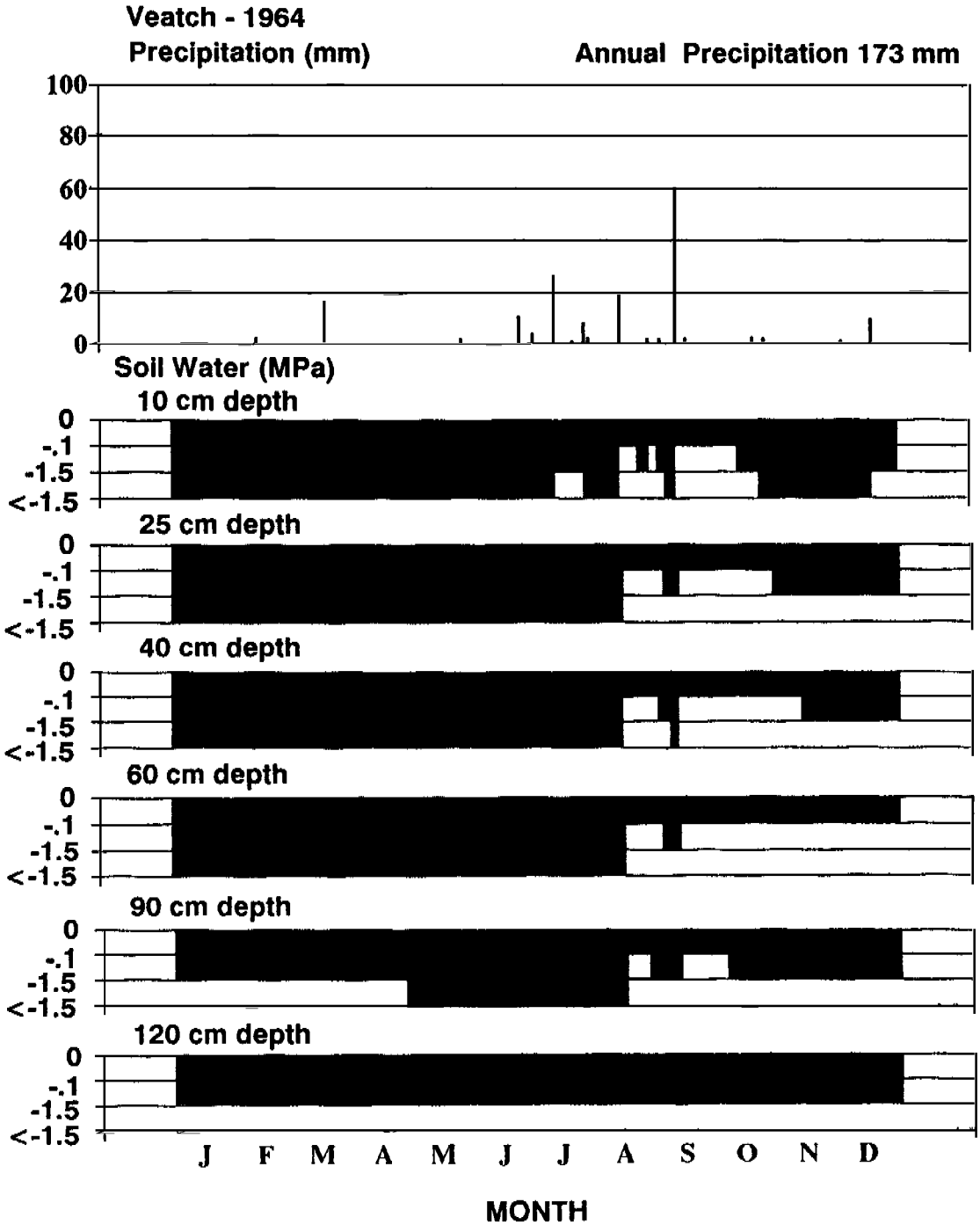


Figure 387. Annual (173 mm) and daily (mm) precipitation for 1964 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1964 at the Veatch site.

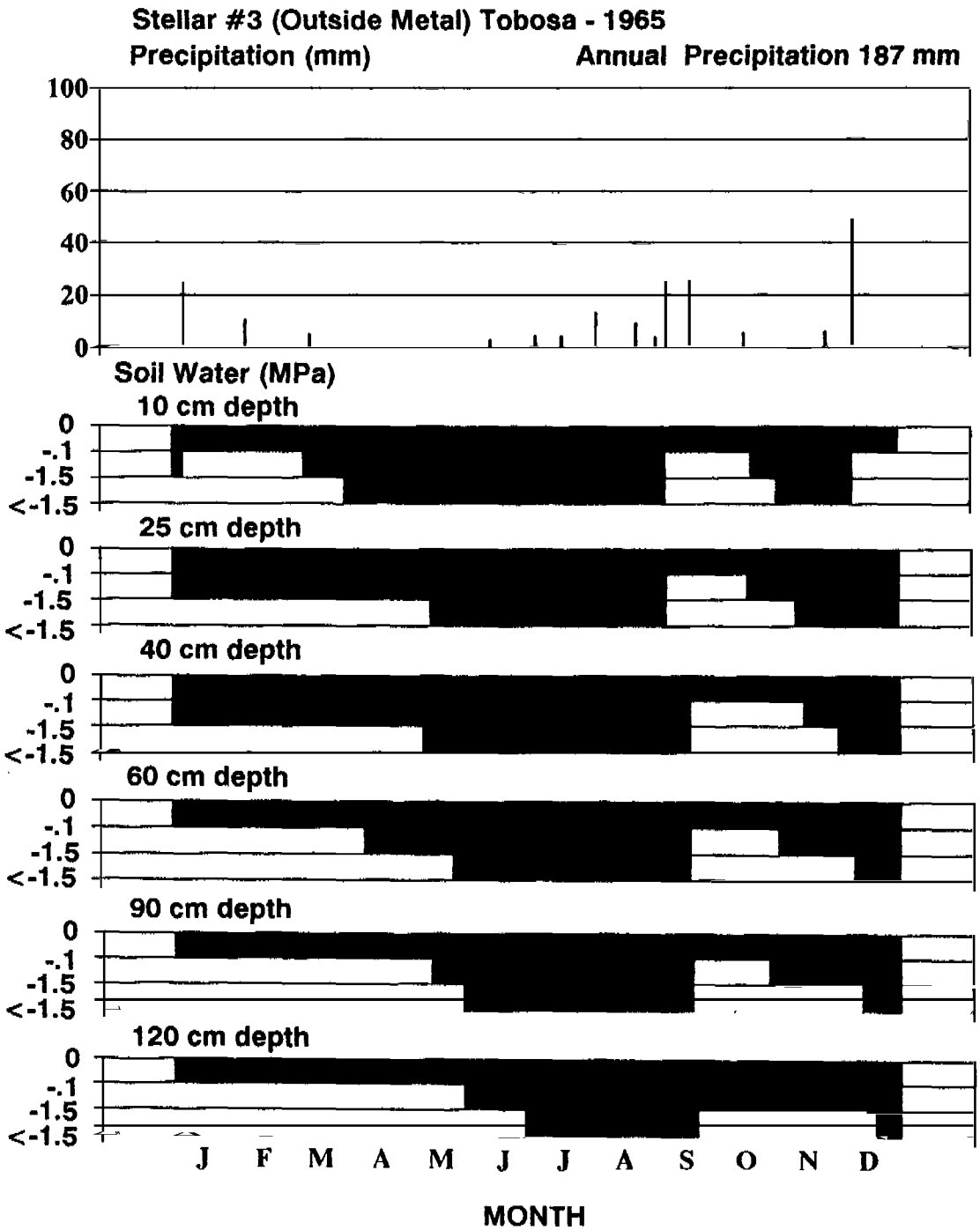


Figure 388. Annual (187 mm) and daily (mm) precipitation for 1965 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1965 at the Stellar #3 site dominated by tobosa.

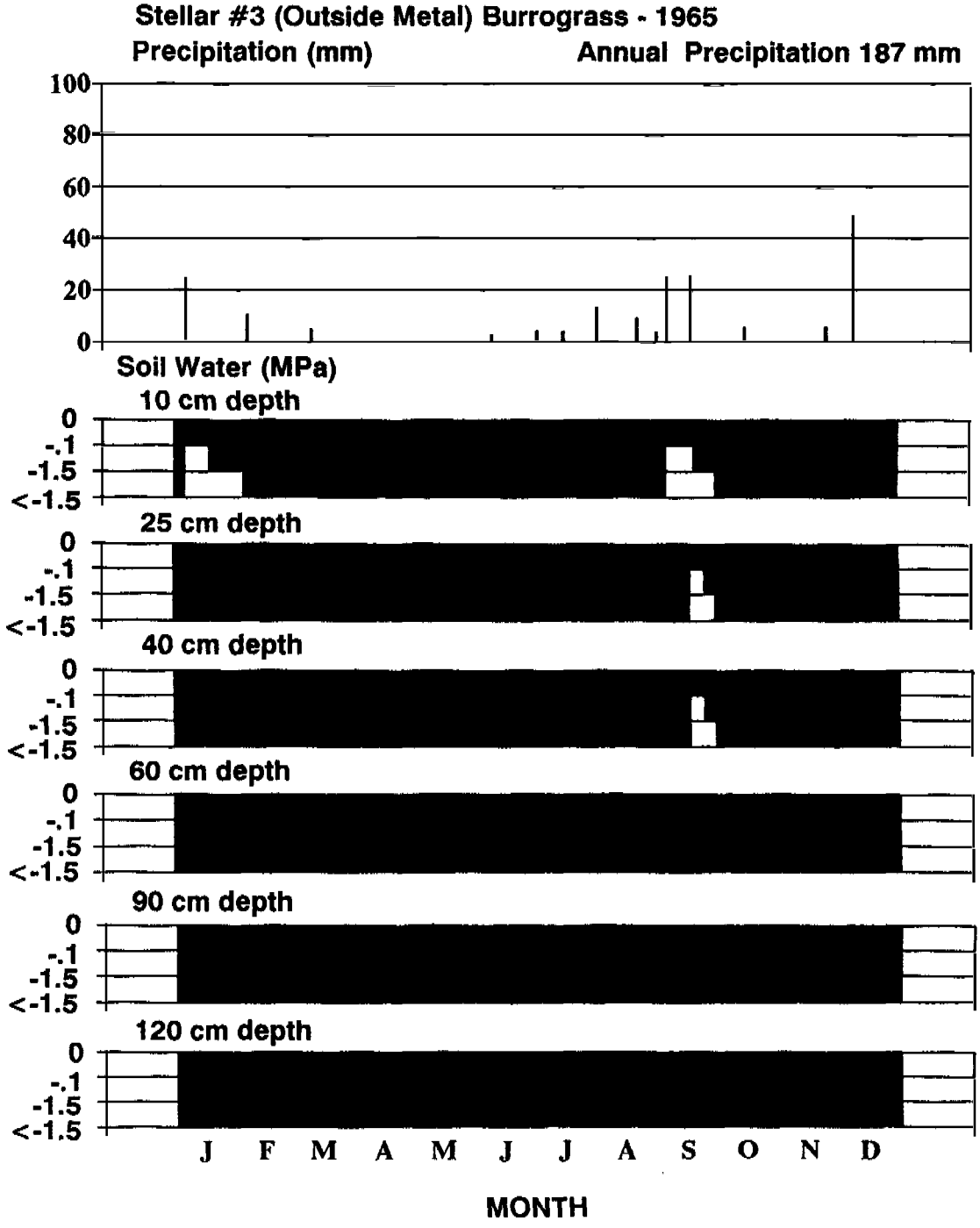


Figure 389. Annual (187 mm) and daily (mm) precipitation for 1965 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1965 at the Stellar #3 site dominated by burrograss.

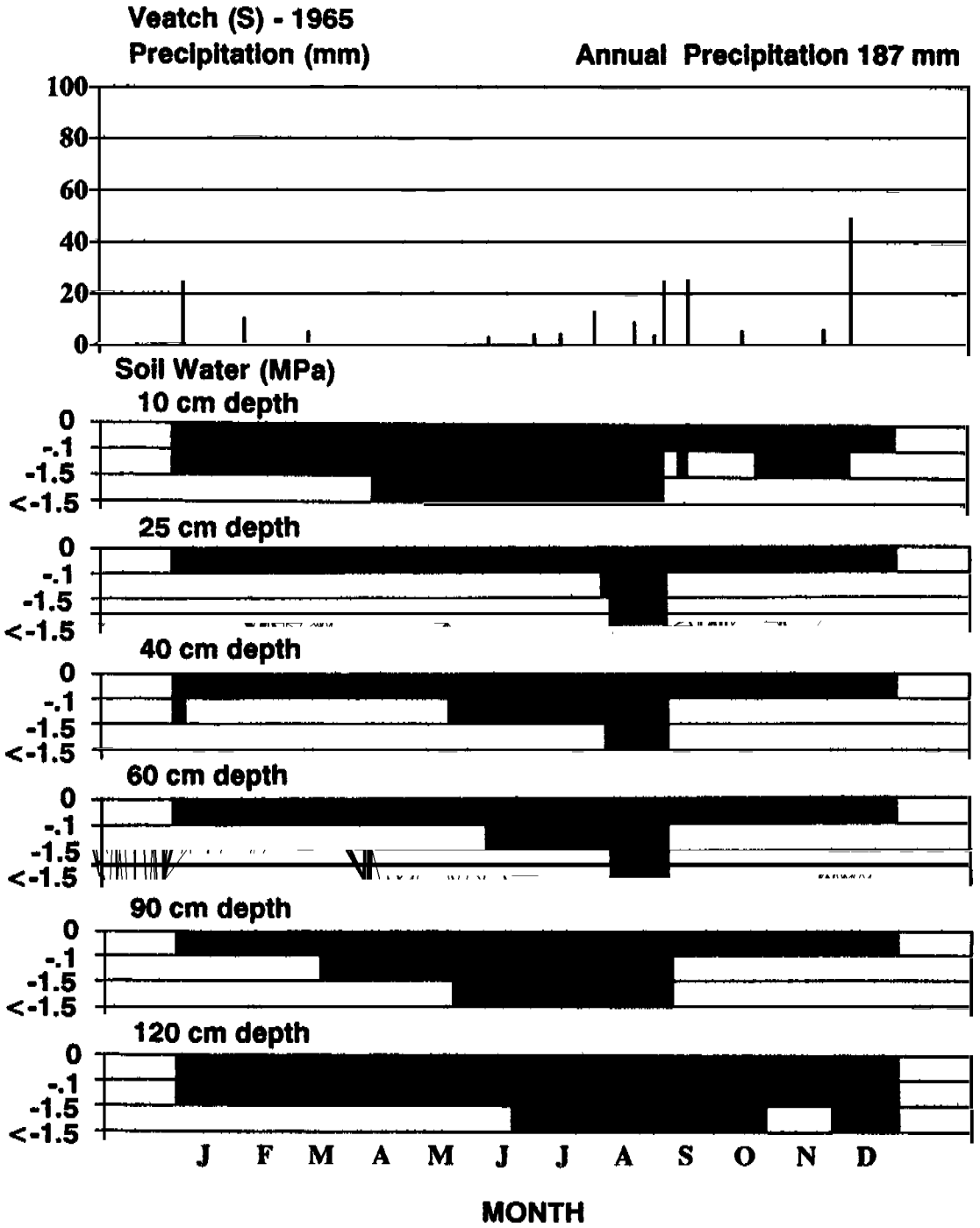


Figure 390. Annual (187 mm) and daily (mm) precipitation for 1965 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90 and 120 cm for 1965 at the Veatch (S) site.

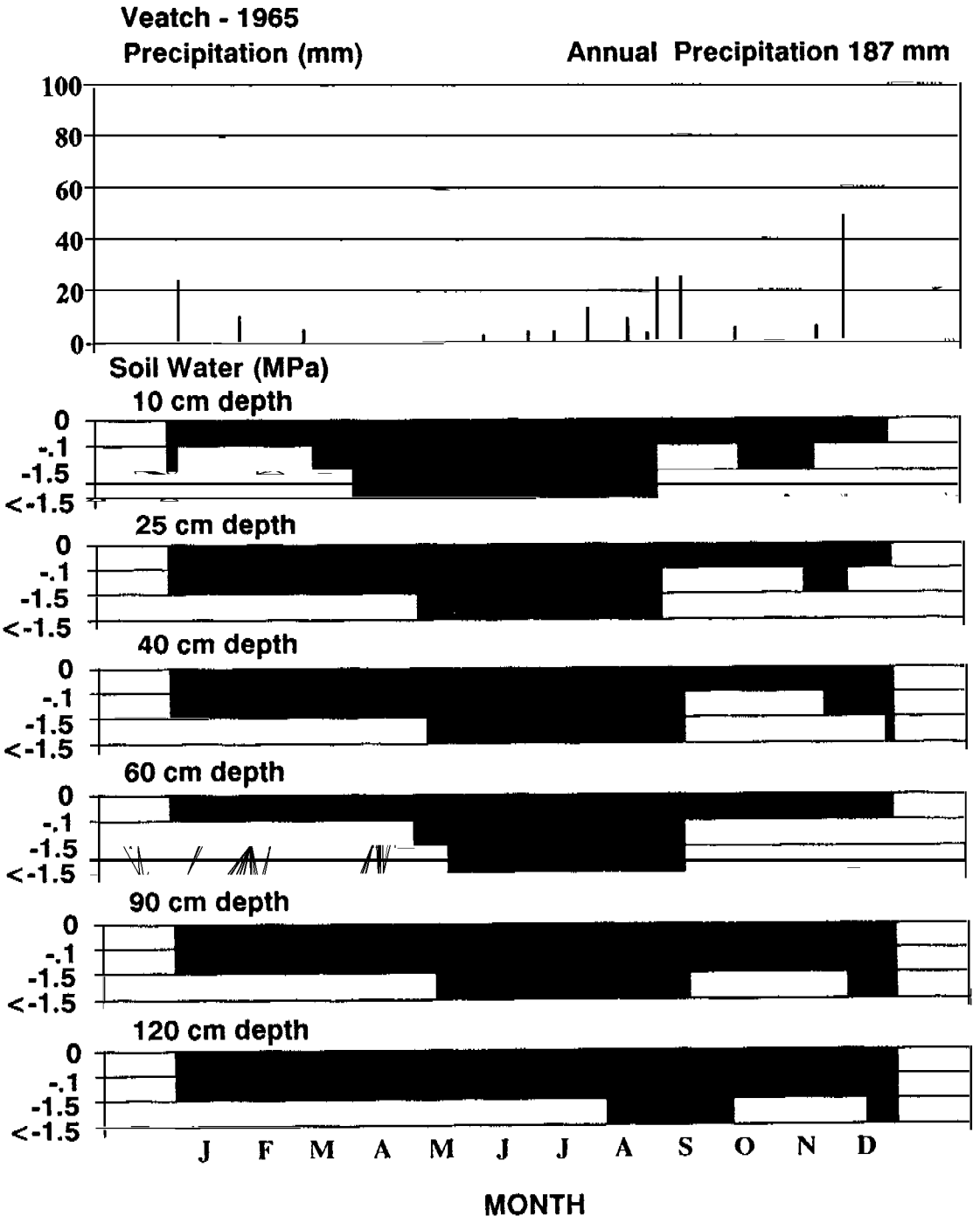


Figure 391. Annual (187 mm) and daily (mm) precipitation for 1965 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1965 at the Veatch site.

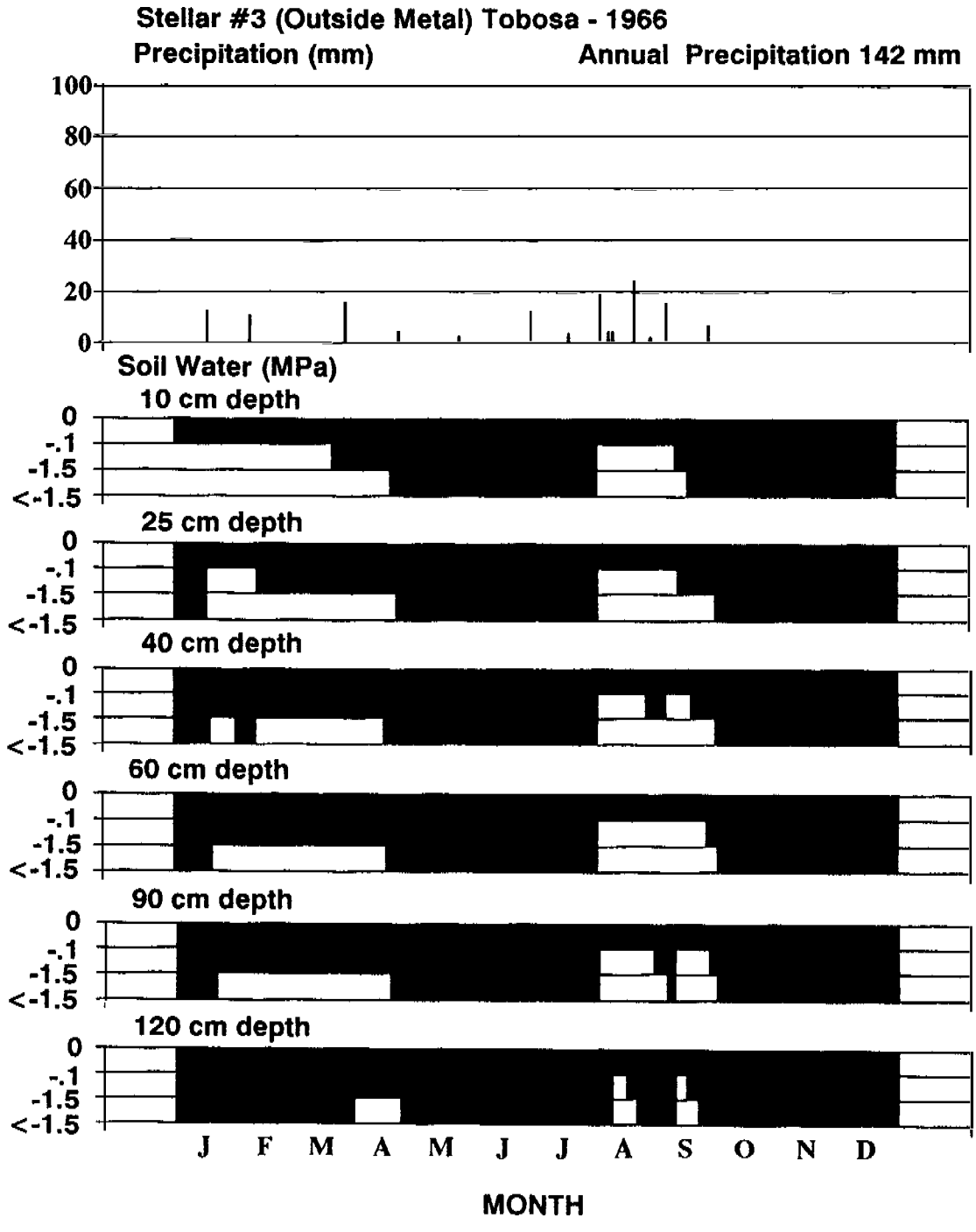


Figure 392. Annual (142 mm) and daily (mm) precipitation for 1966 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1966 at the Stellar #3 site dominated by tobosa.

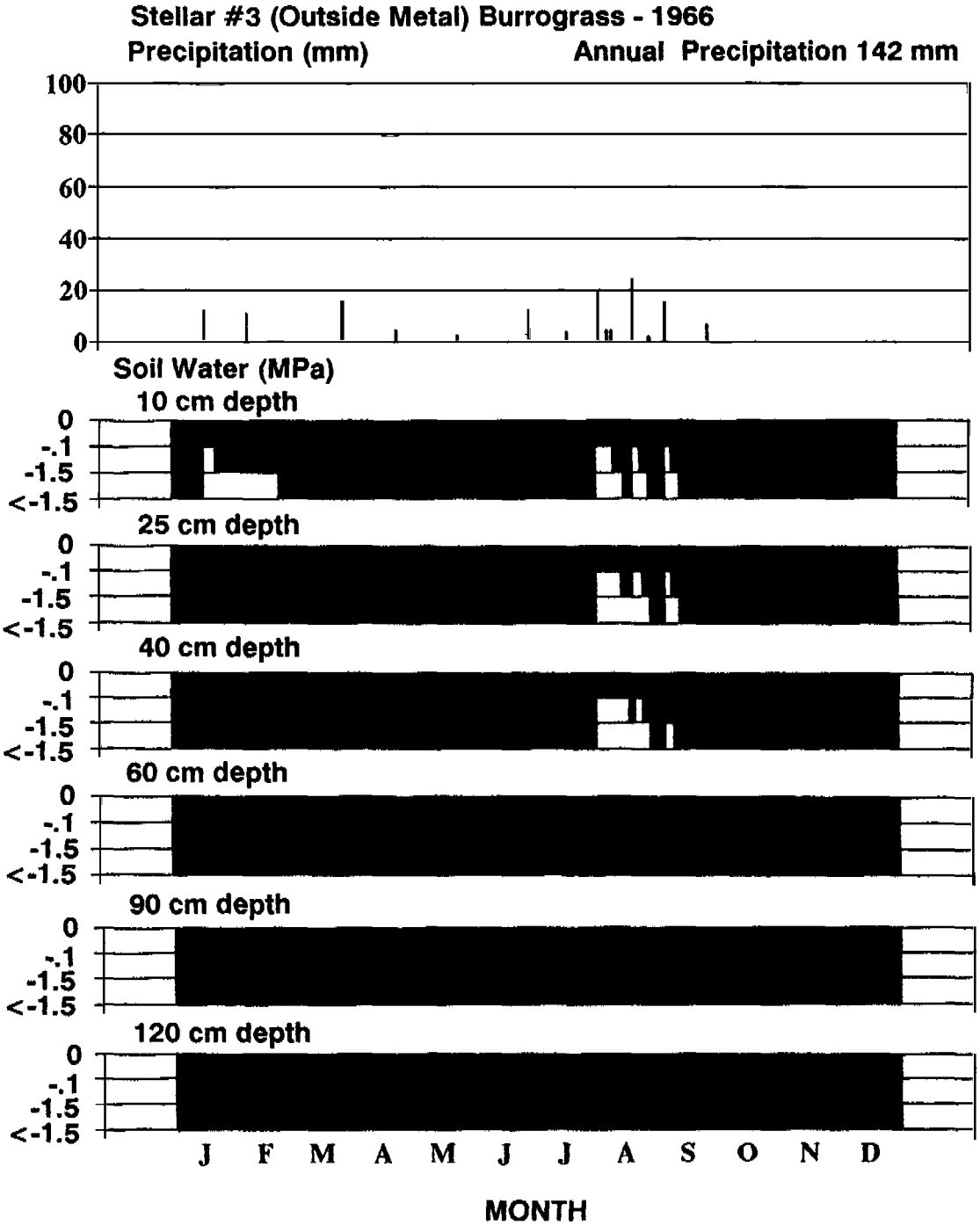


Figure 393. Annual (142 mm) and daily (mm) precipitation for 1966 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1966 at the Stellar #3 site dominated by burrograss.

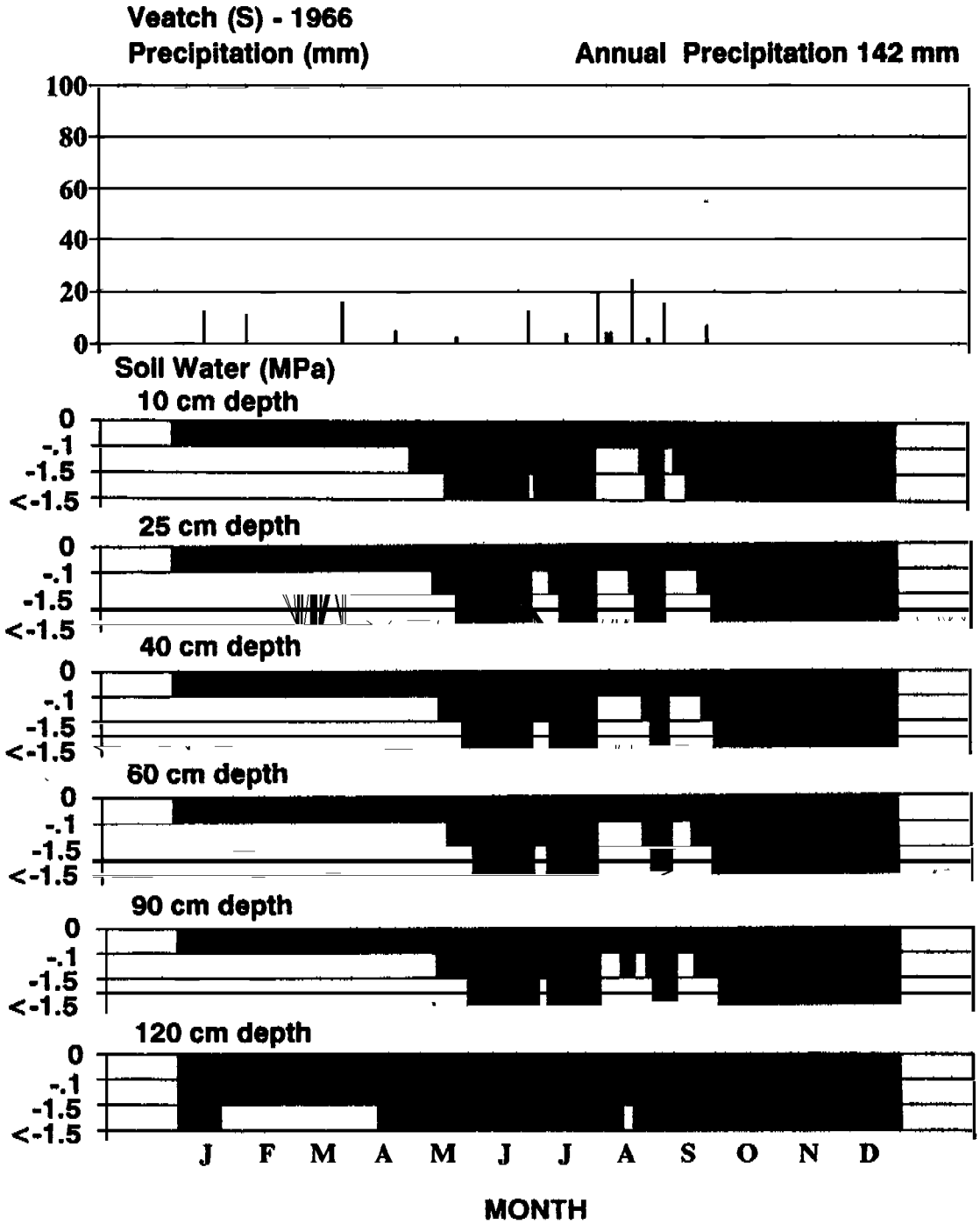


Figure 394. Annual (142 mm) and daily (mm) precipitation for 1966 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1966 at the Veatch (S) site.

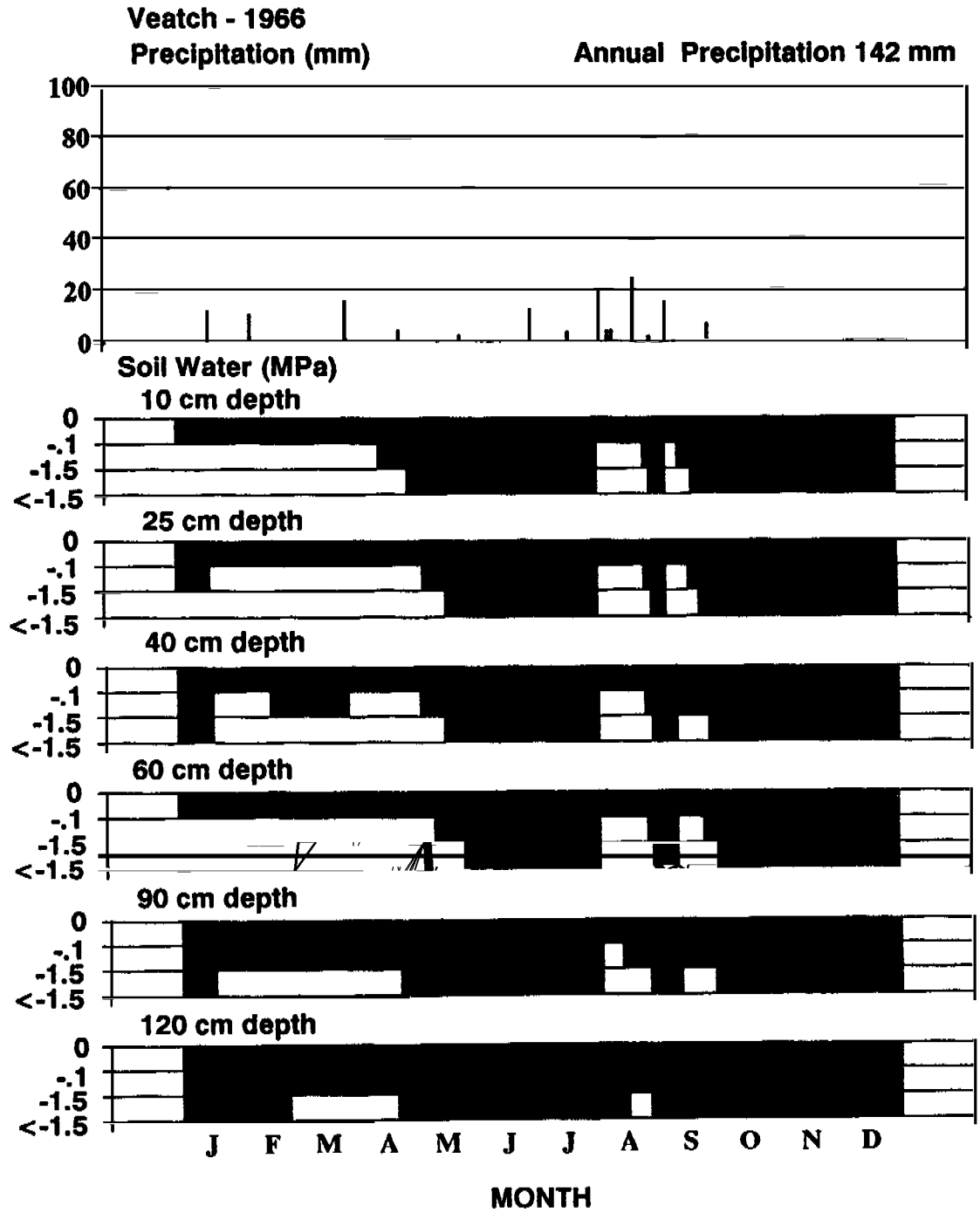


Figure 395. Annual (142 mm) and daily (mm) precipitation for 1966 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1966 at the Veatch site.

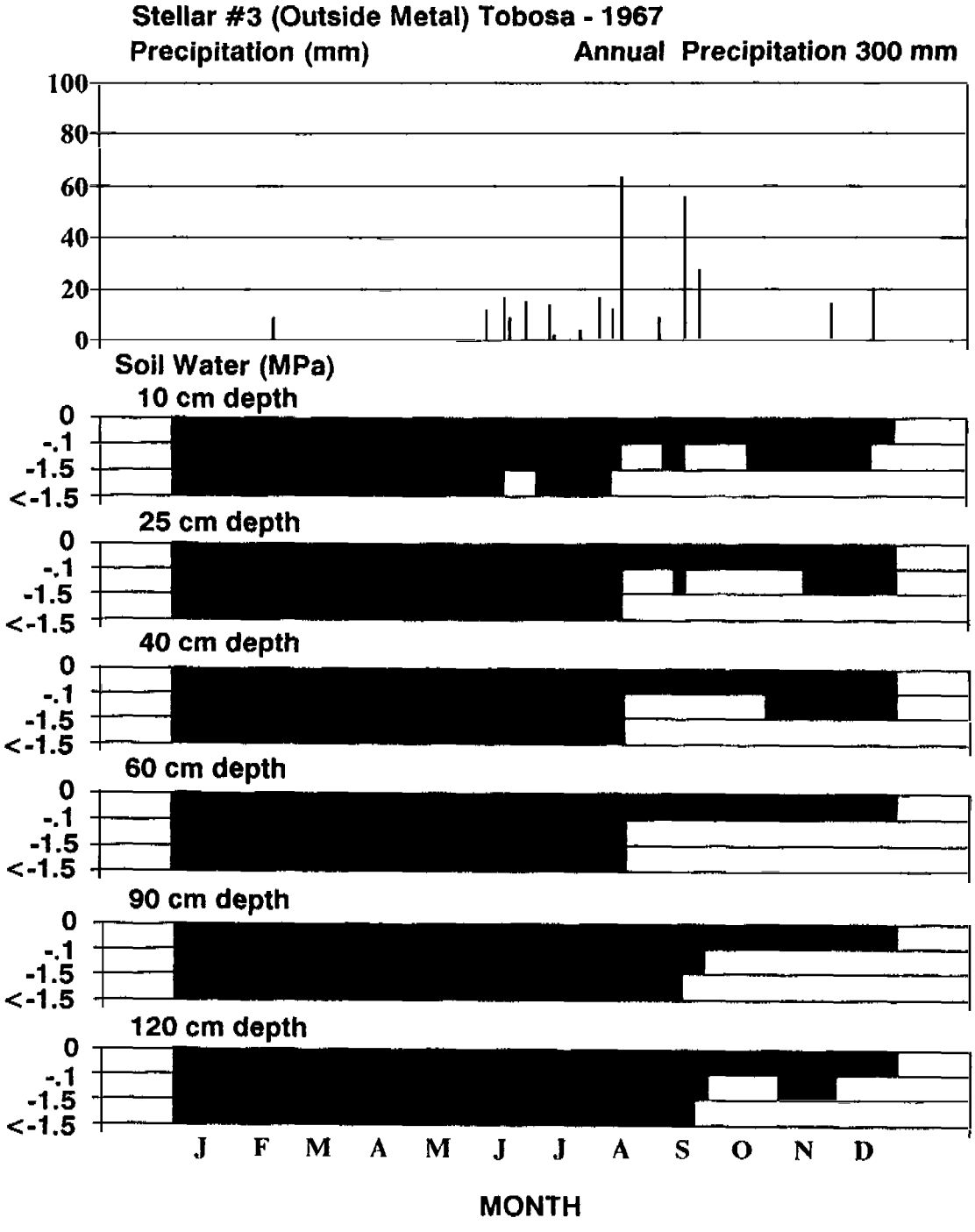


Figure 396. Annual (300 mm) and daily (mm) precipitation for 1967 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1967 at the Stellar #3 site dominated by tobosa.

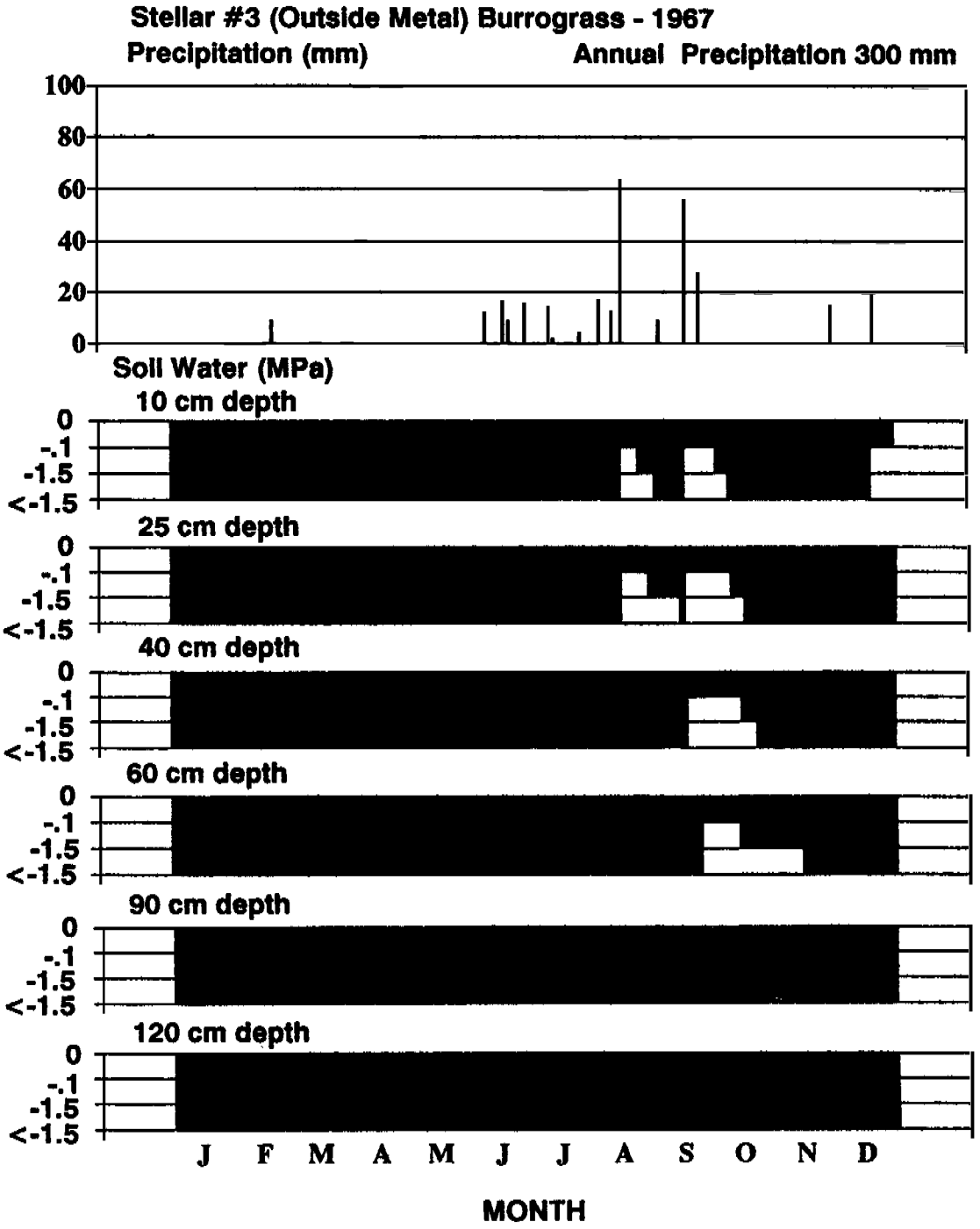


Figure 397. Annual (300 mm) and daily (mm) precipitation for 1967 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1967 at the Stellar #3 site dominated by burrograss.

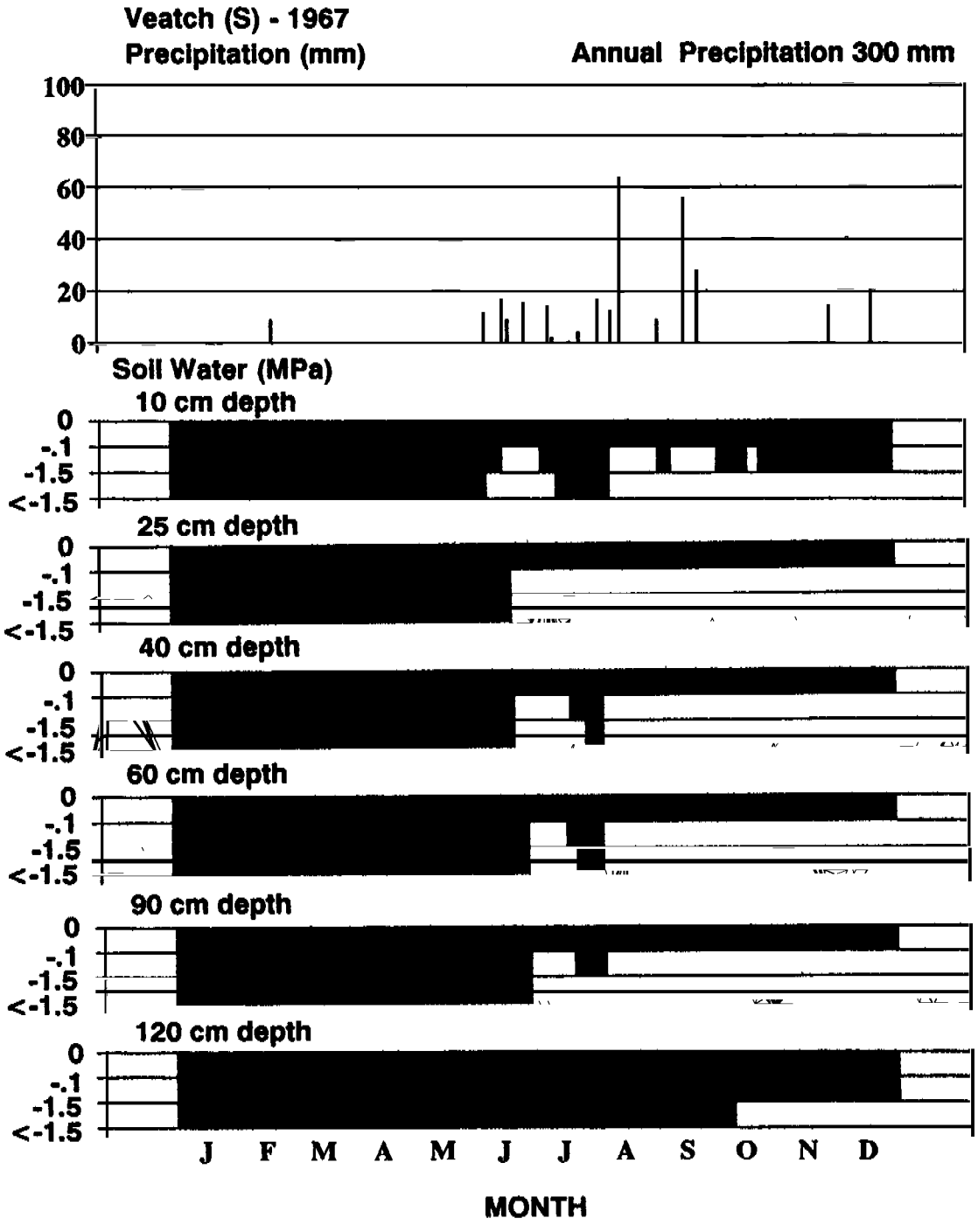


Figure 398. Annual (300 mm) and daily (mm) precipitation for 1967 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1967 at the Veatch (S) site.

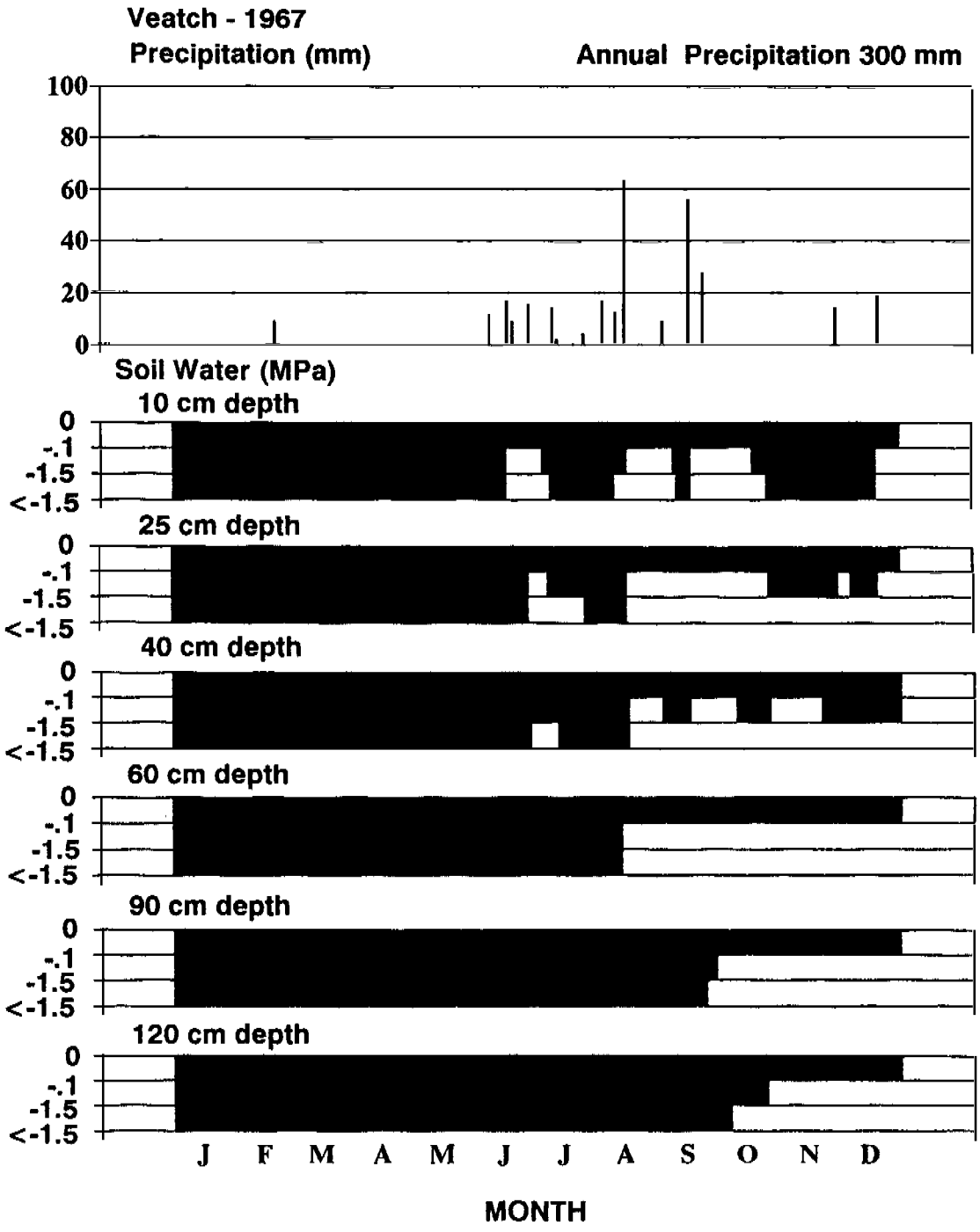


Figure 399. Annual (300 mm) and daily (mm) precipitation for 1967 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1967 at the Veatch site.

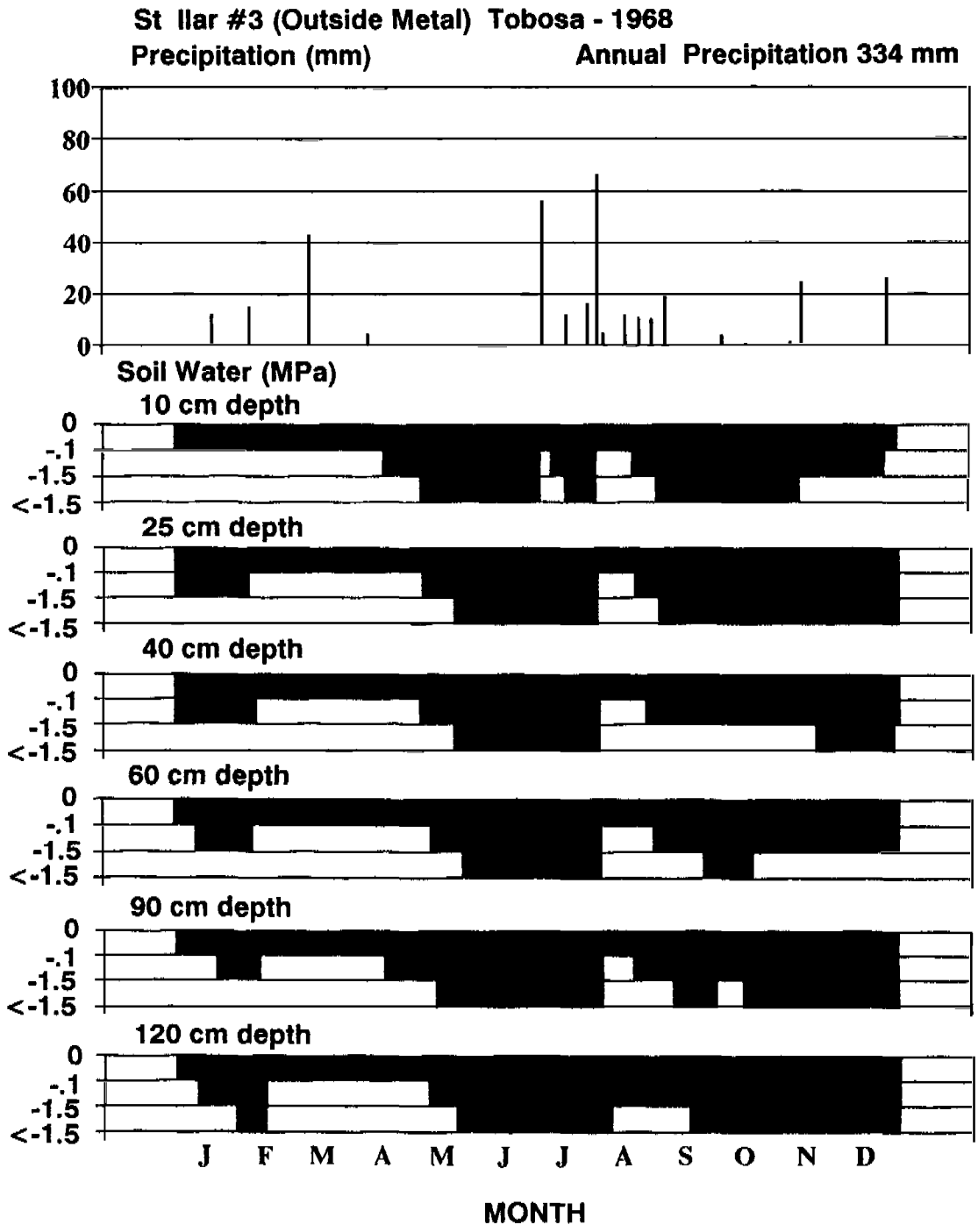


Figure 400. Annual (334 mm) and daily (mm) precipitation for 1968 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1968 at the Stellar #3 site dominated by tobosa.

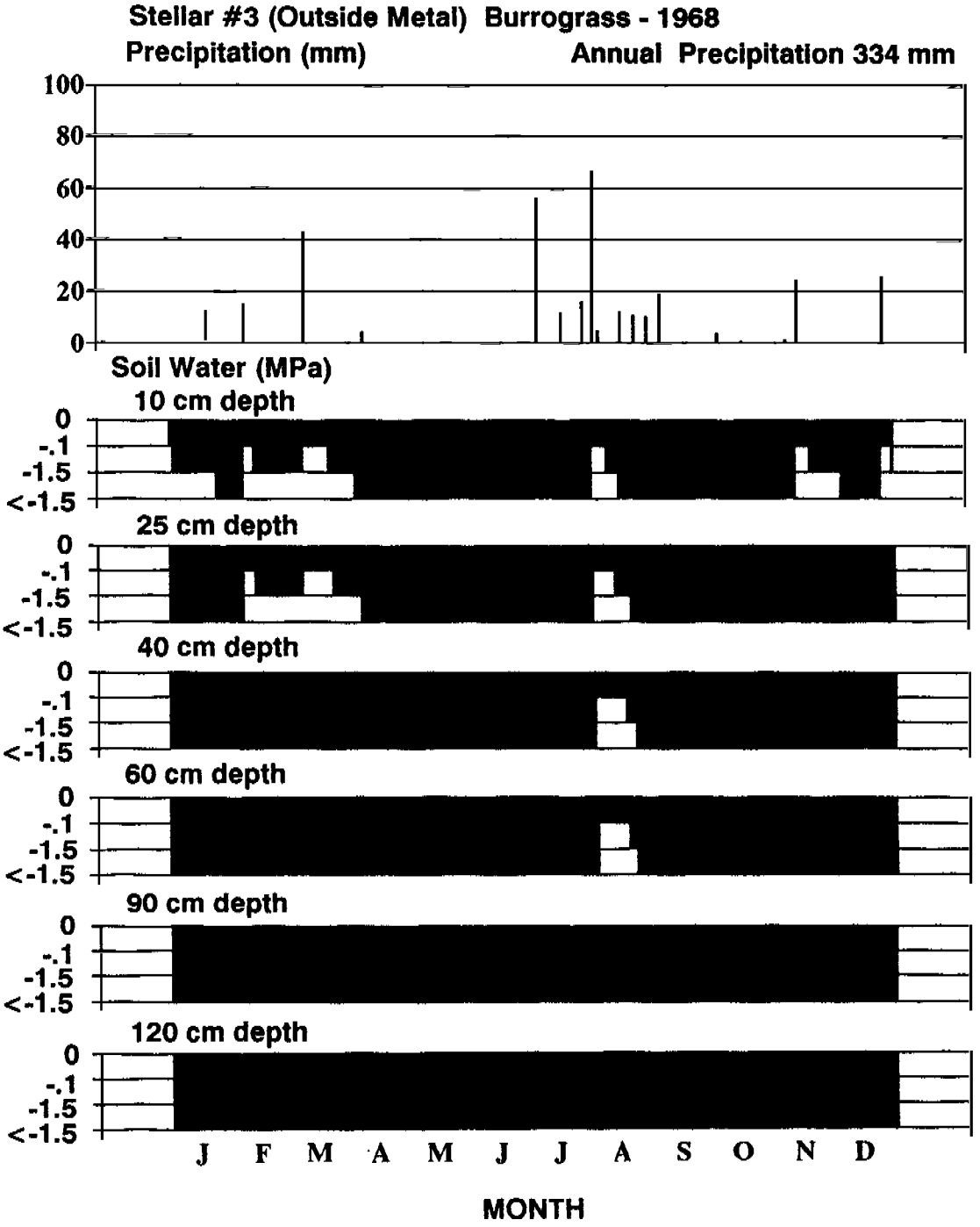


Figure 401. Annual (334 mm) and daily (mm) precipitation for 1968 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1968 at the Stellar #3 site dominated by burrograss.

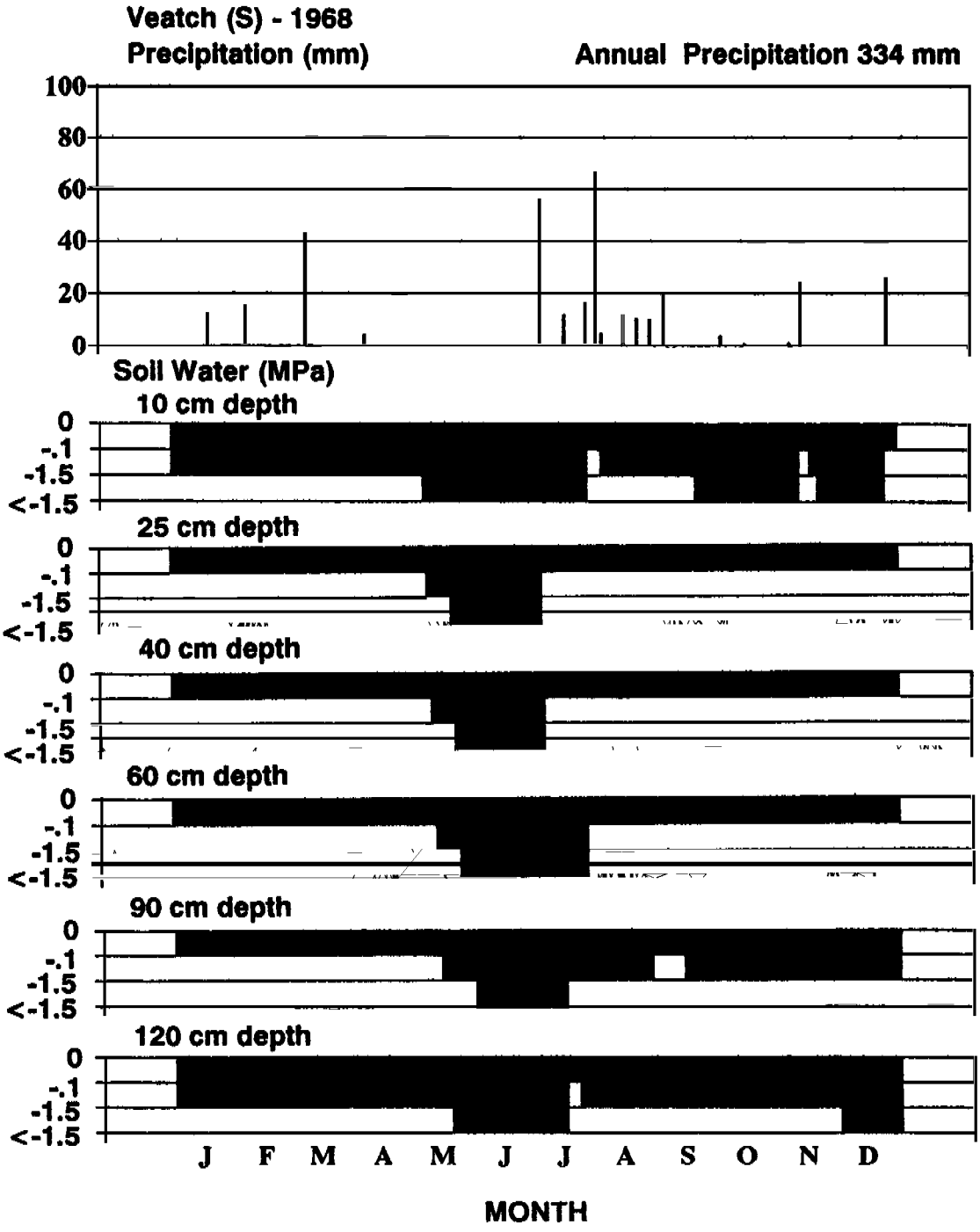


Figure 402. Annual (334 mm) and daily (mm) precipitation for 1968 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1968 at the Veatch (S) site.

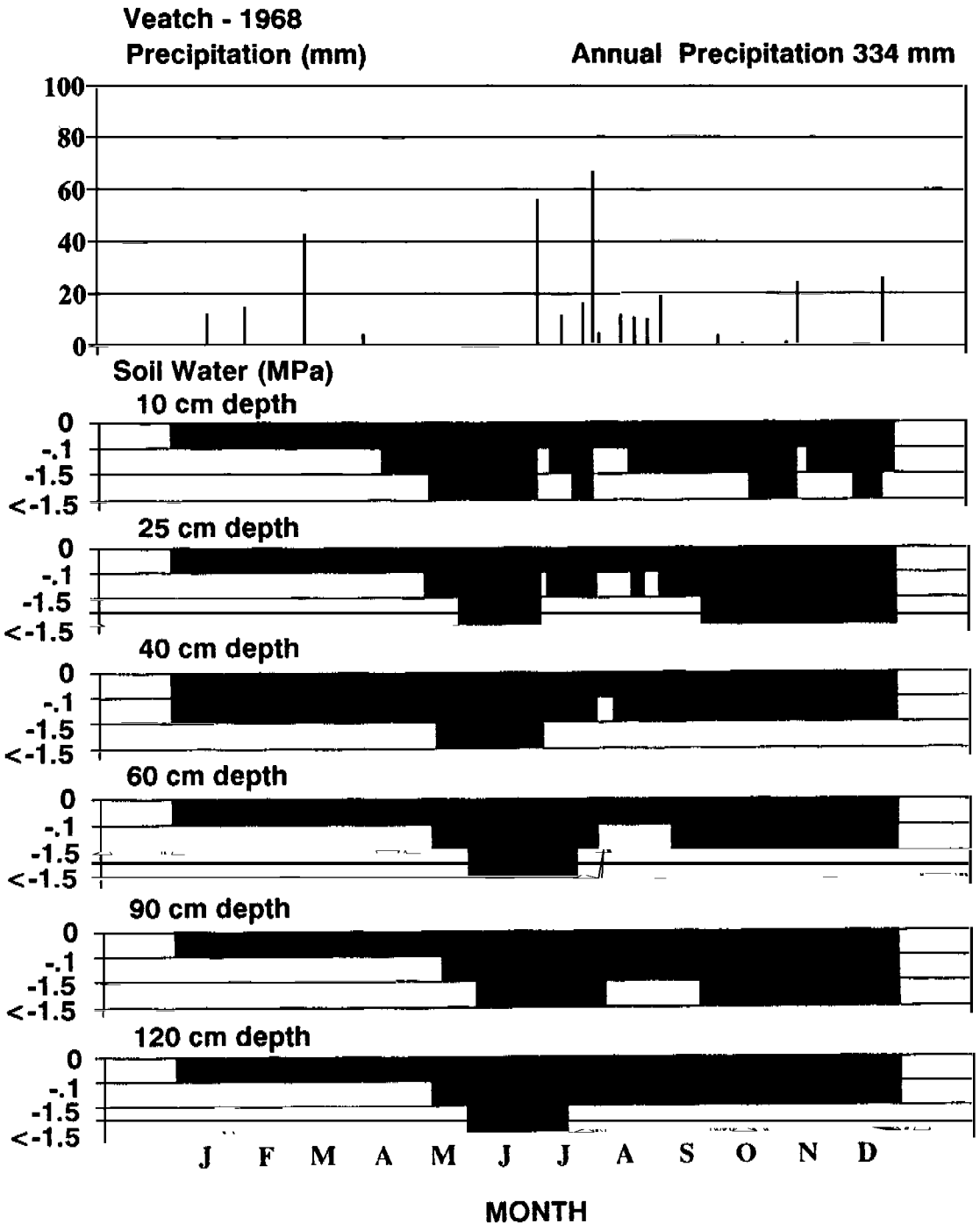


Figure 403. Annual (334 mm) and daily (mm) precipitation for 1968 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1968 at the Veatch site.

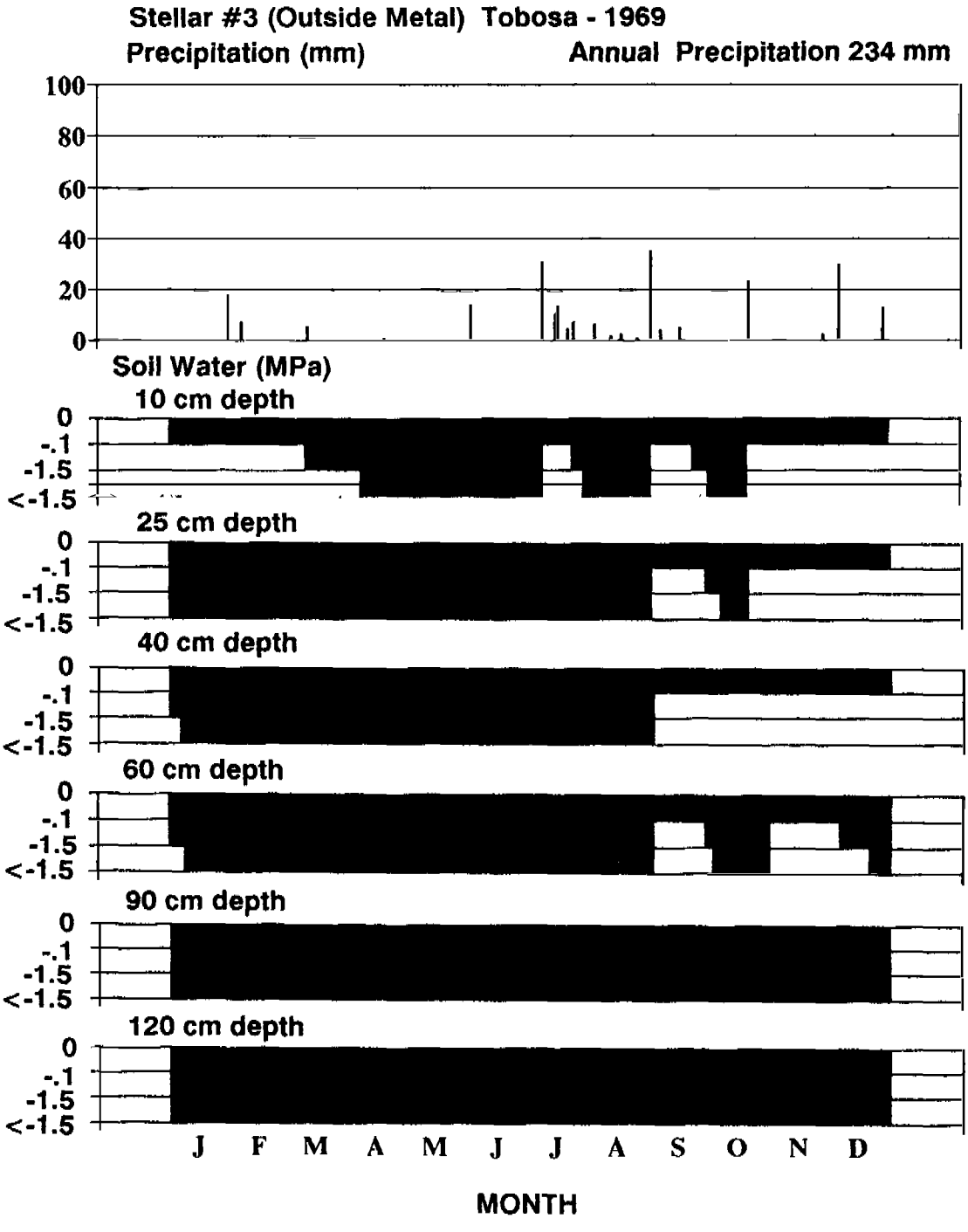


Figure 404. Annual (234 mm) and daily (mm) precipitation for 1969 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1969 at the Stellar #3 site dominated by tobosa.

dominated by burrograss September 2-23 and October 22-December 31 (fig. 405); at Veatch (S) January 1-May 21 and July 11-December 31 (fig. 406); and Veatch September 5-December 31 (fig. 407).

The 1970 precipitation at Stuart Rain Gauge was 112 mm (figs. 408-411). The soil water at Fertilizer at 25 cm was >-1.5 MPa at Stellar #3 tobosa January 1-May 6, June 9-July 4, July 13-18, July 25-August 7, August 26-September 9, and October 6-23 (fig. 408); Stellar #3 dominated by burrograss January 1-March 31 and July 27-August 6 (fig. 409); at Veatch (S) January 1-November 20, and December 15-31 (fig. 410); and Veatch January 1-July 24, August 1-September 28, and October 5-December 31, 1970 (fig. 411).

Annual precipitation for 1971 was 274 mm (figs. 412-415). Water at the 25-cm soil depth was >-1.5 MPa at Stellar #3 dominated by tobosa August 29-September 26 and October 25-December 31 (fig. 412); Stellar #3 burrograss August 29-September 19 and October 25-December 31 (fig. 413); Veatch (S) all year (fig. 414); and at Veatch January 1-June 10, June 27-July 7, August 19-November 4, and November 16-December 31, 1971 (fig. 415).

The annual precipitation for 1972 was 369 mm (figs. 416-419) but the soil water meter was inoperative August 8-December 31. There was soil water >-1.5 MPa at the 25-cm depth at Stellar #3 tobosa January 1-May 3 (fig. 416); Stellar #3 burrograss January 1-March 14 and June 11-18 (fig. 417); Veatch (S) January 1-August 7 (fig. 418); and Veatch January 1-August 7, 1972 (fig 419).

The 1973 precipitation was 271 mm (figs. 420-423). At 25 cm, there was soil water >-1.5 MPa at Stellar #3 dominated by tobosa January 1-April 24, May 12-31, June 14-30, July 19-August 4, and August 29-September 7 (fig. 420); Stellar #3 burrograss January 6-April 18, May 13-23, June 15-26, July 19-August 5, and August 29-September 7 (fig. 421); at Veatch (S) all of 1973 (fig. 422); and Veatch January 1-May 3, May 13-August 20, August 30-October 21, and December 1-31, 1973 (fig. 423).

The annual precipitation for 1974 at Stuart Rain Gauge was 428 mm (fig. 424-427). Soil water at Fertilizer at 25 cm was >-1.5 MPa at Stellar #3 tobosa July 15-September 13 and September 29-December 31 (fig. 424); Stellar #3 dominated by burrograss July 15-August 19 and September 22-December 31 (fig. 425); at Veatch (S) January 1-December 31 (fig. 426); and Veatch January 1-March 31, June 1-7, July 1-September 26, and October 29-December 31, 1974 (fig. 427).

The 1975 precipitation was 341 mm (figs. 428-431). Soil water at 25 cm was >-1.5 MPa at Stellar #3 dominated by tobosa January 1-April 1, July 26-August 31, and September 6-December 31 (fig. 428); at Stellar #3 burrograss January 1-May 18 and September 4-October 2 (fig. 429); Veatch (S) January 1-December 31 (fig. 430); and Veatch also all year (fig. 431).

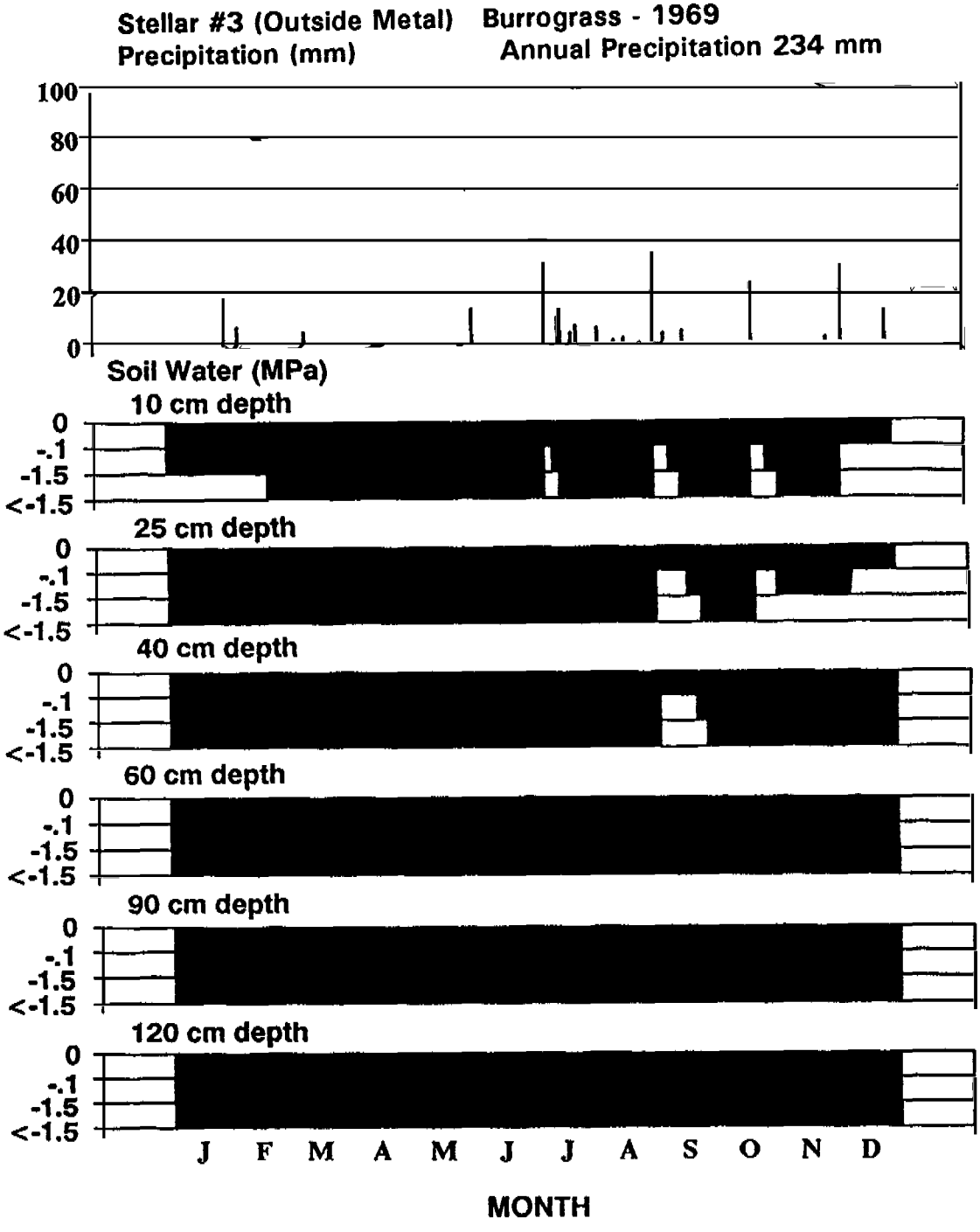


Figure 405. Annual (234 mm) and daily (mm) precipitation for 1969 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1969 at the Stellar #3 site dominated by burrograss.

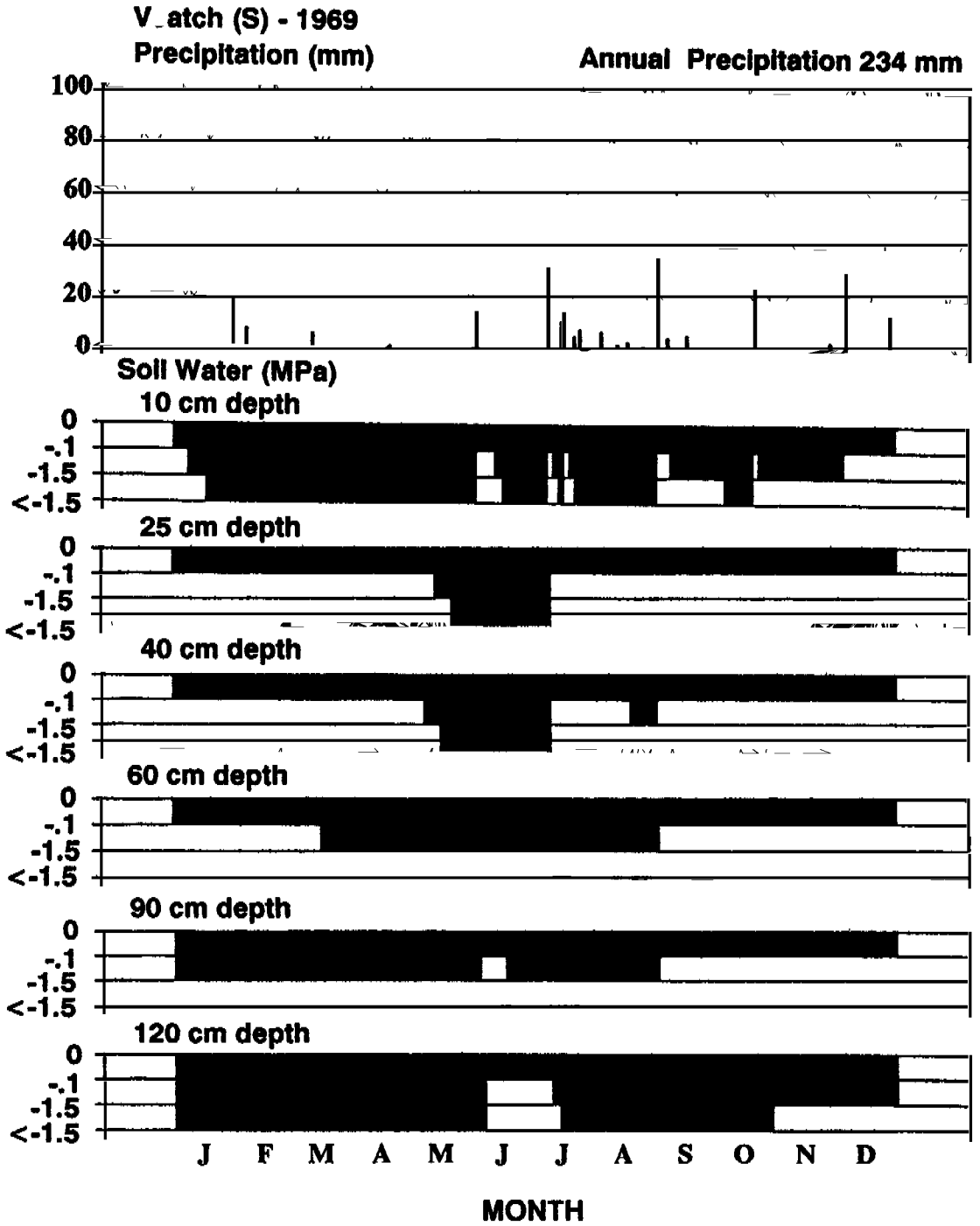


Figure 406. Annual (234 mm) and daily (mm) precipitation for 1969 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1969 at the Veatch (S) site.

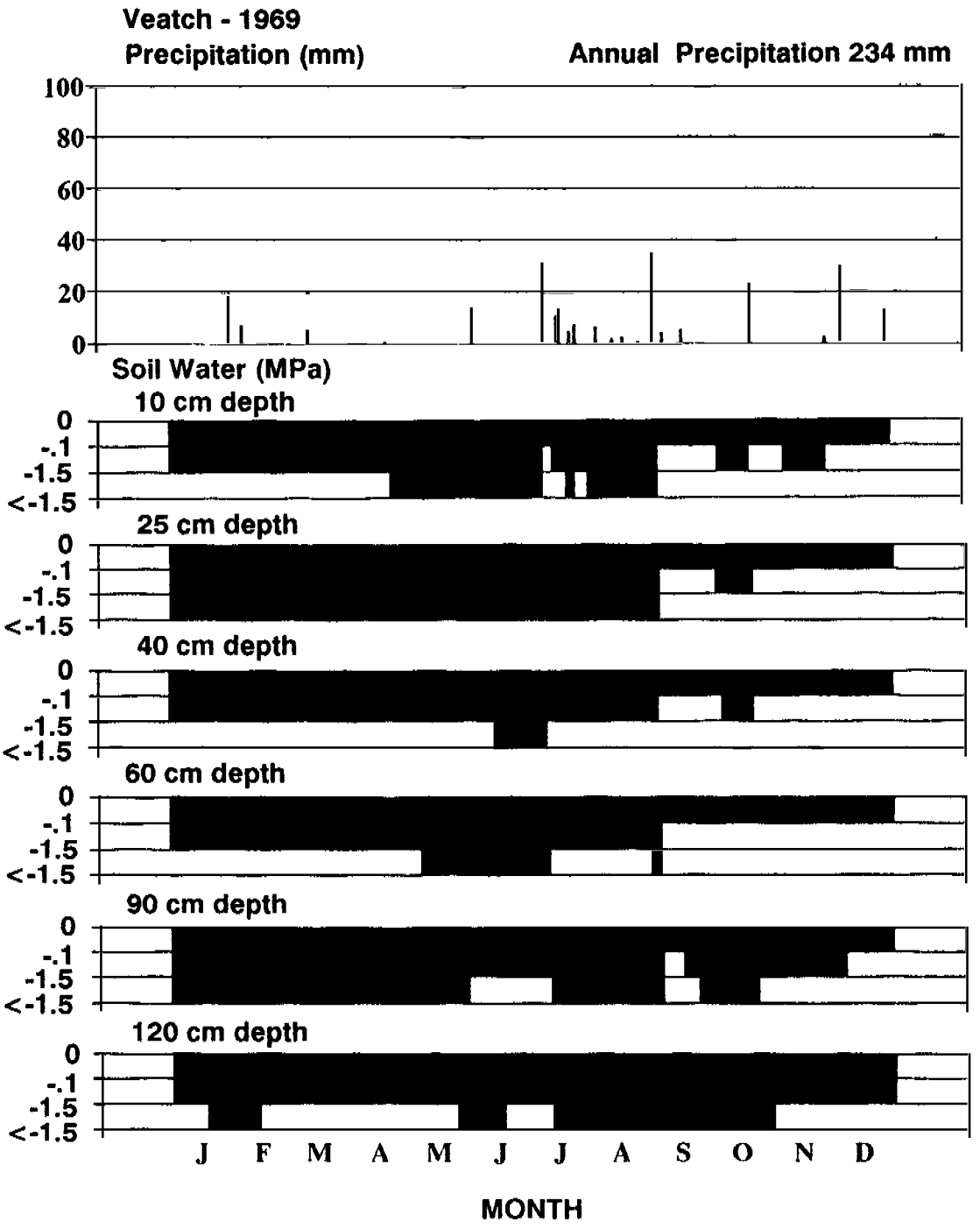


Figure 407. Annual (234 mm) and daily (mm) precipitation for 1969 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1969 at the Veatch site.

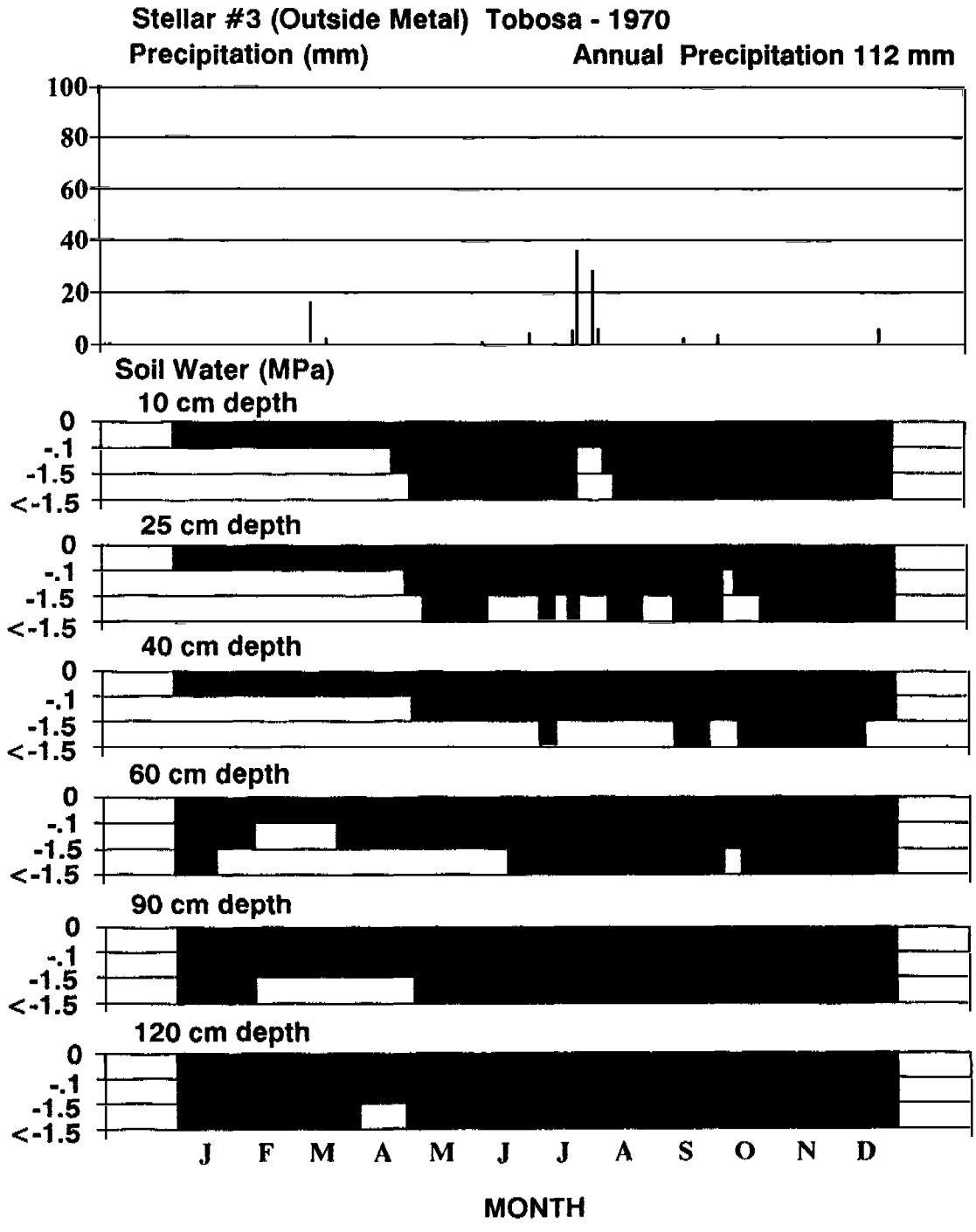


Figure 408. Annual (112 mm) and daily (mm) precipitation for 1970 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1970 at the Stellar #3 site dominated by tobosa.

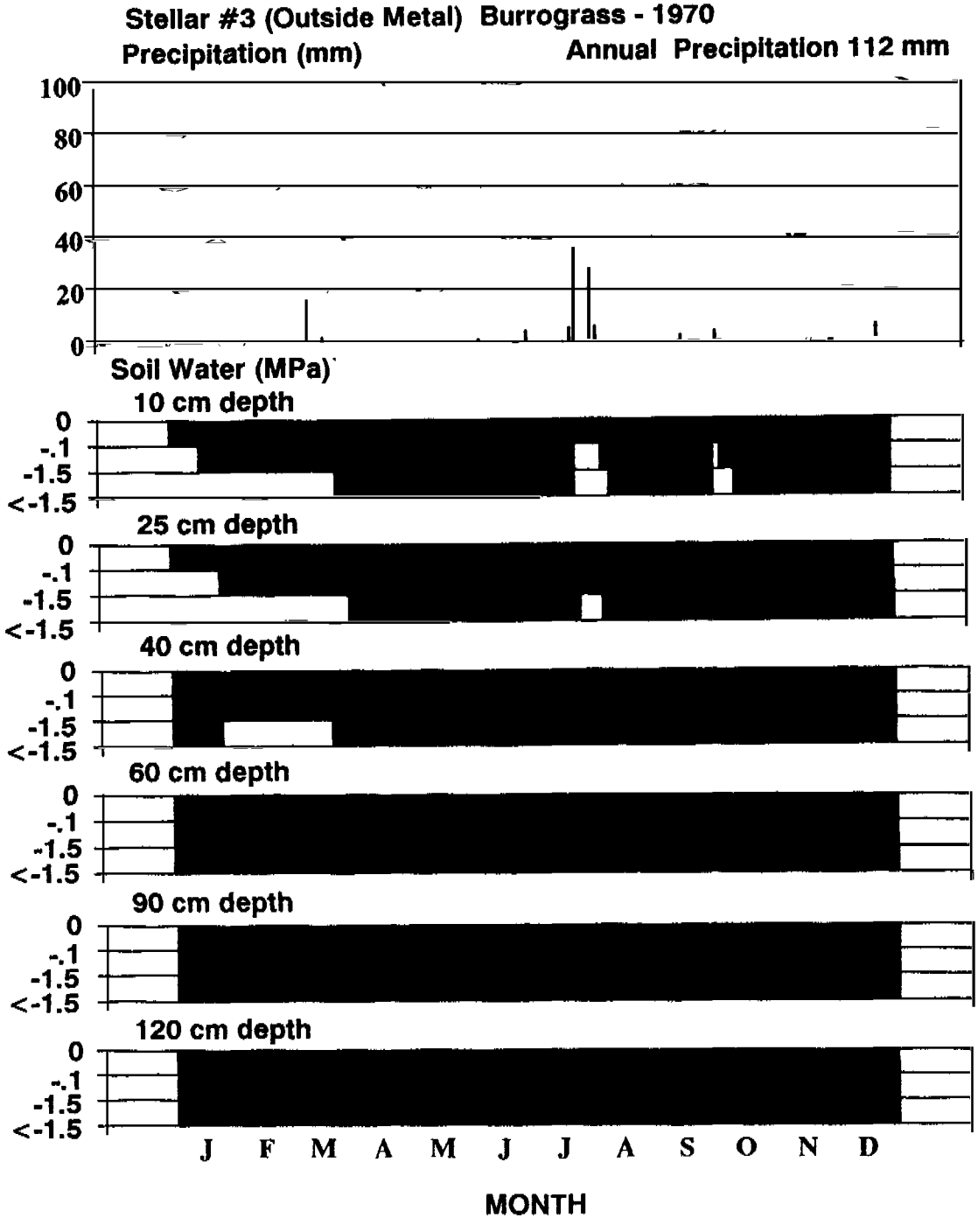


Figure 409. Annual (112 mm) and daily (mm) precipitation for 1970 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1970 at the Stellar #3 site dominated by burrograss.

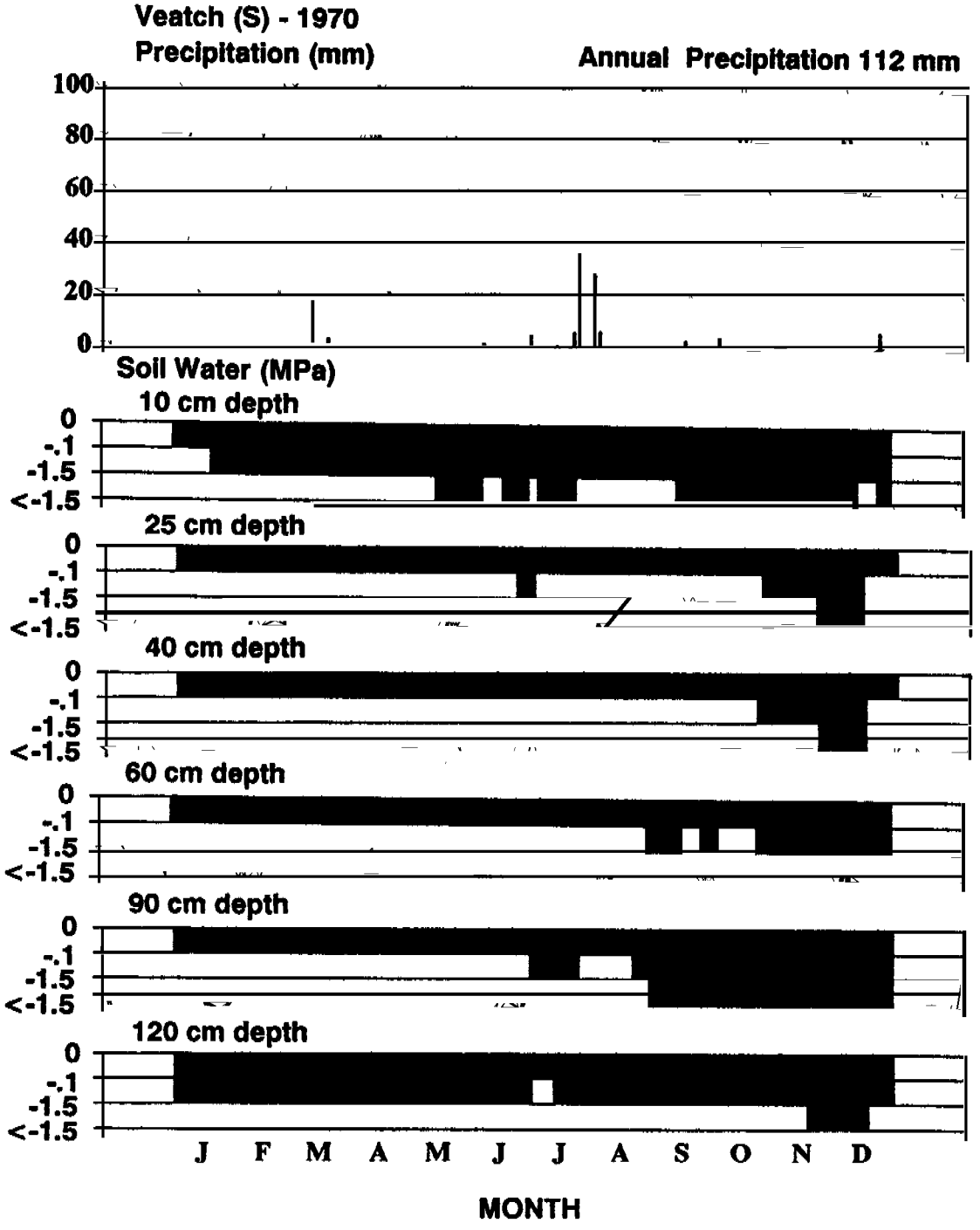


Figure 410. Annual (112 mm) and daily (mm) precipitation for 1970 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1970 at the Veatch (S) site.

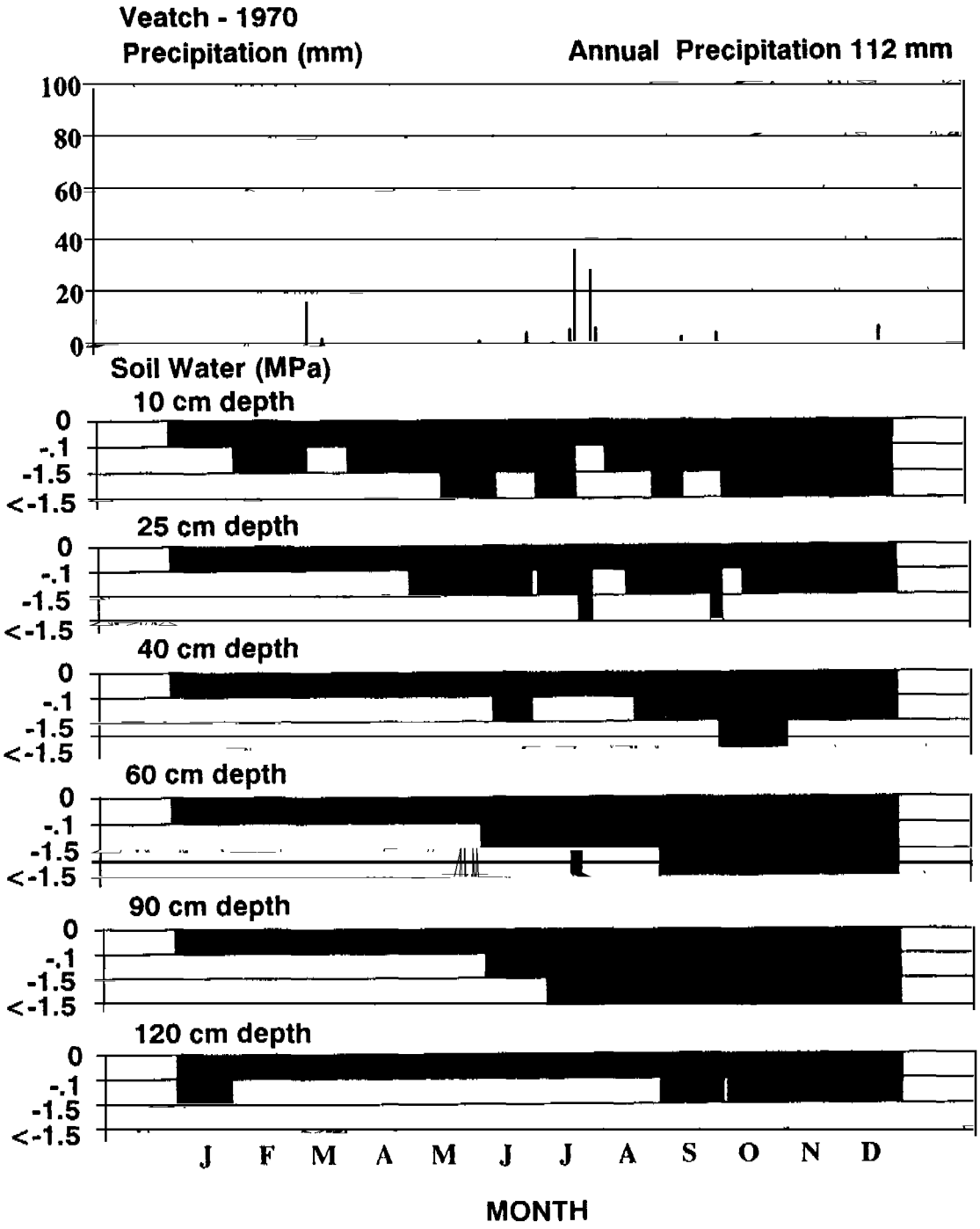


Figure 411. Annual (112 mm) and daily (mm) precipitation for 1970 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1970 at the Veatch site.

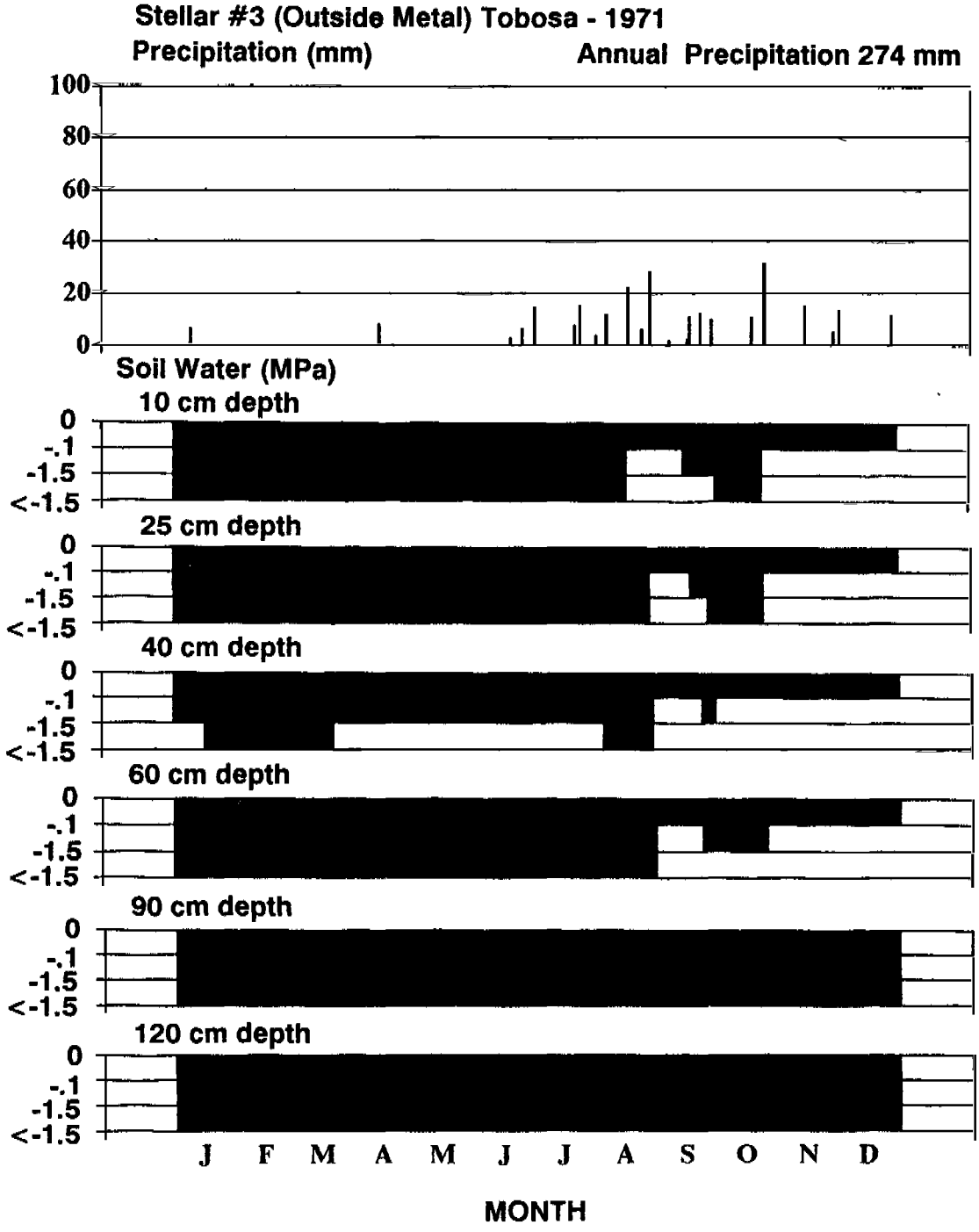


Figure 412. Annual (274 mm) and daily (mm) precipitation for 1971 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1971 at the Stellar #3 site dominated by tobosa.

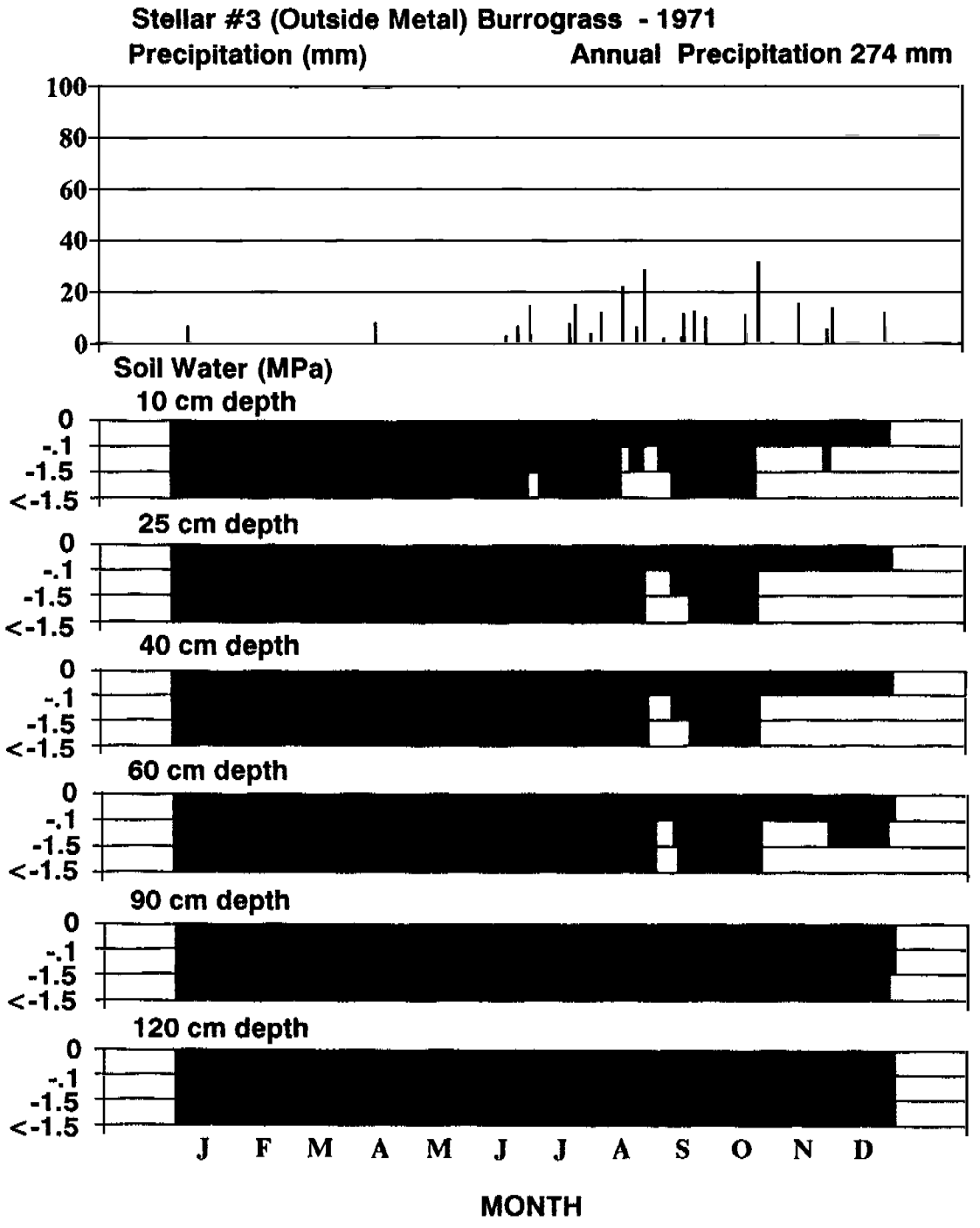


Figure 413. Annual (274 mm) and daily (mm) precipitation for 1971 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1971 at the Stellar #3 site dominated by burrograss.

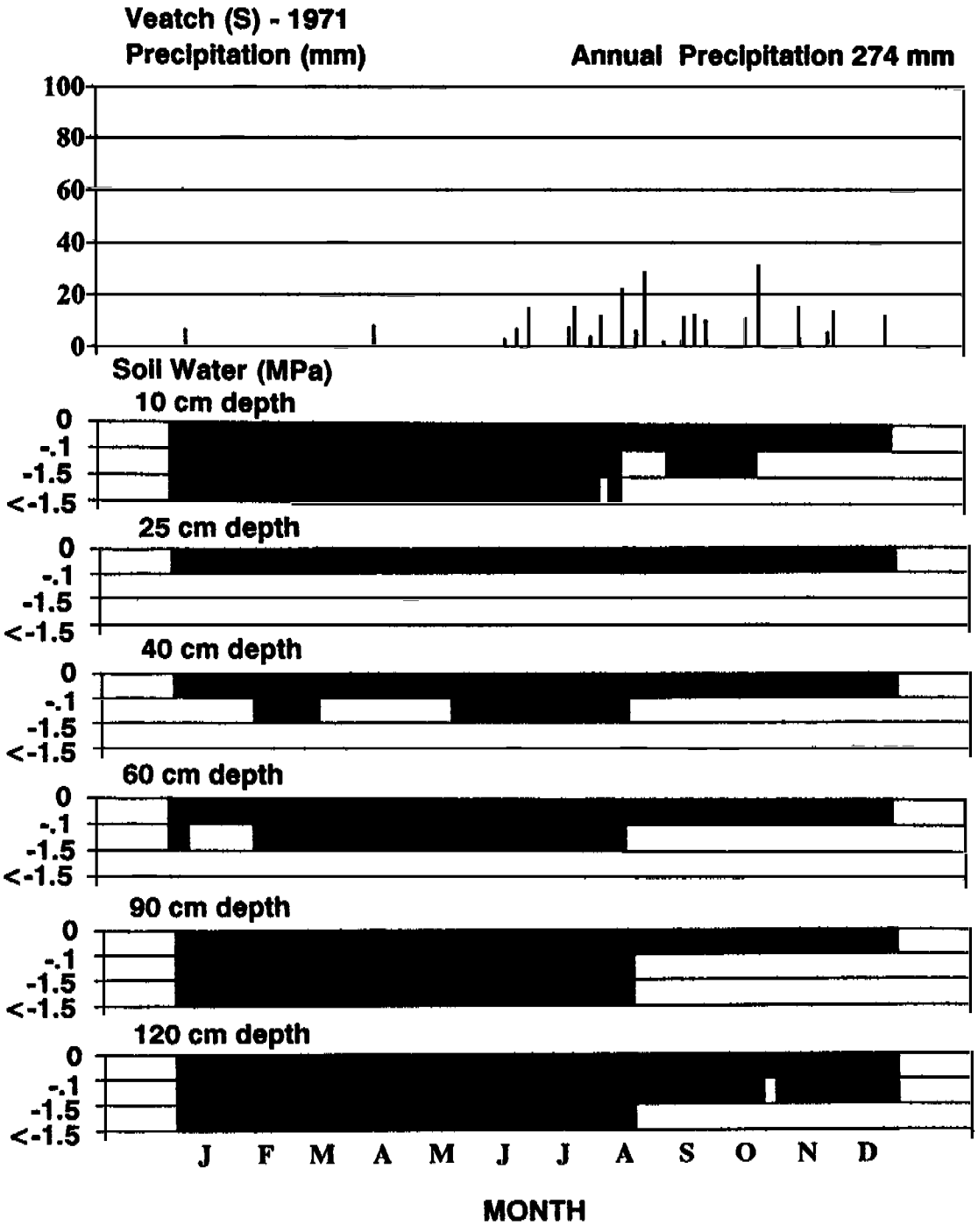


Figure 414. Annual (274 mm) and daily (mm) precipitation for 1971 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40,60,90, and 120 cm for 1971 at the Veatch (S) site.

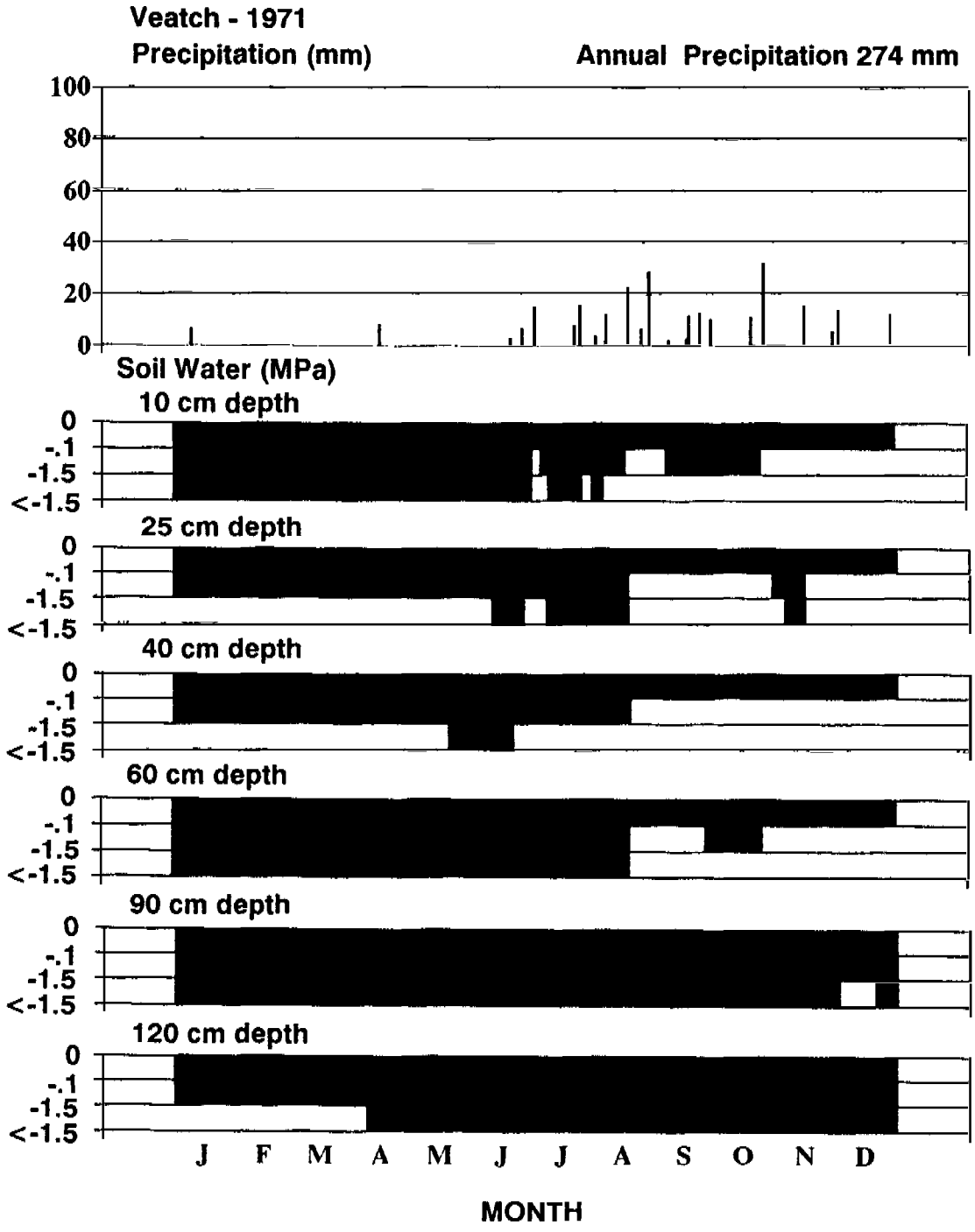


Figure 415. Annual (274 mm) and daily (mm) precipitation for 1971 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1971 at the Veatch site.

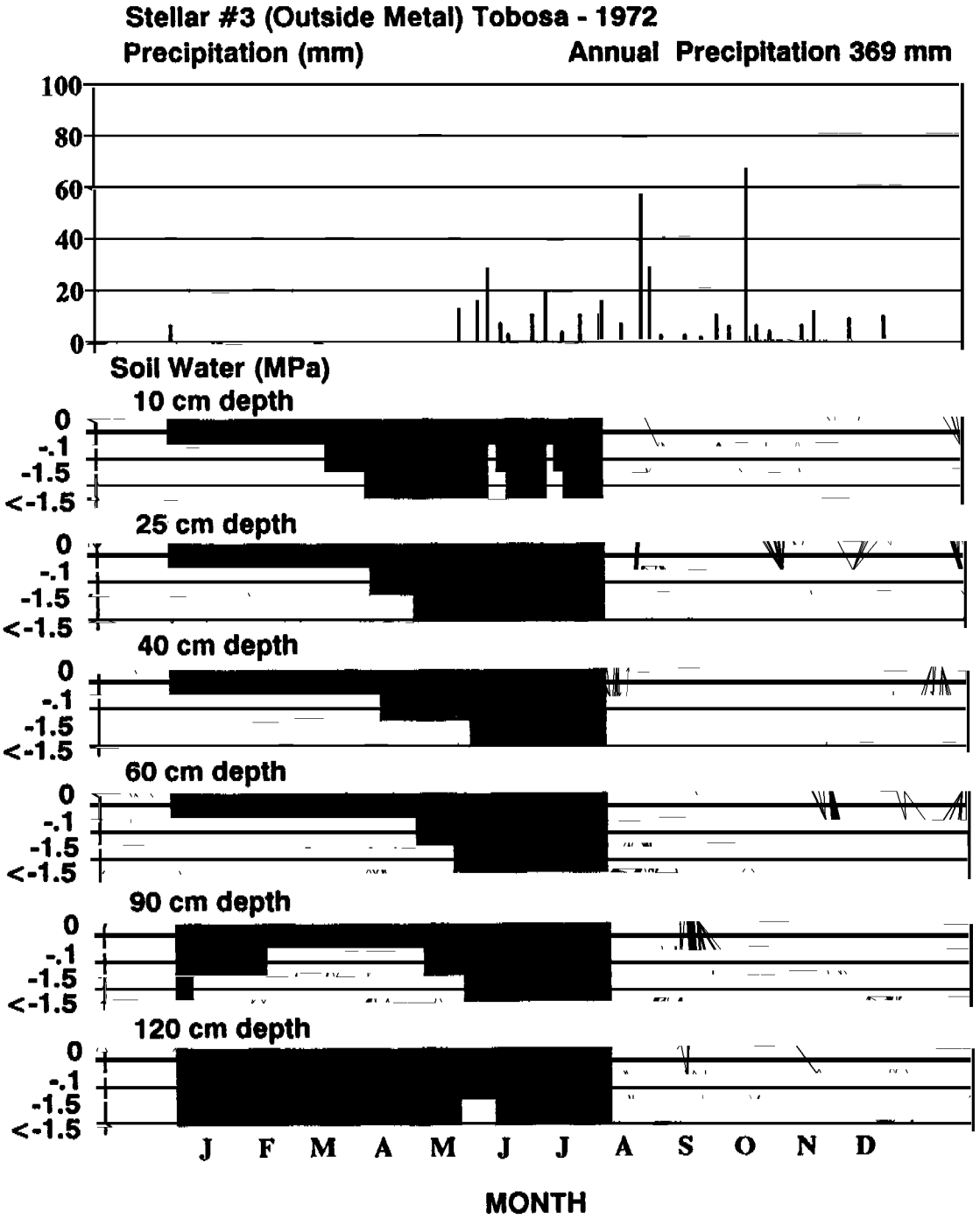


Figure 416. Annual (369 mm) and daily (mm) precipitation for 1972 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for January 1-August 7, 1972 at the Stellar #3 site dominated by tobosa.

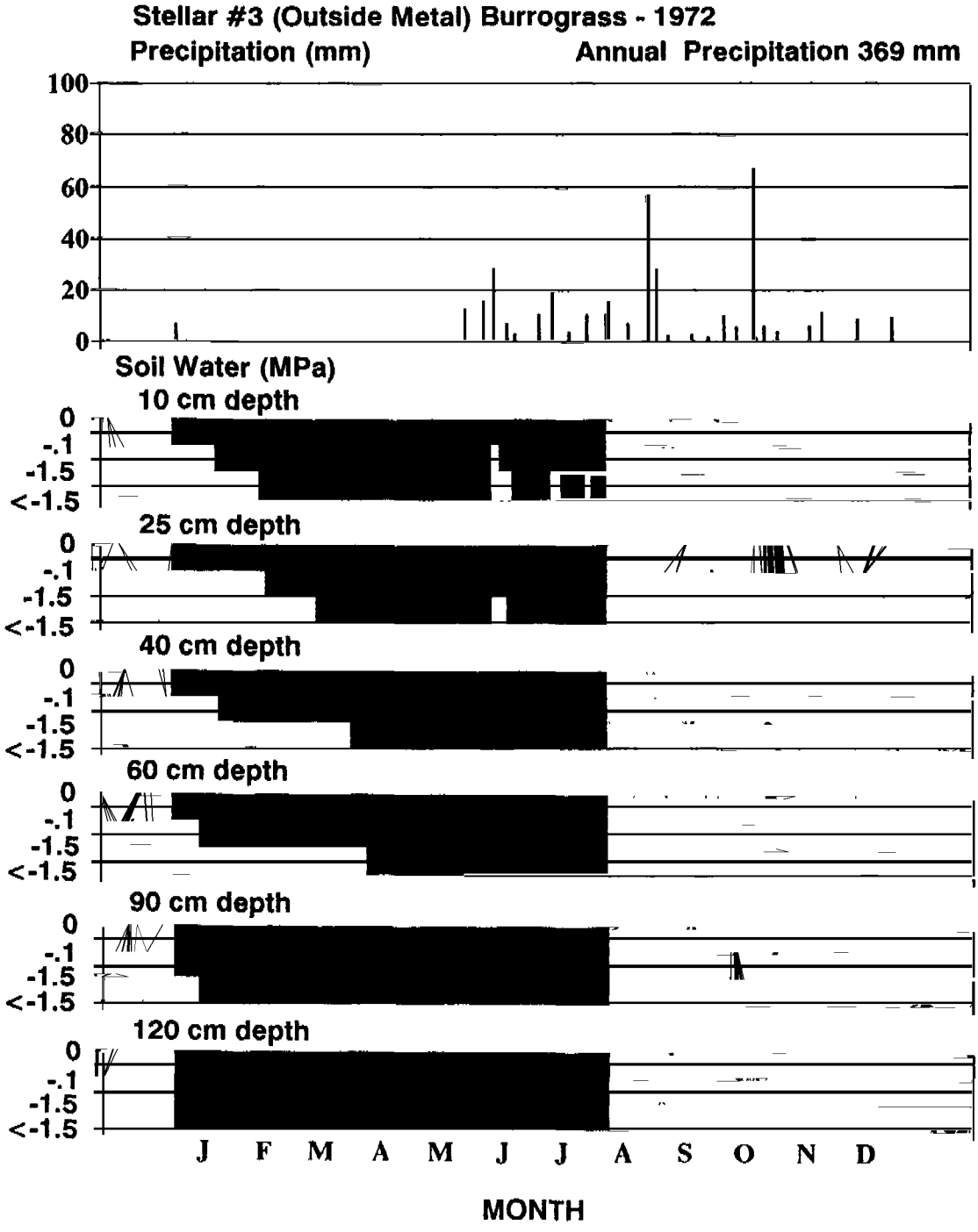


Figure 417. Annual (369 mm) and daily (mm) precipitation for 1972 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for January 1-August 7, 1972 at the Stellar #3 site dominated by burrograss.

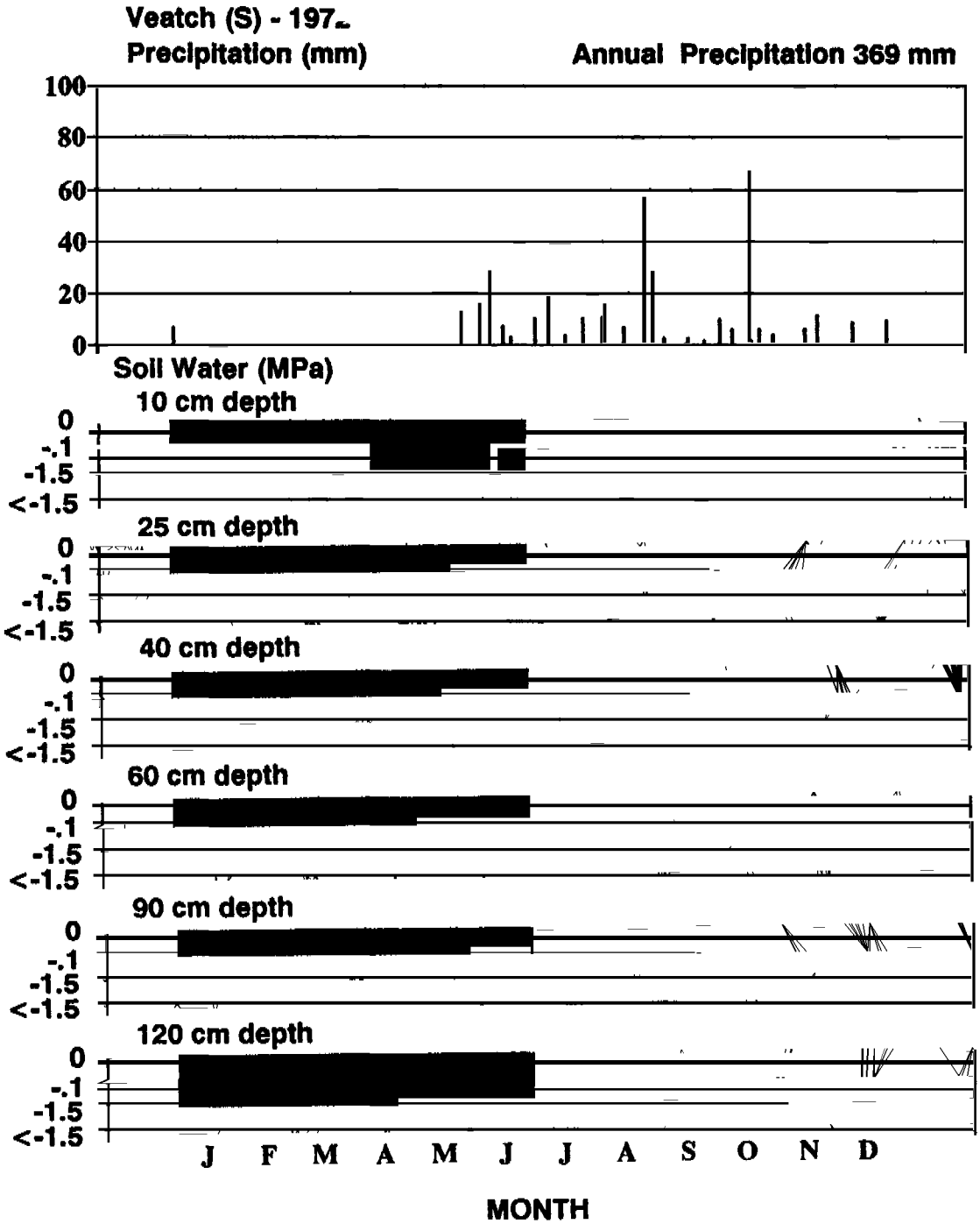


Figure 418. Annual (369 mm) and daily (mm) precipitation for 1972 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for January 1-August 7, 1972 at the Veatch (S) site.

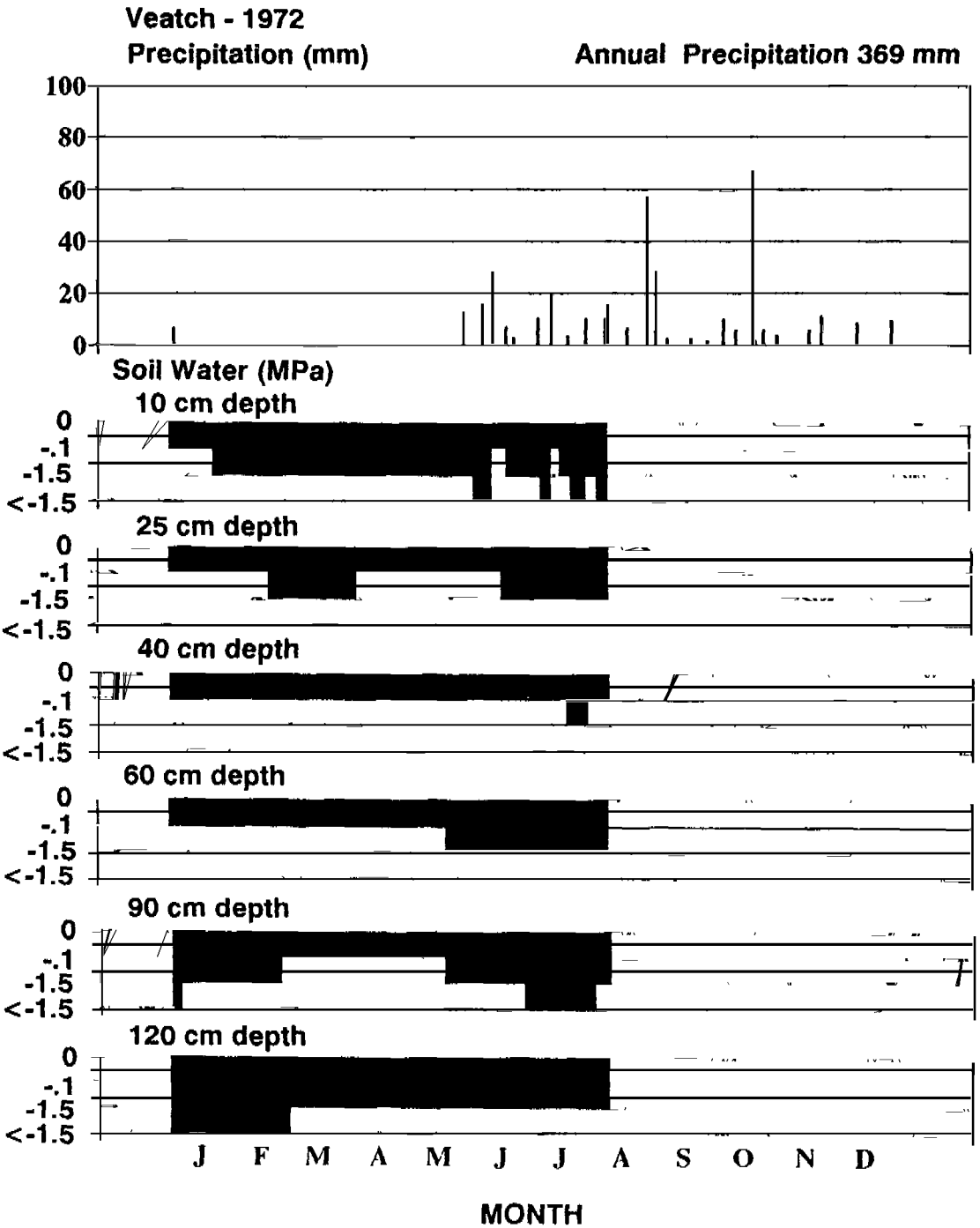


Figure 419. Annual (369 mm) and daily (mm) precipitation for 1972 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for January 1-August 7, 1972 at the Veatch site.

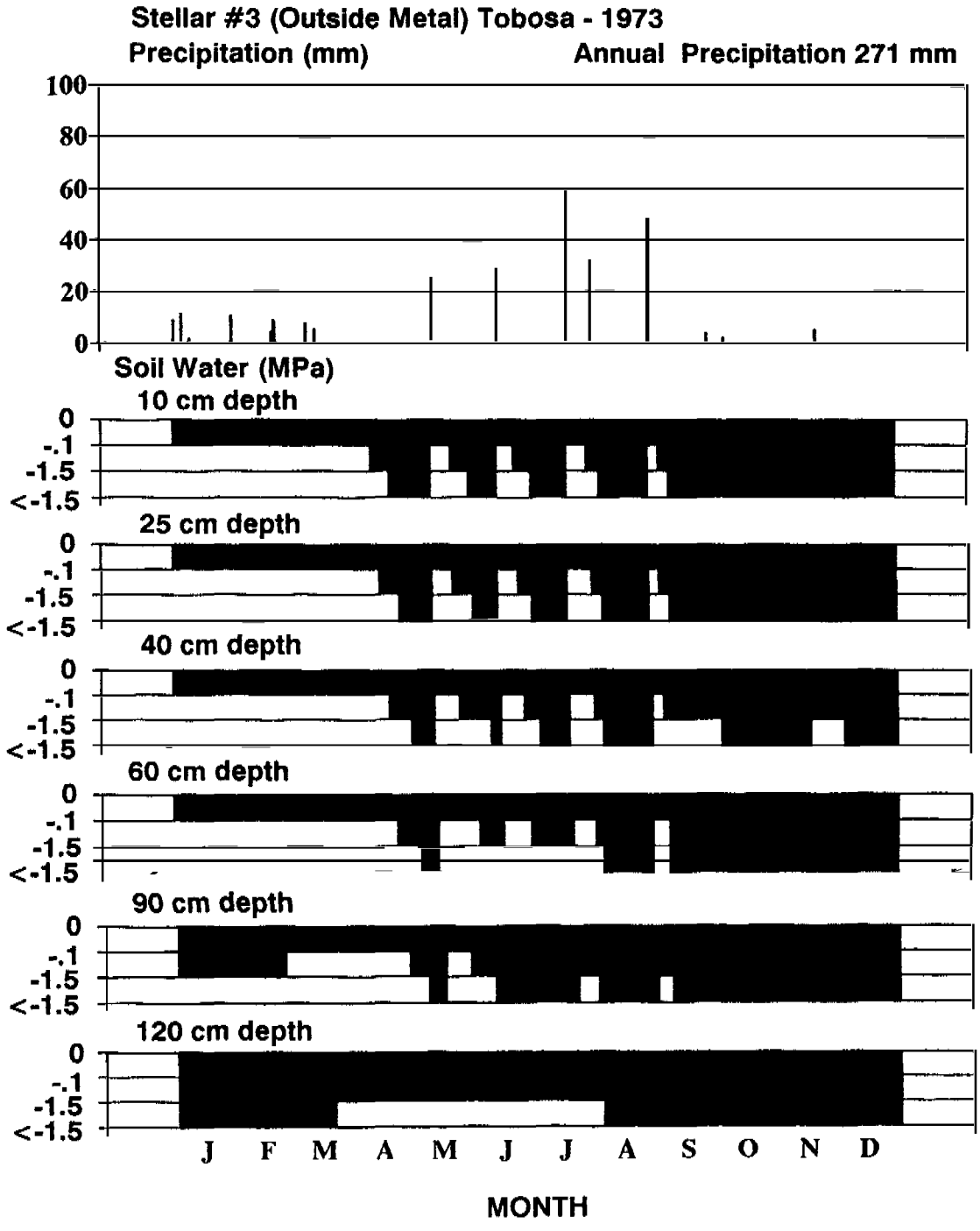


Figure 420. Annual (271 mm) and daily (mm) precipitation for 1973 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1973 at the Stellar #3 site dominated by tobosa.

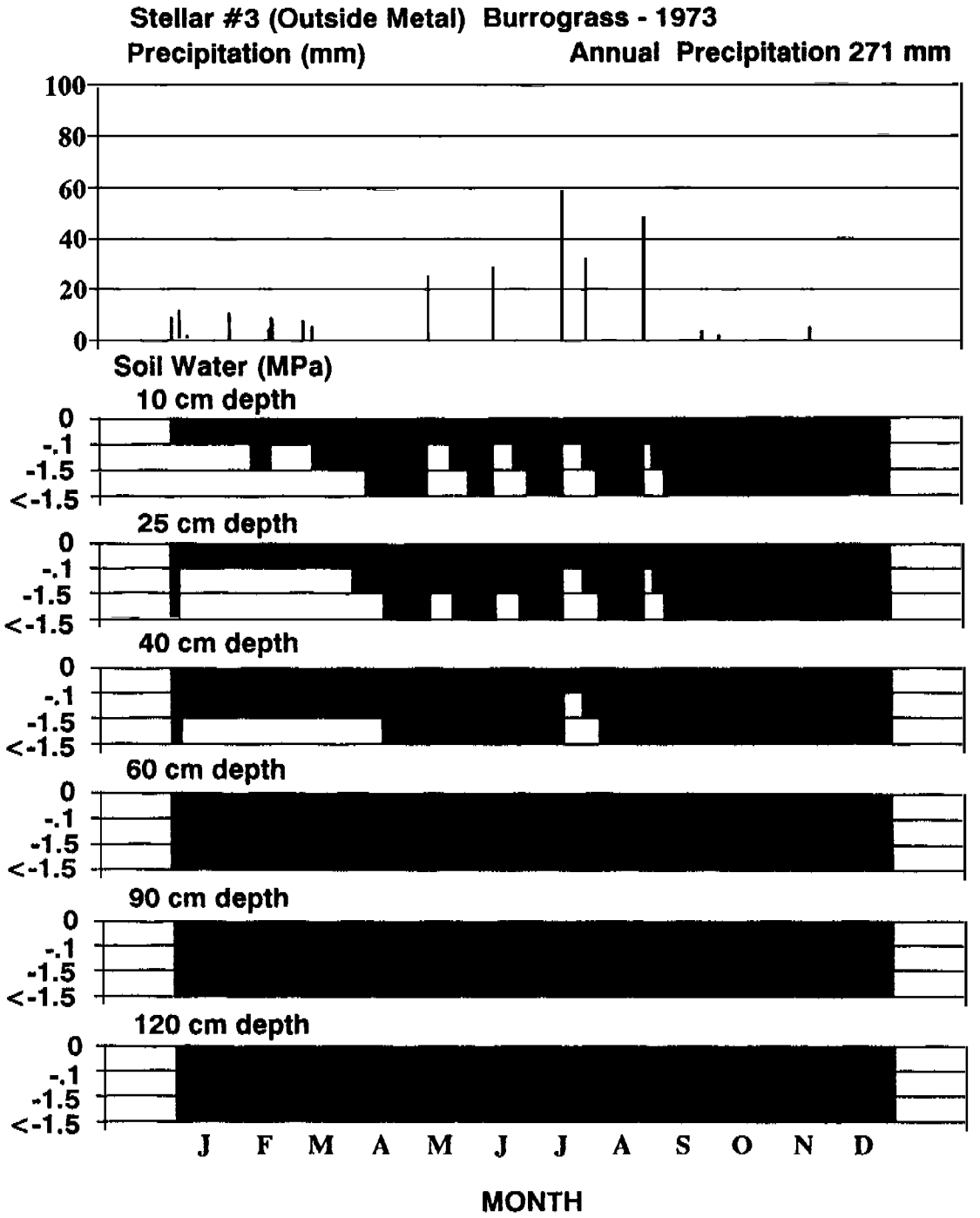


Figure 421. Annual (271 mm) and daily (mm) precipitation for 1973 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1973 at the Stellar #3 site dominated by burrograss.

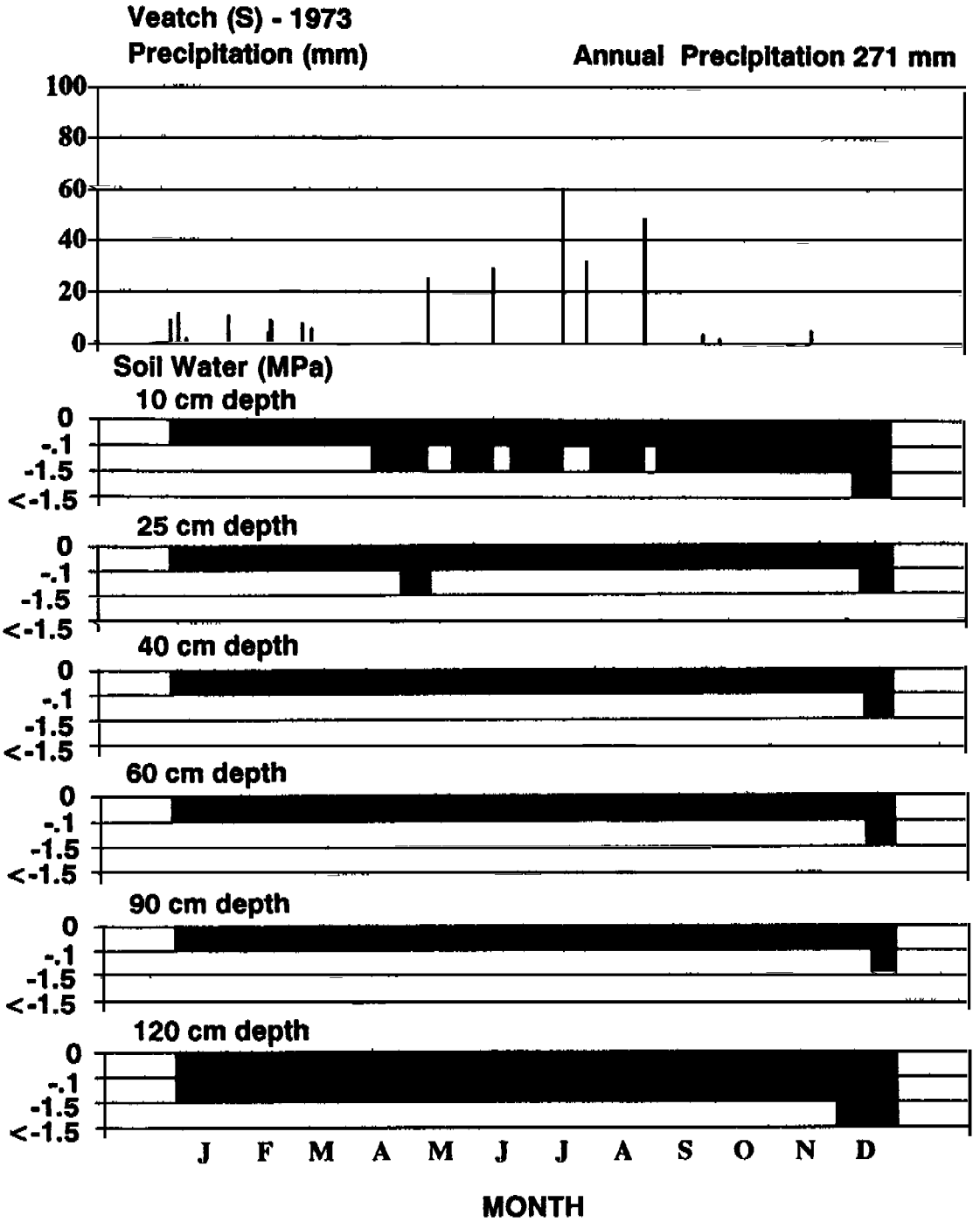


Figure 422. Annual (271 mm) and daily (mm) precipitation for 1973 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1973 at the Veatch (S) site.

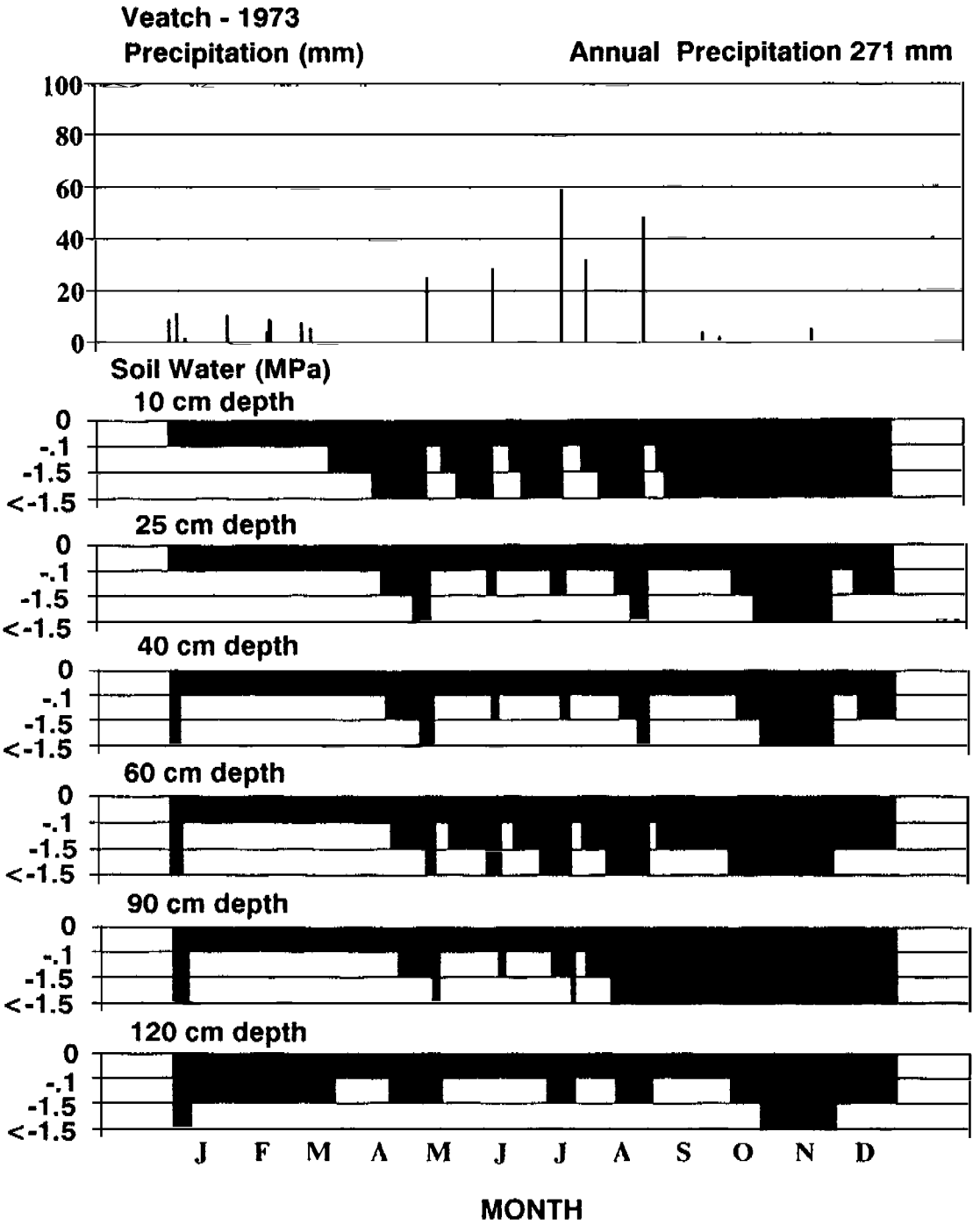


Figure 423. Annual (271 mm) and daily (mm) precipitation for 1973 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1973 at the Veatch site.

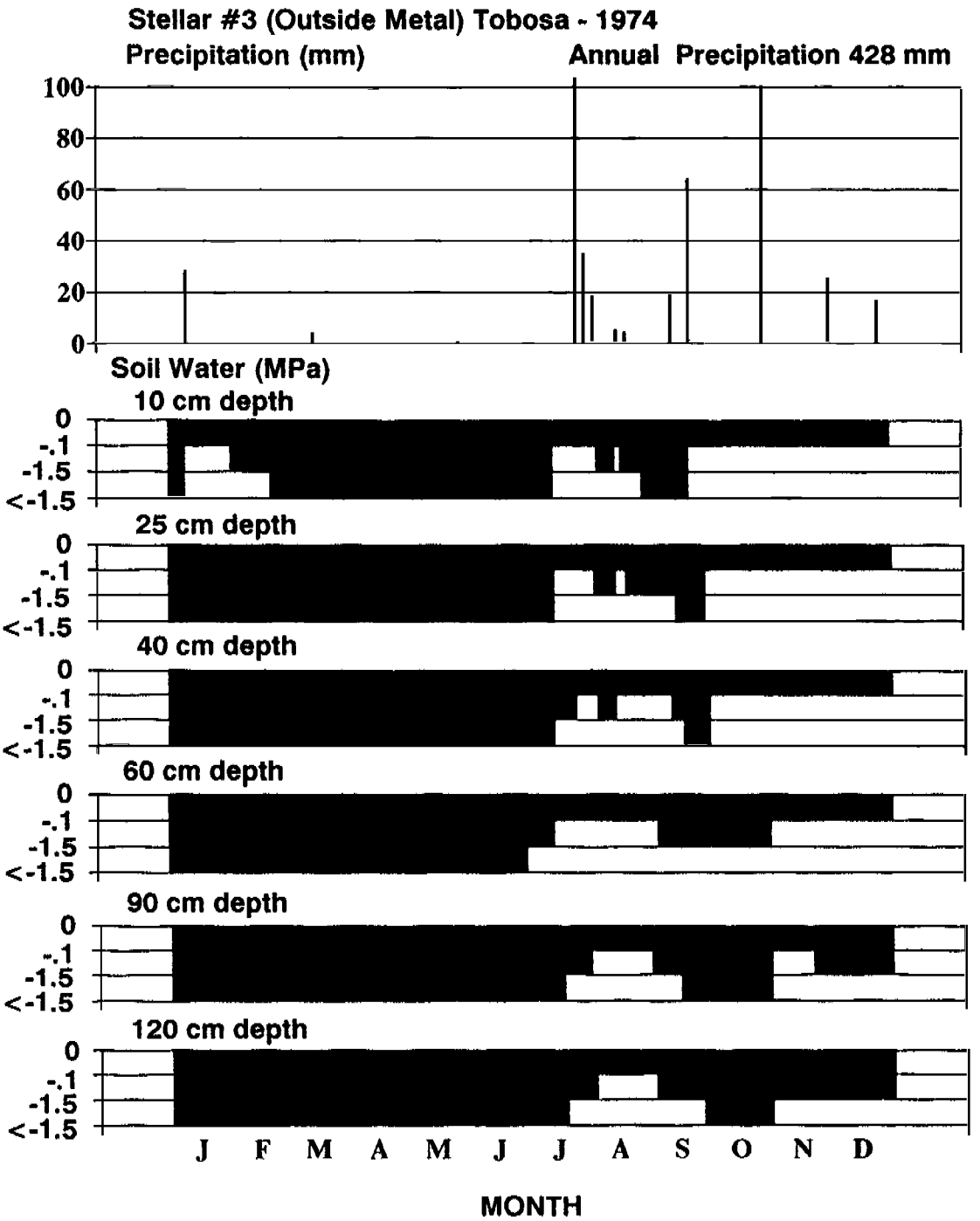


Figure 424. Annual (428 mm) and daily (mm) precipitation for 1974 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1974 at the Stellar #3 site dominated by tobosa.

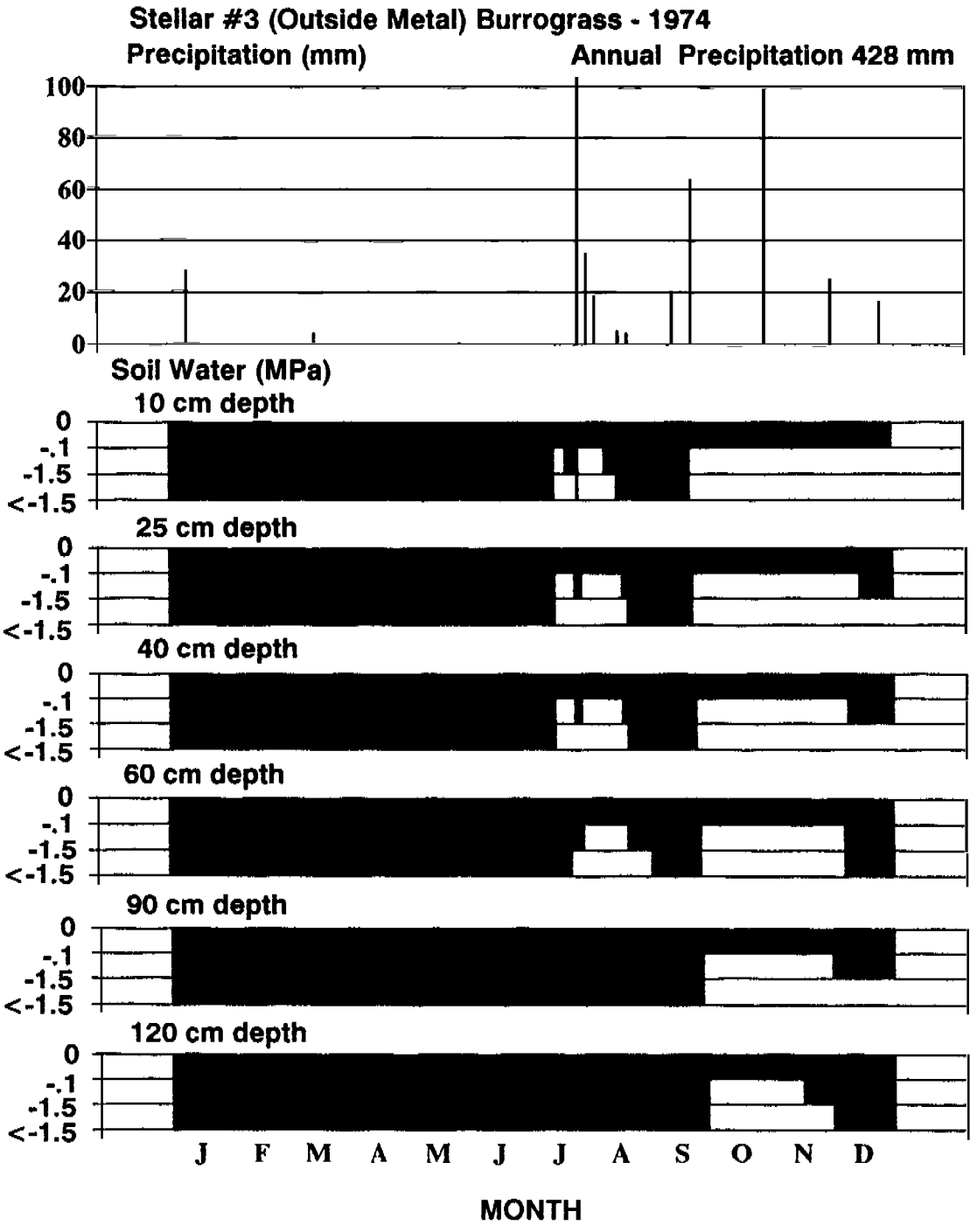


Figure 425. Annual (428 mm) and daily (mm) precipitation for 1974 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1974 at the Stellar #3 site dominated by burrograss.

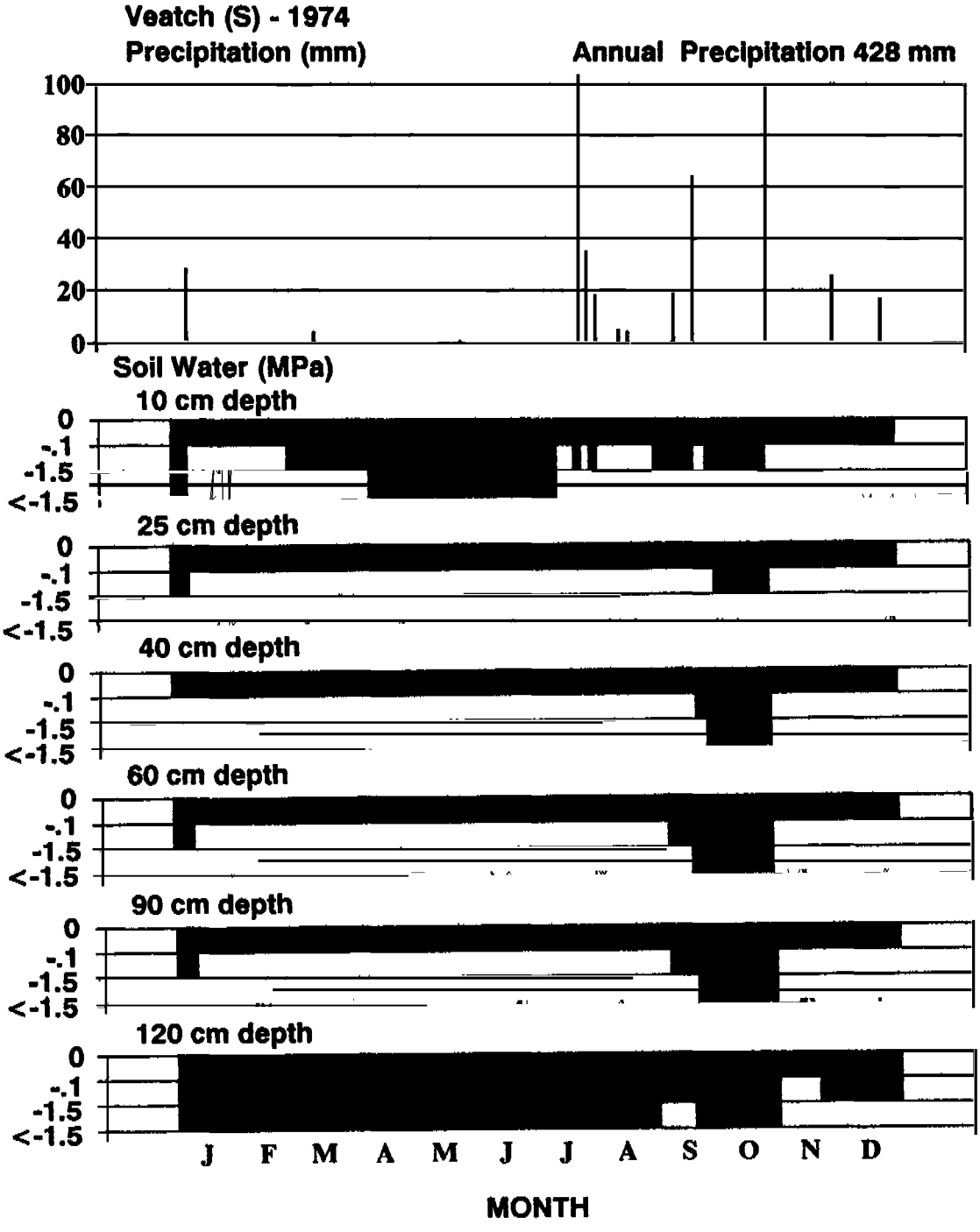


Figure 426. Annual (428 mm) and daily (mm) precipitation for 1974 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1974 at the Veatch (S) site.

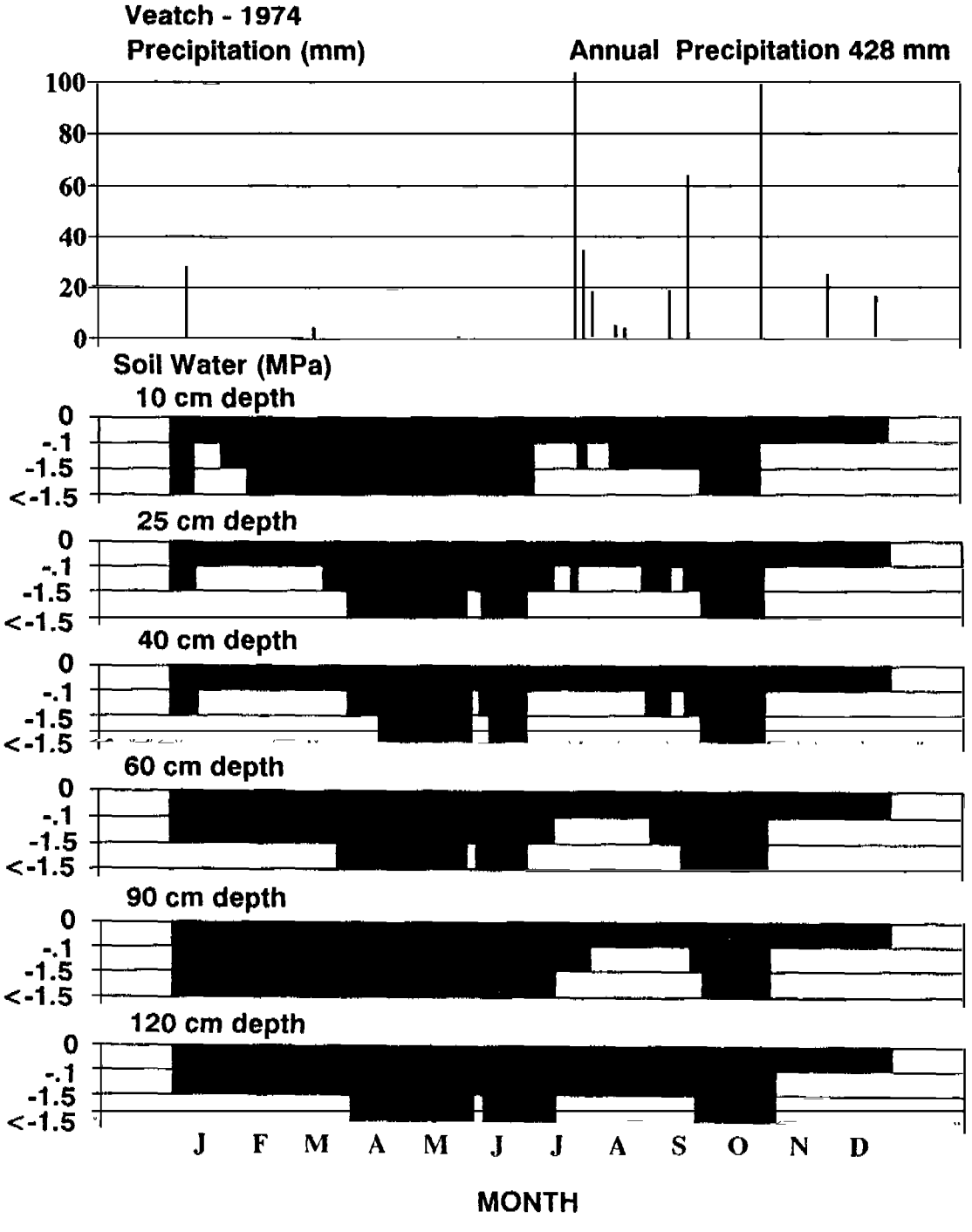


Figure 427. Annual (428 mm) and daily (mm) precipitation for 1974 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1974 at the Veatch site.

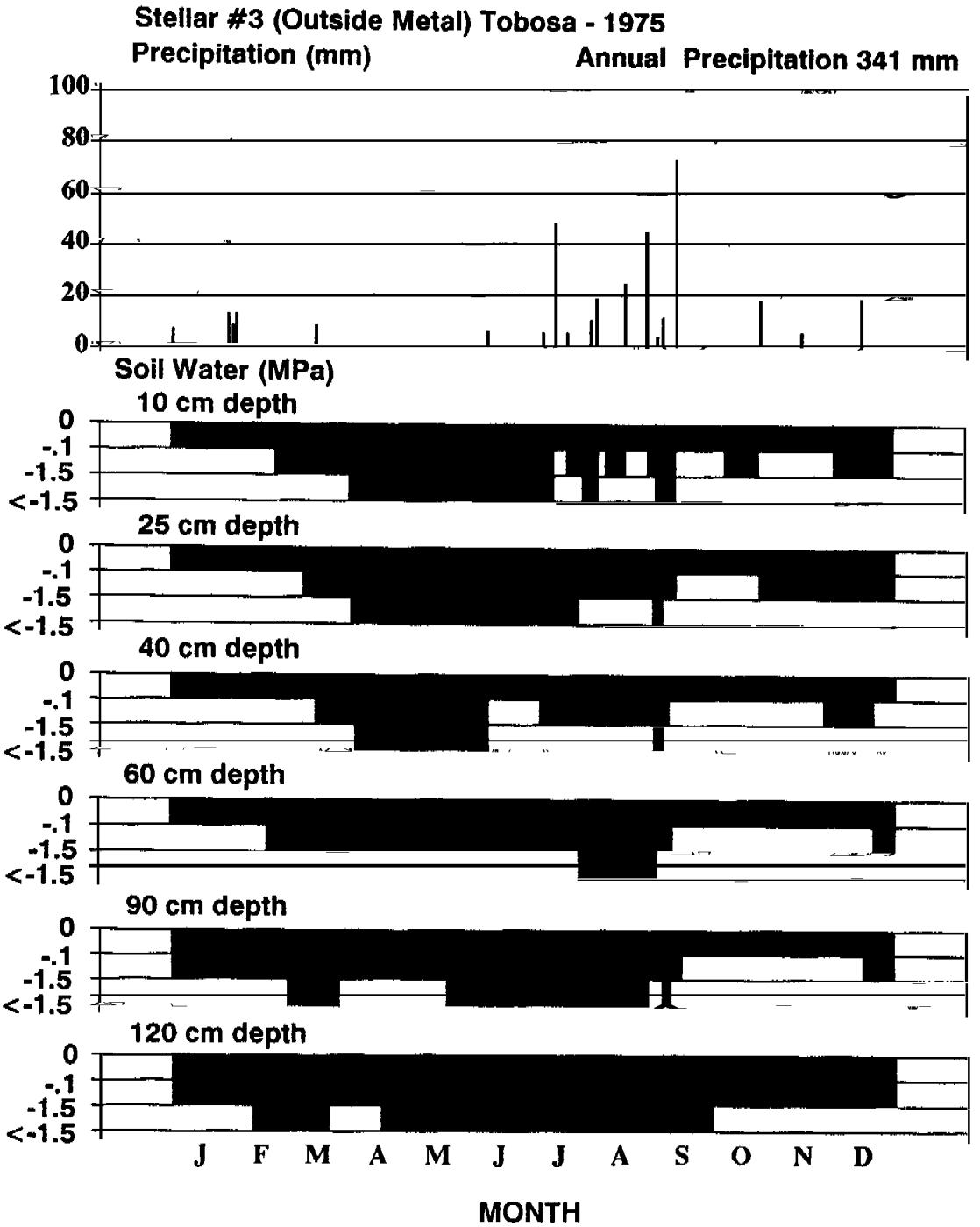


Figure 428. Annual (341 mm) and daily (mm) precipitation for 1975 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1975 at the Stellar #3 site dominated by tobosa.

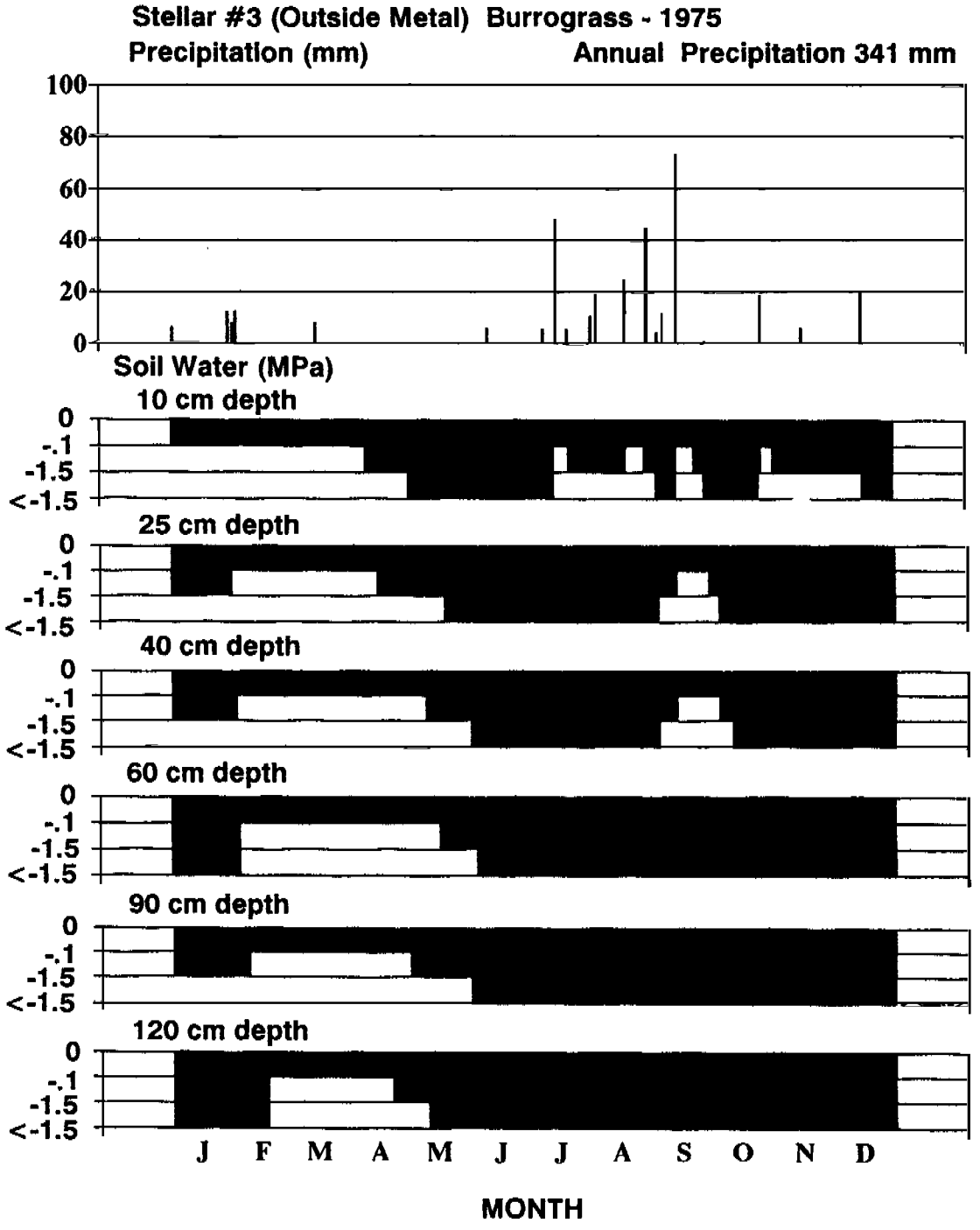


Figure 429. Annual (341 mm) and daily (mm) precipitation for 1975 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1975 at the Stellar #3 site dominated by burrograss.

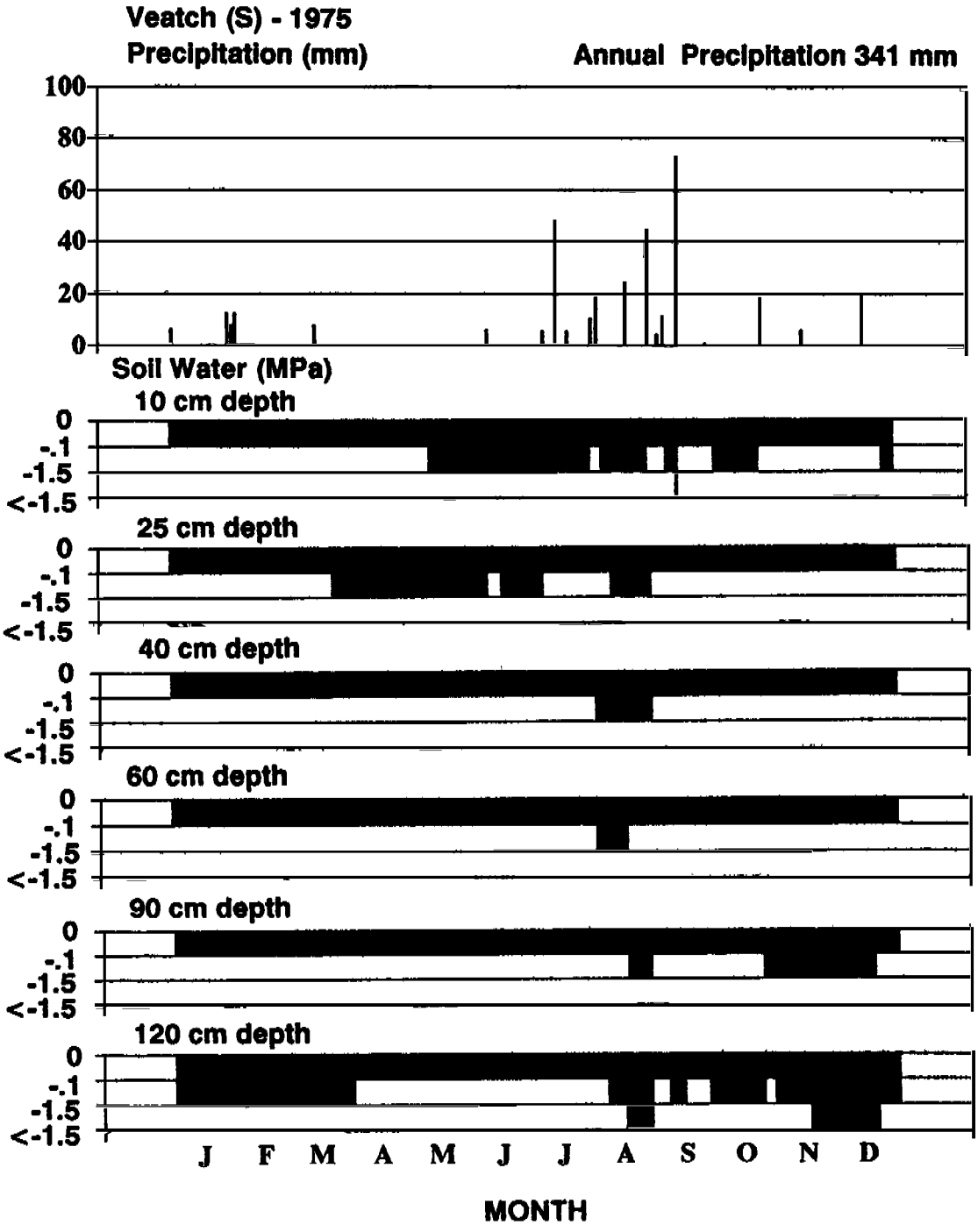


Figure 430. Annual (341 mm) and daily (mm) precipitation for 1975 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1975 at the Veatch (S) site.

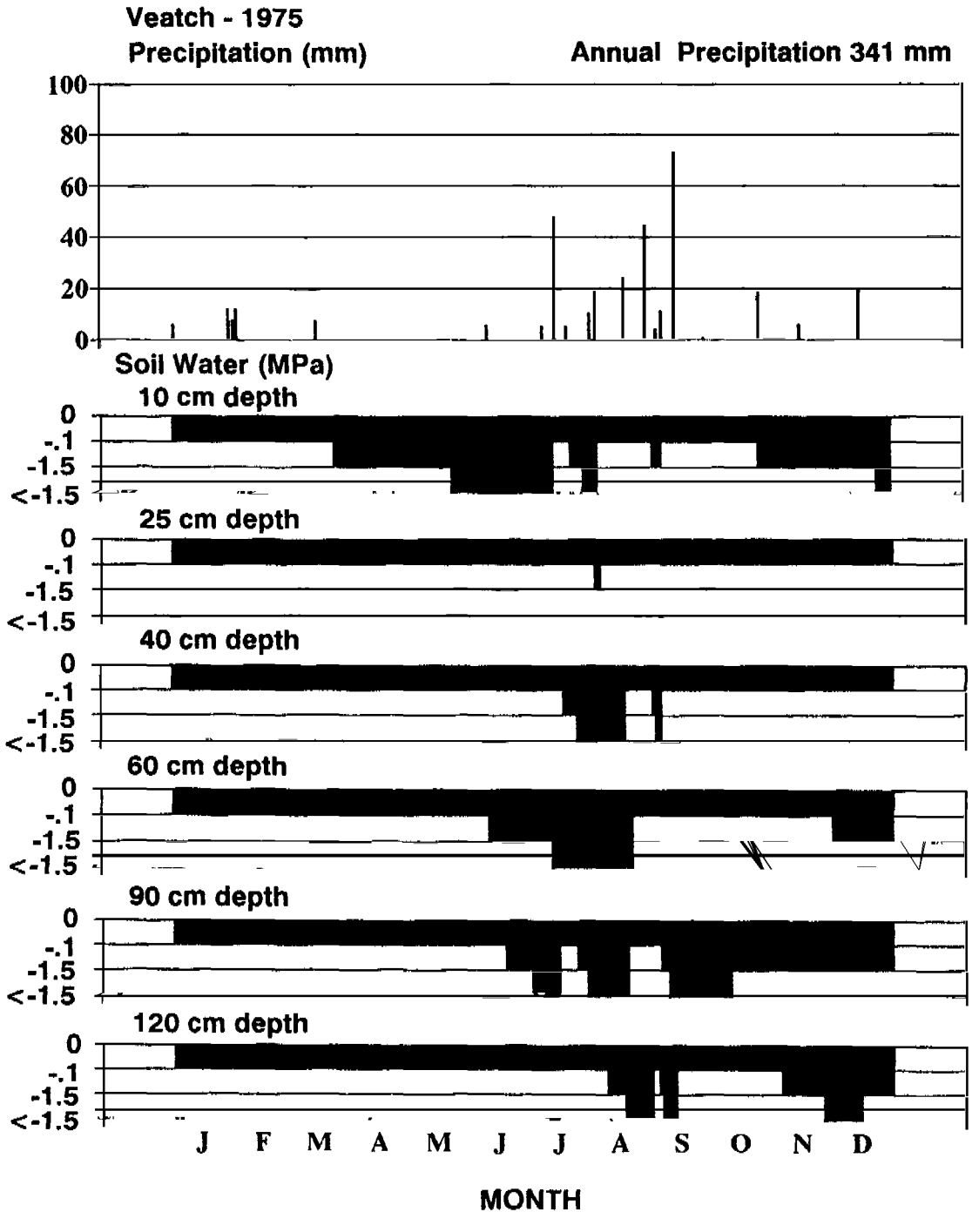


Figure 431. Annual (341 mm) and daily (mm) precipitation for 1975 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1975 at the Veatch site.

Annual precipitation for 1976 was 293 mm (figs. 432-435). At the 25-cm depth, soil water was >-1.5 MPa at Stellar #3 tobosa January 1-June 17 (fig. 432); Stellar #3 dominated by burrograss May 12-25 and June 11-14 (fig. 433); at Veatch (S) all year (fig. 434); and at Veatch also all 1976 (fig. 435).

The annual precipitation at Stuart Rain Gauge for 1958-76 averaged 270 mm. It was below average for 7 years, about average (± 10 mm) for 3 years, and above average for 9 years. Tobosa yields on the control plots at Fertilizer for 1958-66 averaged 2428 kg/ha. The probability of the soil water >-1.5 MPa at the 25-cm depth at Stellar #3 dominated by tobosa averaged 54.6% for December-April, 15.6% for May-June, 46.5% for July-September, and 50.7% for October-November (fig. 436). At Stellar #3 dominated by burrograss, the probability of soil water >-1.5 MPa at 25 cm averaged 26.6% for December-April, 6.4% for May-June, 29.8% for July-September, and 25.8% for October-November (fig. 437). The probability of soil water >-1.5 MPa at 25 cm for Veatch (S) averaged 82.4% for December-April, 62.5% for May-June, 87.5% for July-September, and 81.4% for October-November (fig. 438). For Veatch, it averaged 72.6% for December-April, 43.3% for May-June, 73.3% for July-September, and 68.5% for October-November (fig. 439). The two Veatch sites had a greater probability of having soil water >-1.5 MPa than the two Stellar sites at all depths sampled. Surface run-in was not permitted at the Veatch sites but both of them had a higher probability of soil water >-1.5 MPa than the two Stellar sites at this location. There was about twice the number of days per year that had soil water >-1.5 MPa at the Stellar site dominated by tobosa than the Stellar site dominated by burrograss.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime at the Stellar #3 site dominated by tobosa, 11 of 19 years had soil water <-1.5 MPa more than half the time at depths of 10 and 25 cm; 9 of 19 years at 40 cm; 10 of 18 years at 60 cm; 13 of 18 years at 90 cm; and 14 of 18 years at a soil depth of 120 cm. Eight of 19 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 6 of 19 years at 25 cm; 4 of 19 years at 40 cm; 4 of 18 years at 60 cm; 7 of 18 years at 90 cm; and 8 of 18 years at a depth of 120 cm.

For the aridic (torric) moisture regime at the Stellar #3 site dominated by burrograss, 17 of 18 years had soil water <-1.5 MPa more than half the time at depths of 10, 25, 40, and 60 cm; 16 of 18 years at 90 cm; and 15 of 18 years at a depth of 120 cm. Fifteen of 18 years had soil water <-1.5 MPa for >90 consecutive days at depths of 10 and 60 cm; 13 of 18 years at 25 and 40 cm; and 14 of 18 years at soil depths of 90 and 120 cm.

For the aridic (torric) moisture regime at the Veatch (S) site, 7 of 18 years had soil water <-1.5 MPa more than half the time at depths of 10 and 120 cm, and 3 of 18 years at soil depths of 25, 40, 60, and 90 cm. Three of 18 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 2 of 18 years at 25, 40, and 60 cm; 1 of 18 years at 90 cm; and 5 of 18 years at a soil depth of 120 cm.

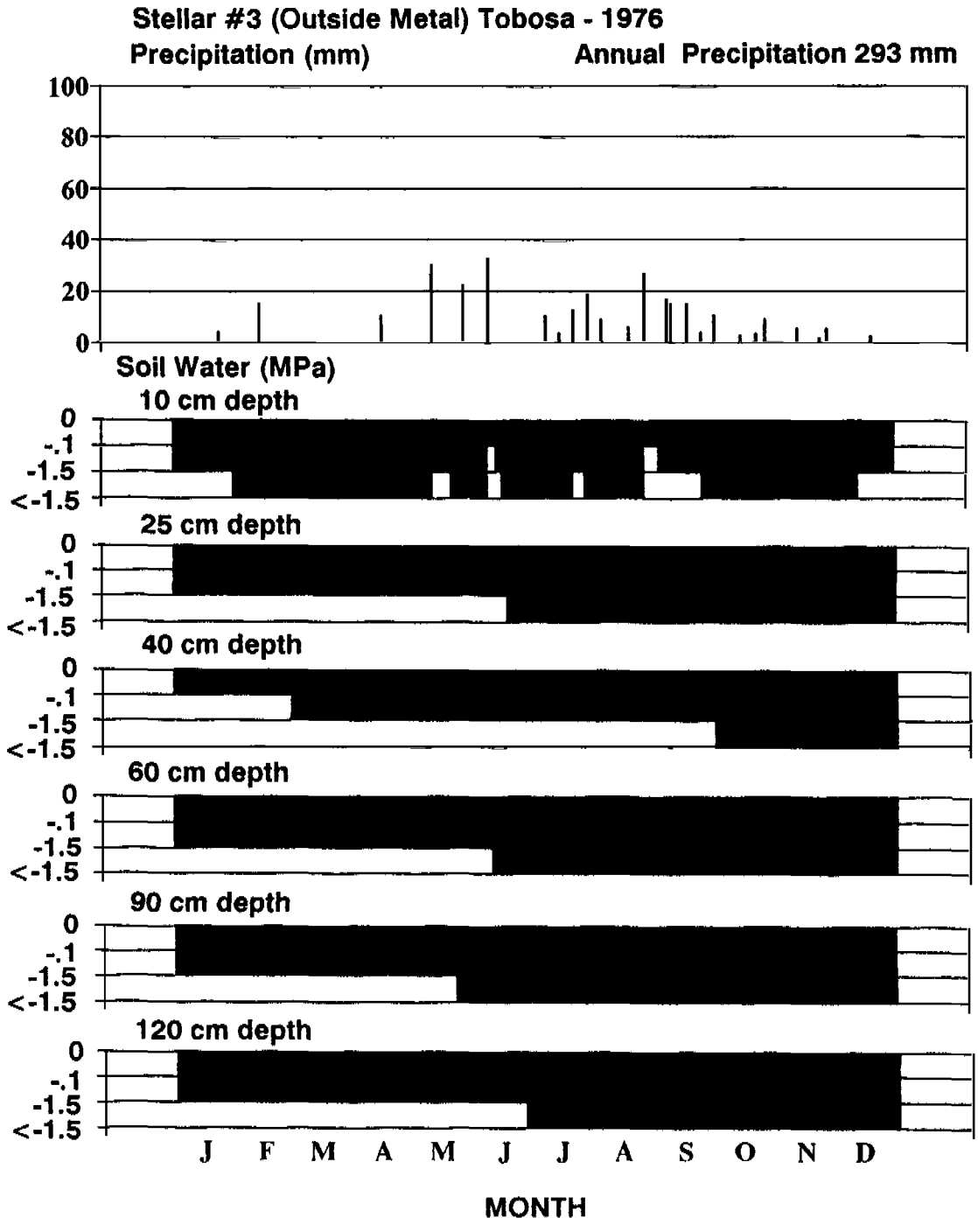


Figure 432. Annual (293 mm) and daily (mm) precipitation for 1976 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1976 at the Stellar #3 site dominated by tobosa.

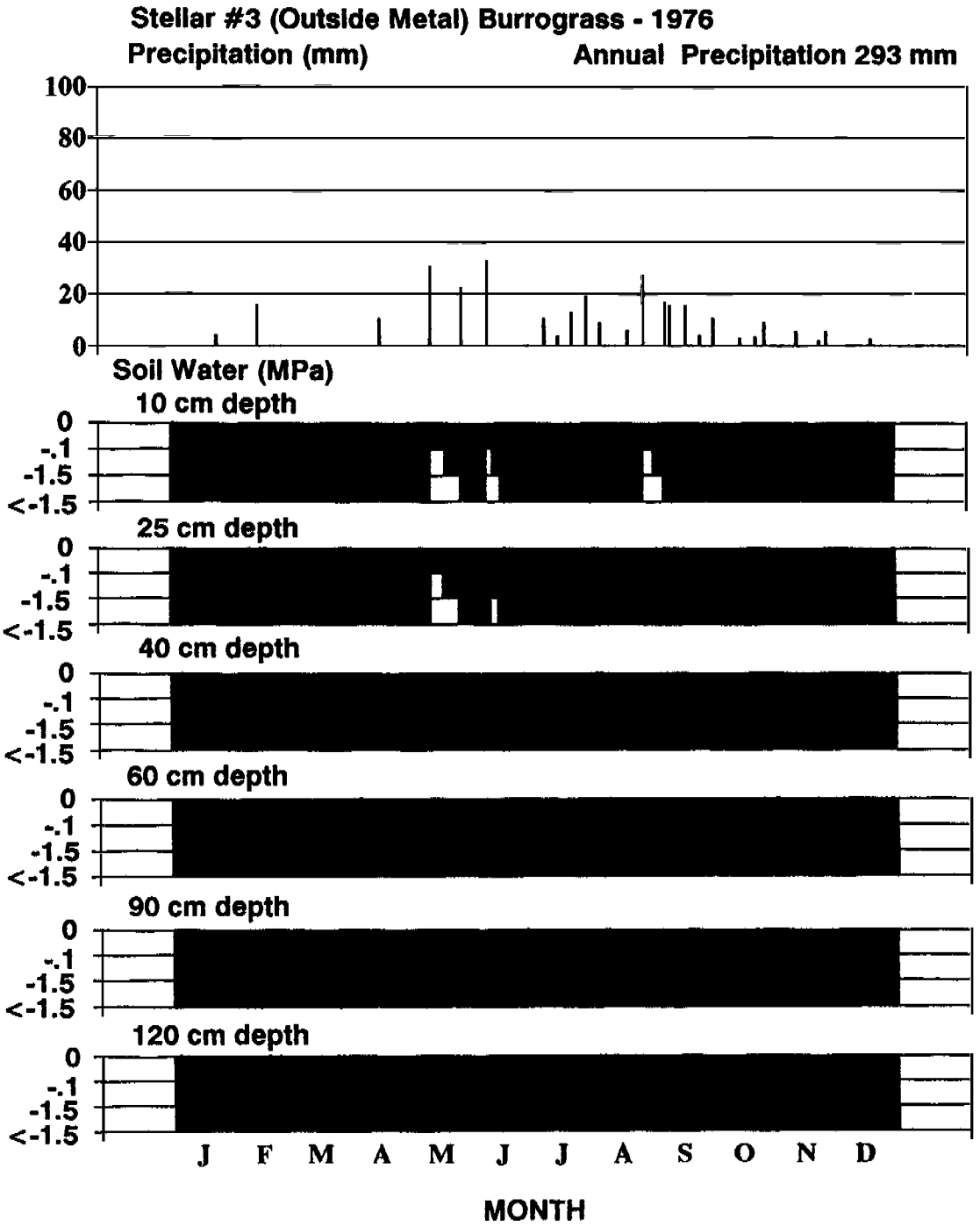


Figure 433. Annual (293 mm) and daily (mm) precipitation for 1976 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1976 at the Stellar #3 site dominated by burrograss.

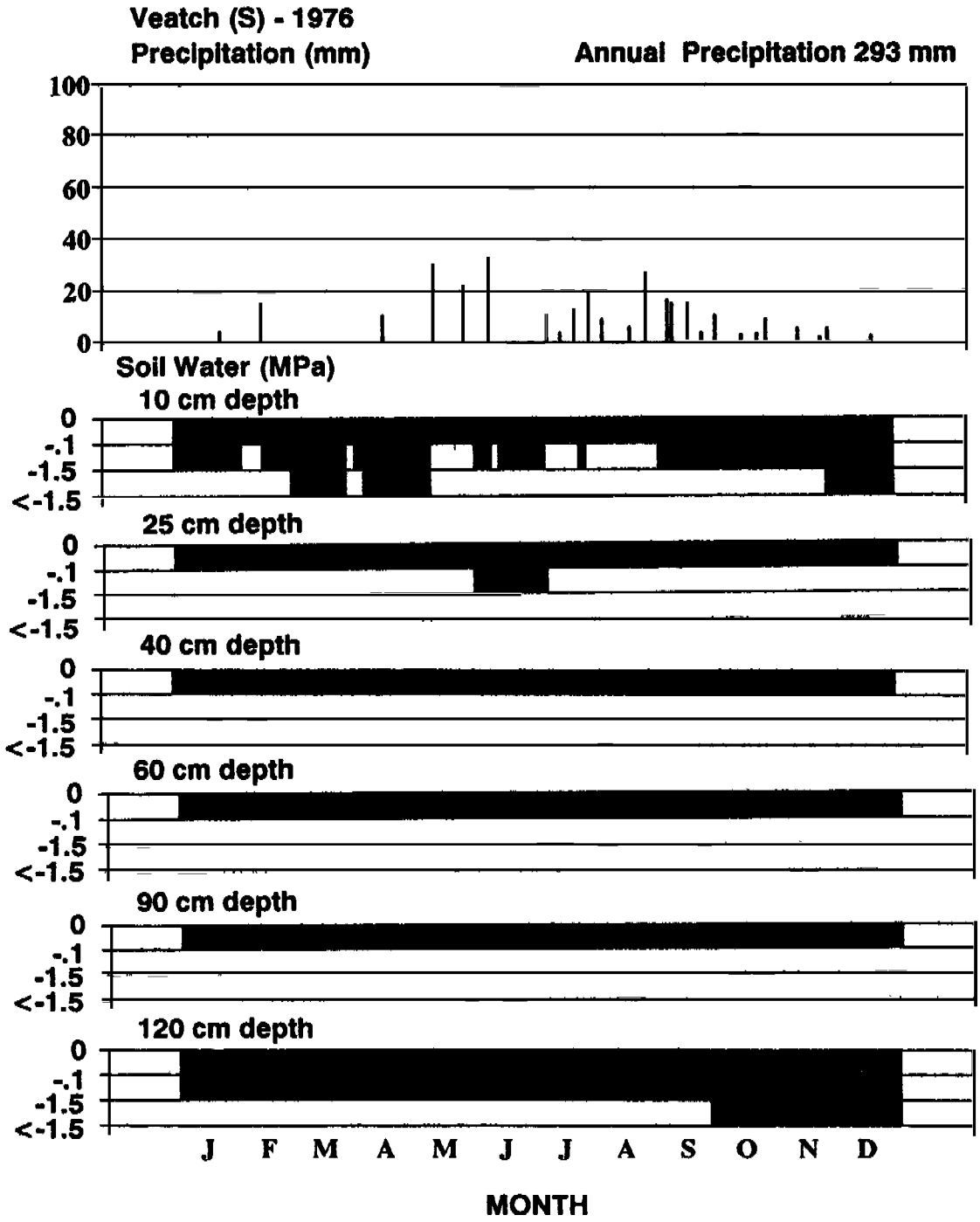


Figure 434. Annual (293 mm) and daily (mm) precipitation for 1976 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1976 at the Veatch (S) site.

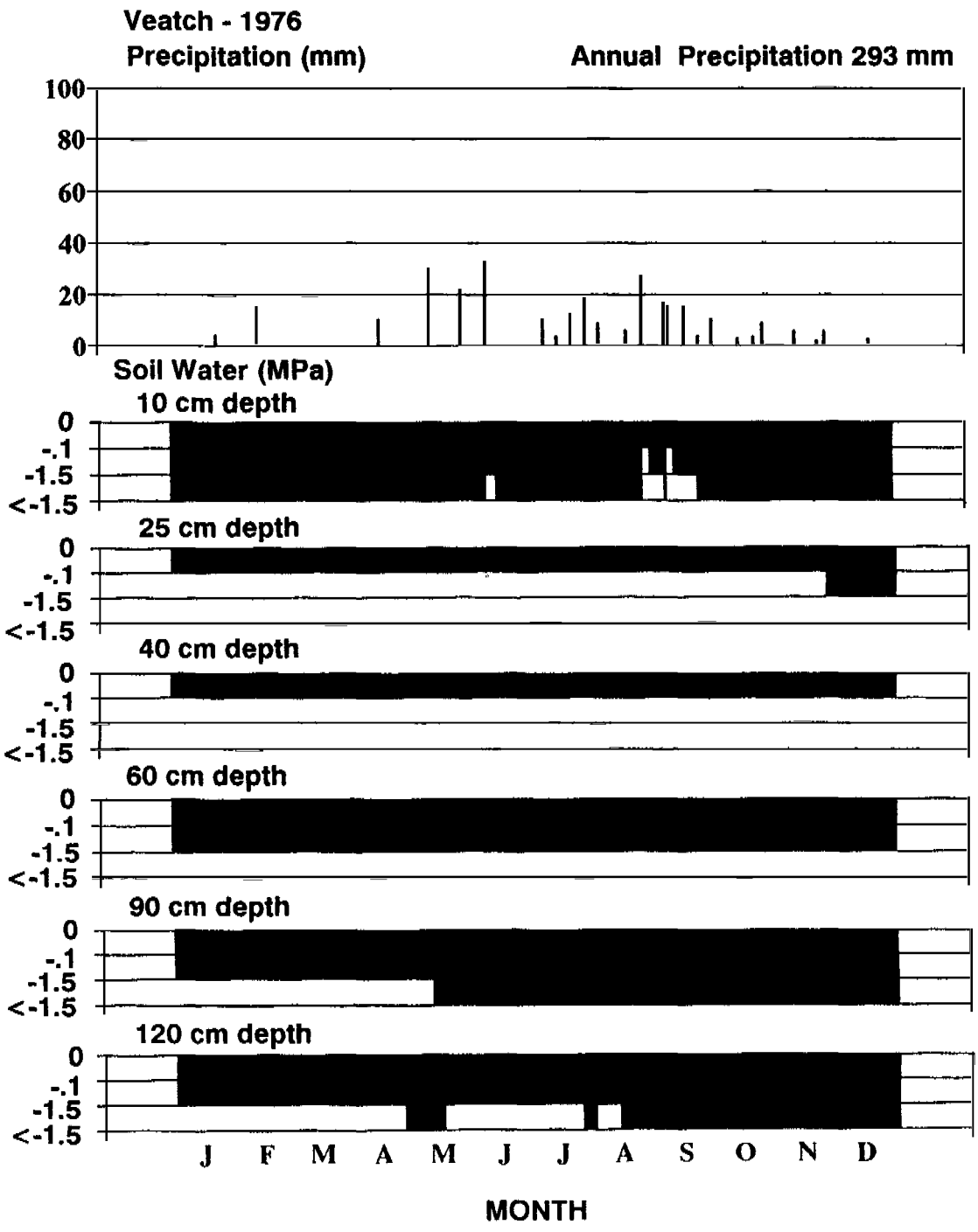


Figure 435. Annual (293 mm) and daily (mm) precipitation for 1976 at Stellar #2; and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm for 1976 at the Veatch site.

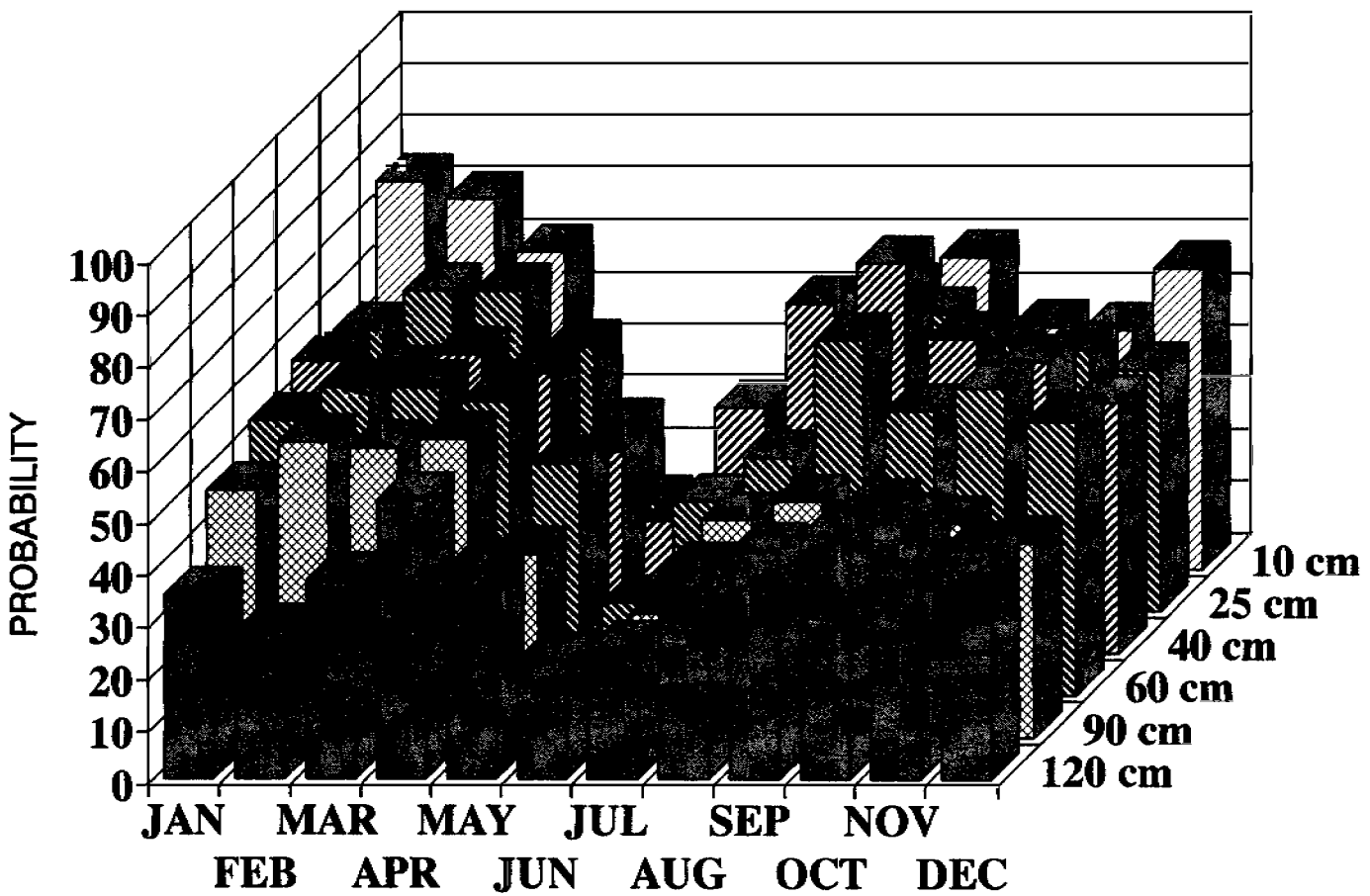


Figure 436. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #3 site dominated by tobosa.

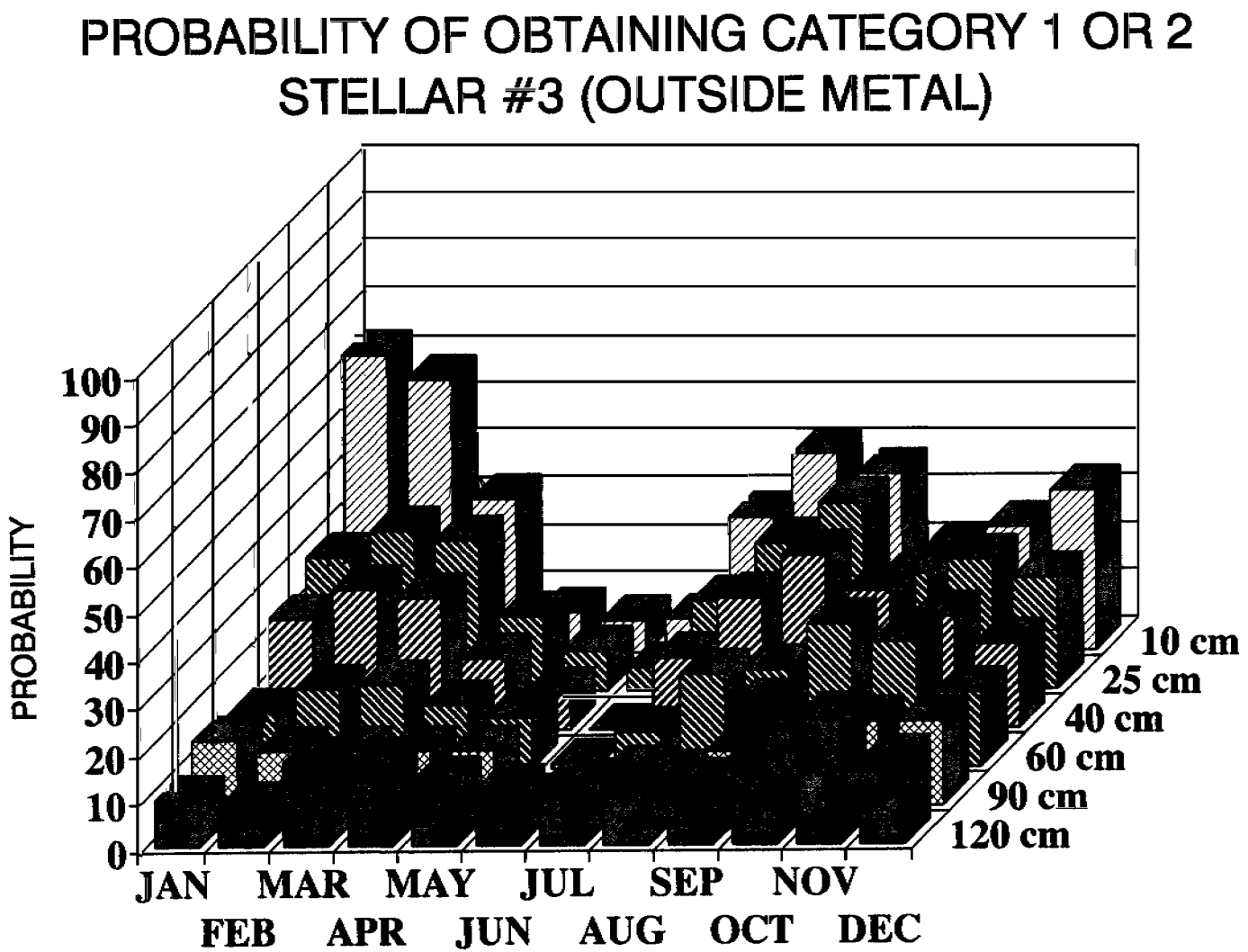


Figure 437. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm at the Stellar #3 site dominated by burrograss.

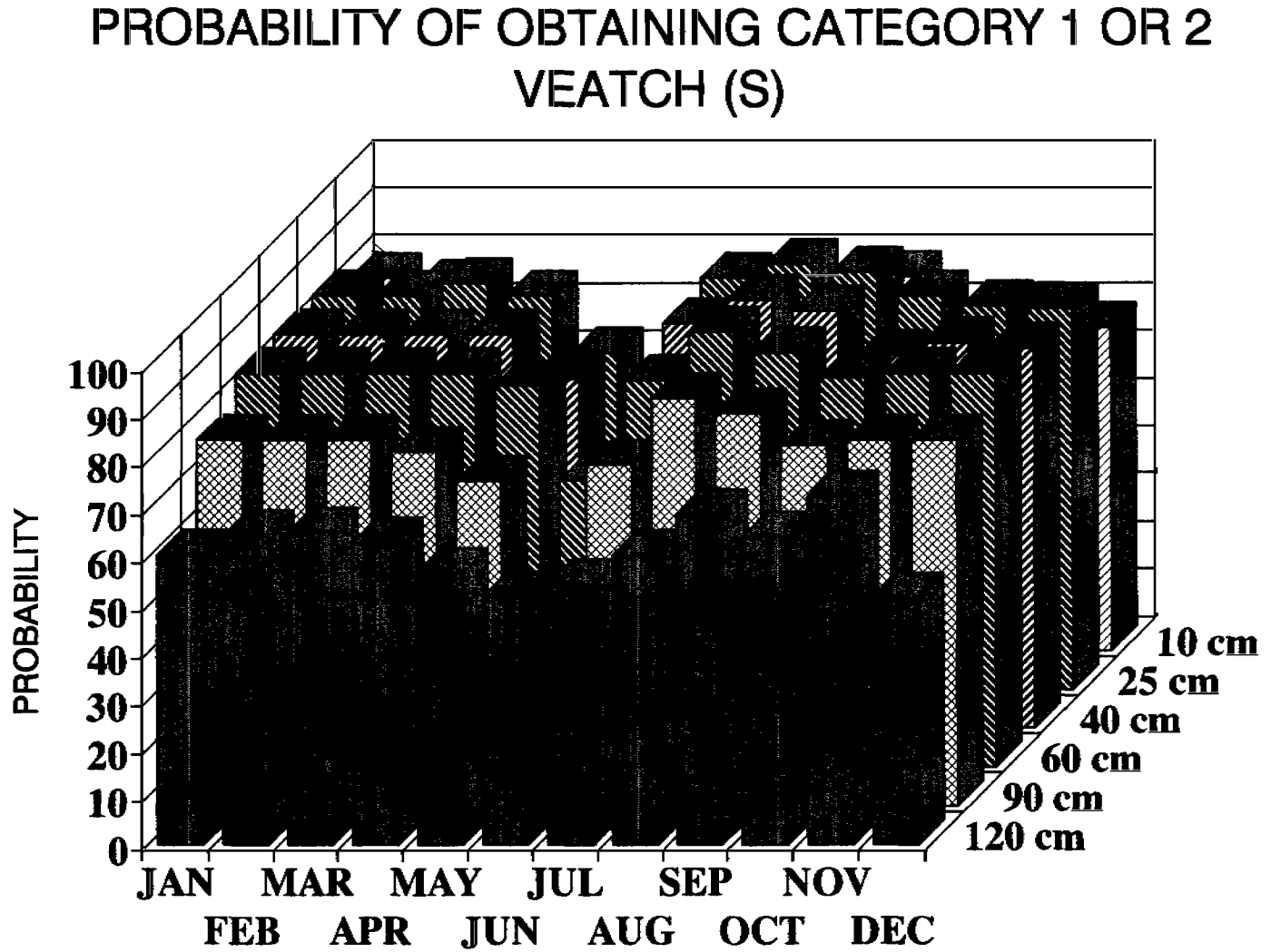


Figure 438. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm at the Veatch (S) site.

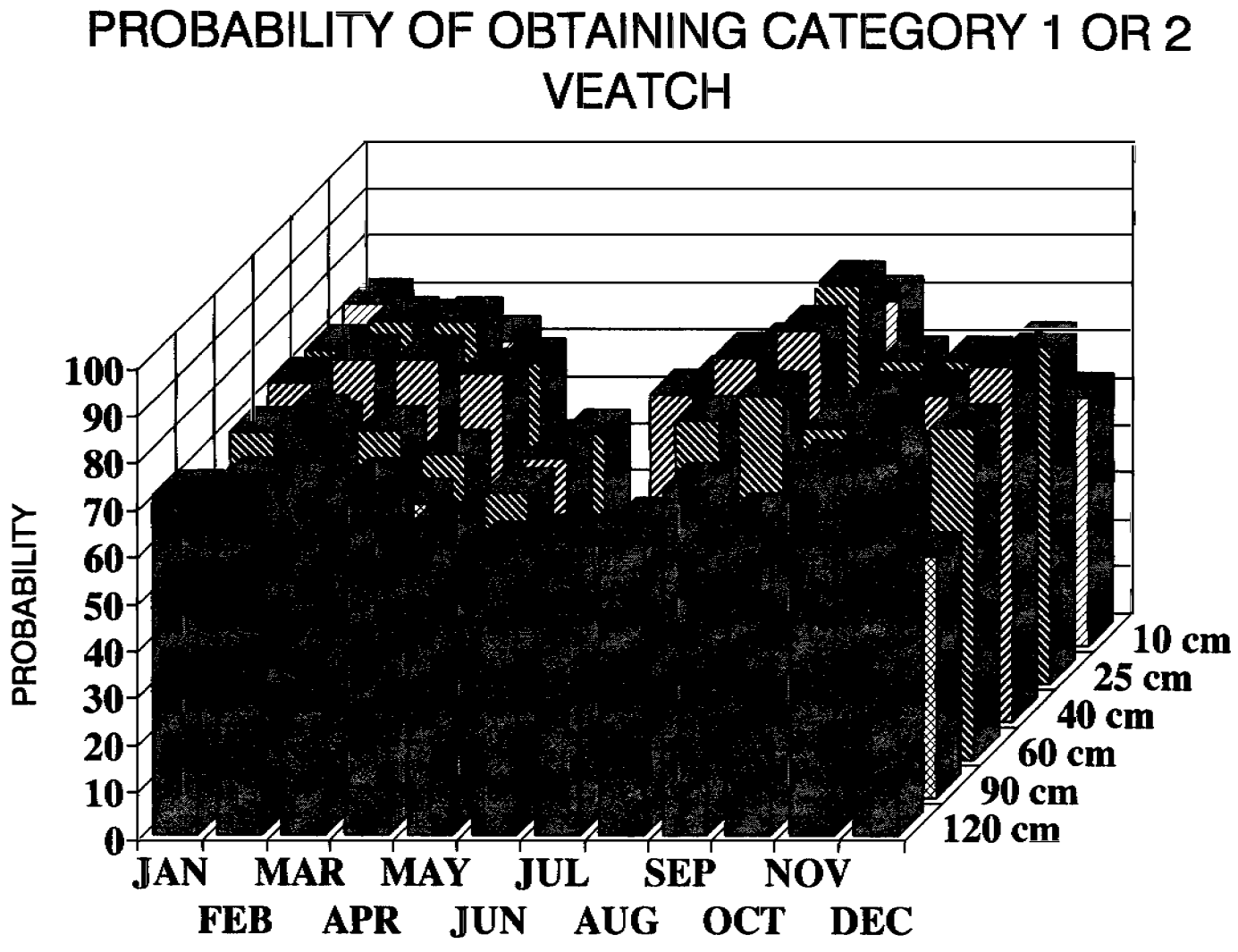


Figure 439. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm at the Veatch site.

For the aridic (torric) moisture regime at the Veatch site, 9 of 18 years had soil water <-1.5 MPa more than half the time at a depth of 10 cm; 6 of 18 years at 25 and 40 cm; 5 of 18 years at 60 cm; 7 of 18 years at 90 cm; and 4 of 18 years at a soil depth of 120 cm. Eight of 18 years had soil water <1.5 MPa for >90 consecutive days at a depth of 10 cm; 2 of 18 years at 25 and 40 cm; 3 of 18 years at 60 cm; 6 of 18 years at 90 cm; and 4 of 18 years at a soil depth of 120 cm.

For the bordering ustic moisture regime when the data were complete for the calendar year, there were at least 60 consecutive days of soil water >-1.5 MPa at the 25-cm depth 15 of 17 years at Stellar #3 tobosa, 8 of 16 years at Stellar #3 burrograss, and 15 of 16 years at the two Veatch sites. There were at least 30 consecutive days of soil water >-1.5 MPa in the four months after June 21, 11 of 17 years at Stellar #3 tobosa, 4 of 16 years at Stellar #3 burrograss, 13 of 16 years at Veatch (S), and 15 of 16 years at Veatch. The soil water data were incomplete in the initial year of observation and in 1972 but the 60-day criterion was observed at all sites except during the initial year (1959) at Stellar #3 dominated by burrograss. The 30-day criterion was observed at all sites at Fertilizer during the initial year of soil water observations and at the two Veatch sites during 1972.

Small Playa with Run-in

Site Barcross (B)

Site B (figs. 4, 440, 441, table 14) is in the Northeast Exclosure on the Jornada Experimental Range. The site is level, and is in a small playa at the end of a drainageway that begins on the slopes of the San Andres Mountains. The study trench is 8 m west of the west fence of the exclosure at a point about 23 m north of the southwest corner.

The playa is flooded about twice every 3 years. Vegetation on this site is a mixed stand of tobosa and burrograss. The yields at this site are more variable than those reported for site S1, R, and S3.

Soils. The soil moisture blocks are in the Typic Calciorthid Barcross (fig. 441, table 14). Diagnostic horizons are an ochric epipedon and a calcic horizon. The soil has formed primarily in alluvium resting on gypsum that appears to be of lacustrine origin. The alluvium apparently was originally derived from rocks of the San Andres Mountains to the east--dominantly from limestone, sandstone, siltstone, and shale, with some from igneous rocks. The alluvium is thickest in the lowest part of the playa, as at this site. At other parts of the playa, gypsum is nearer the surface or at the surface. A nodular, weak stage II carbonate horizon occurs from 90 to 112 cm, suggesting the possibility of Isaacks' Ranch age (table 1).

Table 14. Characteristics of the Typic Calciorthid Barcross at site B.

Horizon	Depth cm	Hue	Value/chroma		Structure	Consistence		Eff. with HC1	Textural class
			Dry	Moist		Dry	Moist		
C	0-3	8YR	6.5/4	5/4	sg	l	l	es	fsl
A	3-12	10YR	7/2	5/3	m,lmpl	h	fr	es	fsl
BA1	12-31	10YR	7/2	5/3	lcpr-lmsbk	vh	fi	es	cl
BA2	31-50	7.5YR	6.5/3	5/3	lmpr-lmsbk	vh	fi	es	scl
Bk1	50-65	7.5YR	7/3	5/4	lmpr-lf,msbk	sh,h	fi	es	sicl
Bk2	65-90	7.5YR	7/3	5/4	2f,mpr-lf, msbk	sh,h	fr	es	sicl
Bk3	90-112	10YR	7/3	5/3	2f,mpr-lm, fsbk	h,sh	fr	es	sicl
Ck1	112-120	10YR	9/2	7/2	lmpr-lmsbk	sh,h	fr	es	l
Ck2	120-138	10YR	8/2	6/3	m	vh	fi	es	sl

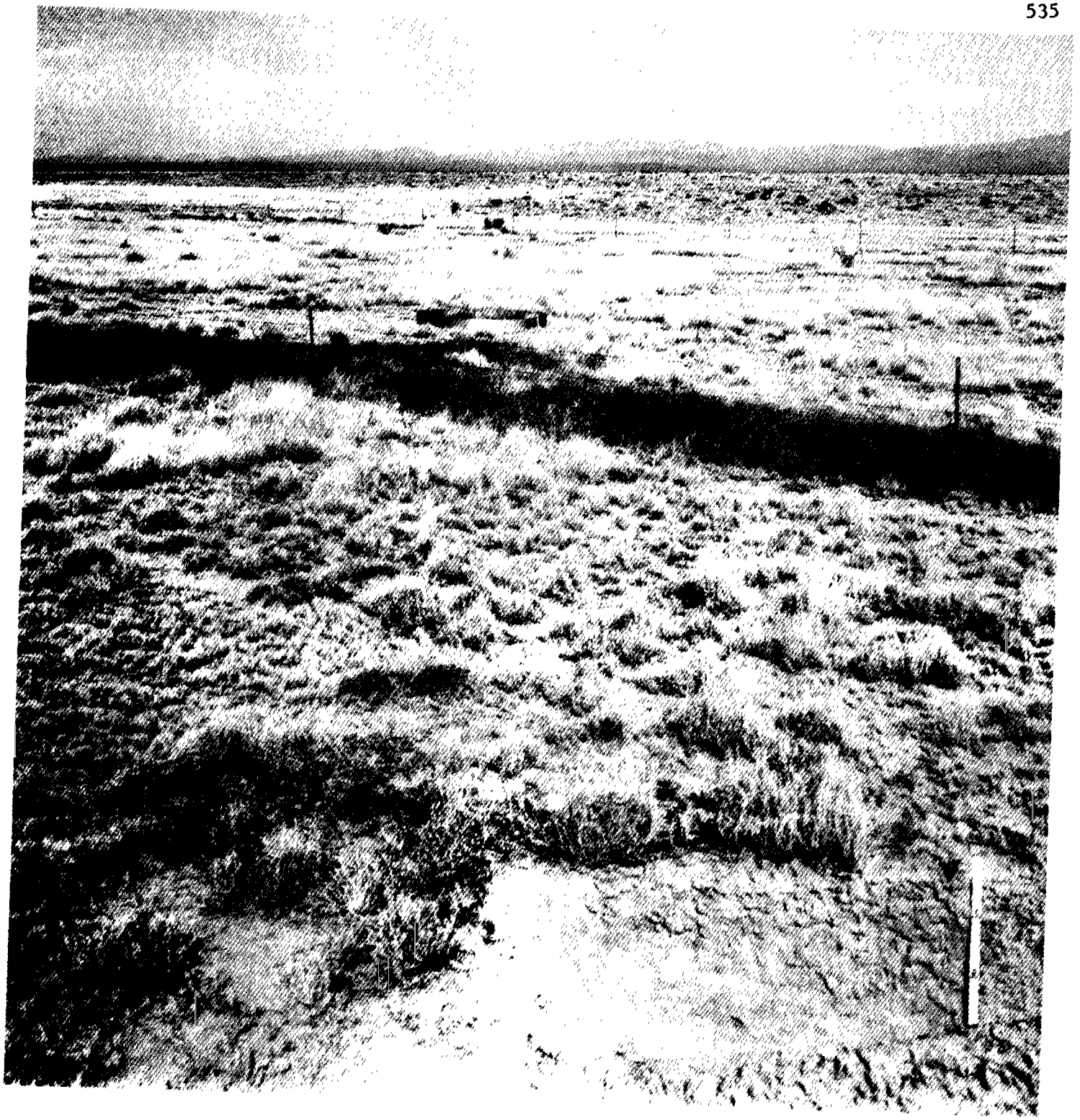


Figure 440. Landscape at Site B (fig. 4), and the Ustollic Calciorthid Barcross, in the Northeast exclosure in the Jornada Experimental Range. The nonrecording rain gauge is at left. Stakes and wires to the soil water blocks are outside and inside the metal cylinder at left center. The San Andres Mountains are on the skyline. Photographed March 1971.

Figure 441. Profile of the Ustollic Calciorthid Barcross. Gypsum of apparent lacustrine origin occurs at a depth of slightly greater than a meter. Scale is in feet.

The soil water data show that the A and BA1 horizons are moistened most frequently. However, these horizons and those below are still strongly calcareous because of the high-carbonate parent materials. Judging from morphology and soil water relations, carbonate is slowly accumulating at the present time, primarily in the upper part of the B horizon. No evidence of illuviation of silicate clay was observed and would not be expected because of abundant carbonate in the parent materials.

Soil Water, Precipitation, and Yields. The rain gauge and gypsum blocks in two replications at depths of 10, 25, and 40 cm were installed August 16, 1957 and at 60, 90, and 120 cm on July 31, 1959 within a livestock exclosure approximately 4.8 km north of Headquarters. On July 29, 1959, two replications of blocks were installed at depths of 10, 25, 40, 60, 90, and 120 cm within a sheet metal cylinder that excluded run-in. The precipitation for August 16-December 31, 1957 was 141 mm. The soil water at 10 cm was >-1.5 MPa August 16-26 (fig. 442); August 30-September 13; and October 9-December 31, 1957. The moisture control section, 25-cm soil depth, had water >-1.5 MPa August 16-September 21 and December 7-31 (fig. 442). There was soil water >-1.5 MPa at the 40-cm depth August 16-September 21, 1957 (fig. 442). The vegetation at this site consisted of burrograss interspersed with stands of tobosa. The grasses on 30.5-cm x 1.5-m quadrats were clipped to ground level each fall, except 1960, beginning in 1957. The 1957 yield of burrograss was 1263 kg/ha (n=25, s.e.=109 kg/ha) while the tobosa yielded 3274 kg/ha (n=15, s.e.=215 kg/ha).

Annual precipitation for 1958 was 241 mm (fig. 443). The 25-cm depth had soil water >-1.5 MPa January 1-4, 1958; January 24-May 10; and September 14-December 18, 1958 (fig. 443). Burrograss yielded 1960 kg/ha (n=25, s.e.=124 kg/ha) and the tobosa yields were 2501 kg/ha (n=25, s.e.=273 kg/ha).

The precipitation for 1959 was 202 mm with 70% occurring in August (figs. 444, 445). The 25-cm depth had soil water >-1.5 MPa July 30-September 16 (fig. 444). The 25-cm depth within the cylinder had soil water >-1.5 MPa July 31-September 12 (fig. 445) indicating that run-in contributed four extra days of soil water >-1.5 MPa to the 25-cm depth in September, 1959. Estimates of burrograss production in fall 1959 were 2582 kg/ha (n=25, s.e.= 340 kg/ha) and tobosa produced 3965 kg/ha (n=25, s.e.=433 kg/ha).

The 1960 precipitation was 130 mm with 56 mm in December (figs. 446, 447). Neither outside nor inside the sheet metal had soil water >-1.5 MPa at 25 cm in 1960 until estimates inside the metal showed water >-0.1 MPa December 28-31 (fig. 447). Visual estimates of grass production were obtained in 1960 because it was so low. These estimates were 9 kg/ha for the burrograss and 11 kg/ha for tobosa.

Annual precipitation was above average and similar for 1961 and 1962. Outside the metal, there was soil water >-1.5 MPa at the 25-cm depth January 2, 1961-May 11 (fig. 448); July 9-August 4; September 8-30; November 16, 1961-April 25, 1962 (figs. 448, 450); July 29-August 14; September 27-November 29; and December 3, 1962-

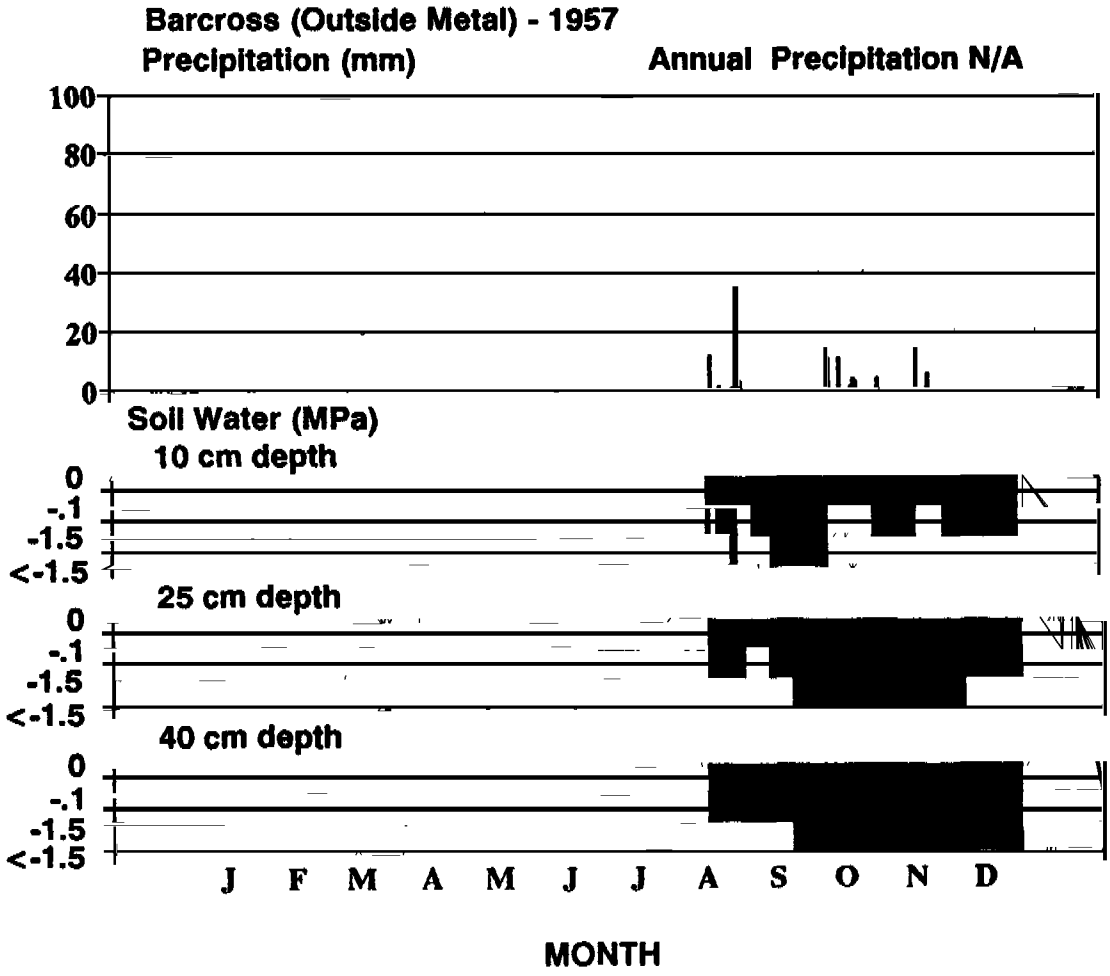


Figure 442. Daily precipitation (mm) and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm for August 16-December 31, 1957 outside a sheet metal cylinder at the Barcross site.

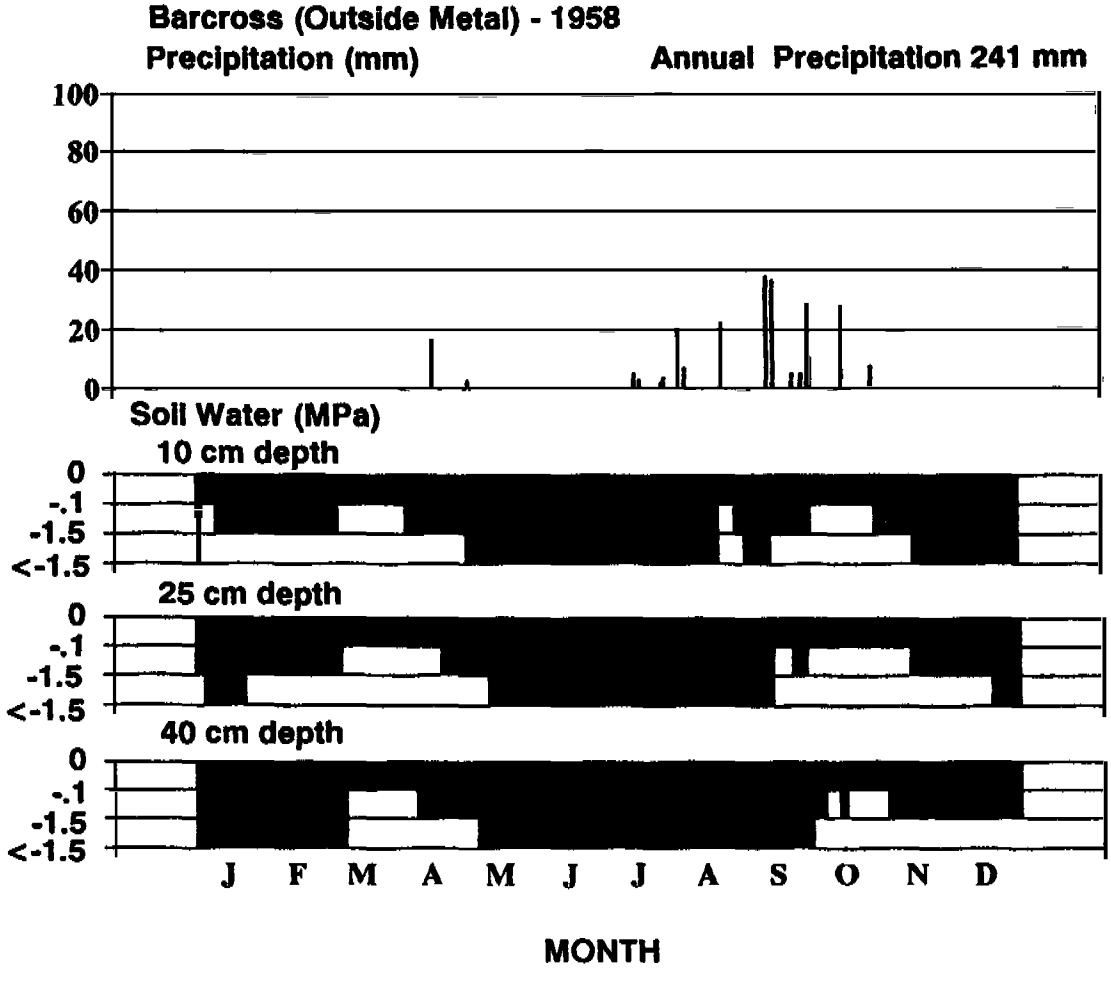


Figure 443. Annual precipitation (241 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm outside a sheet metal cylinder at the Barcross site for 1958.

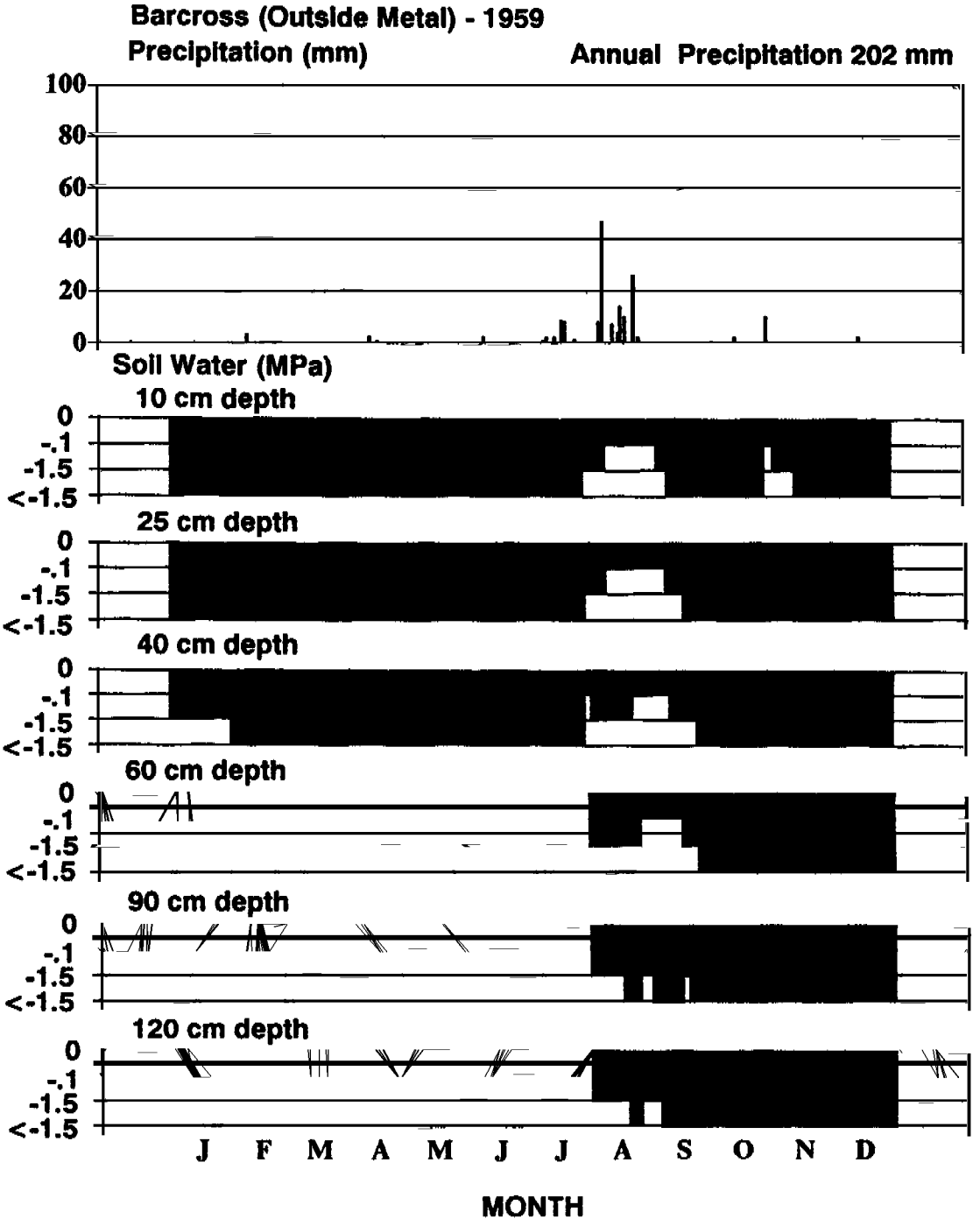


Figure 444. Annual precipitation (202 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, and 40 cm outside a sheet metal cylinder at the Barcross site for 1959. Also shown is the soil water at depths of 60, 90, and 120 cm July 31-December 31, 1959.

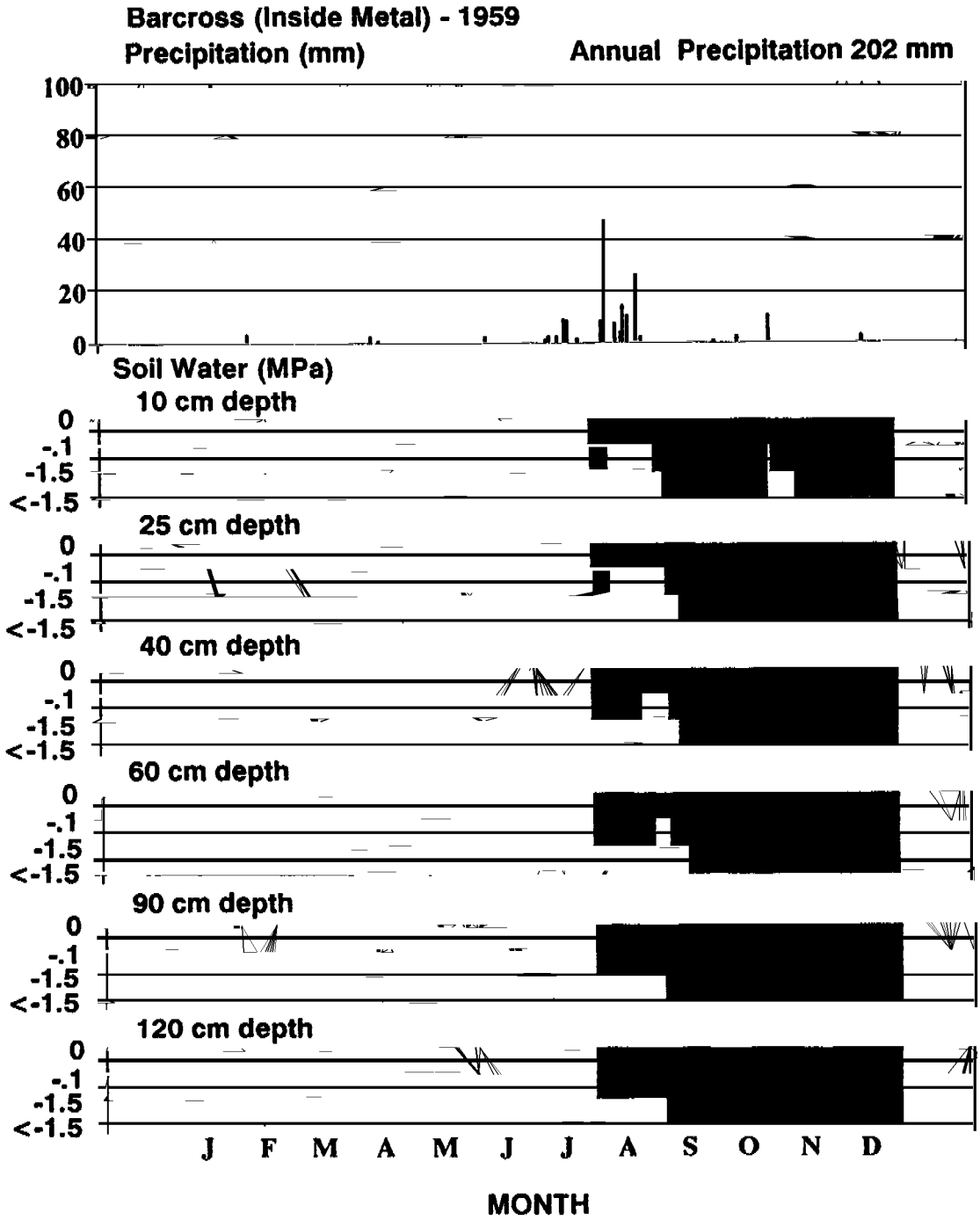


Figure 445. Annual precipitation (202 mm) and daily precipitation (mm) for 1959, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm July 31-December 31, 1959 inside a sheet metal cylinder at the Barcross site.

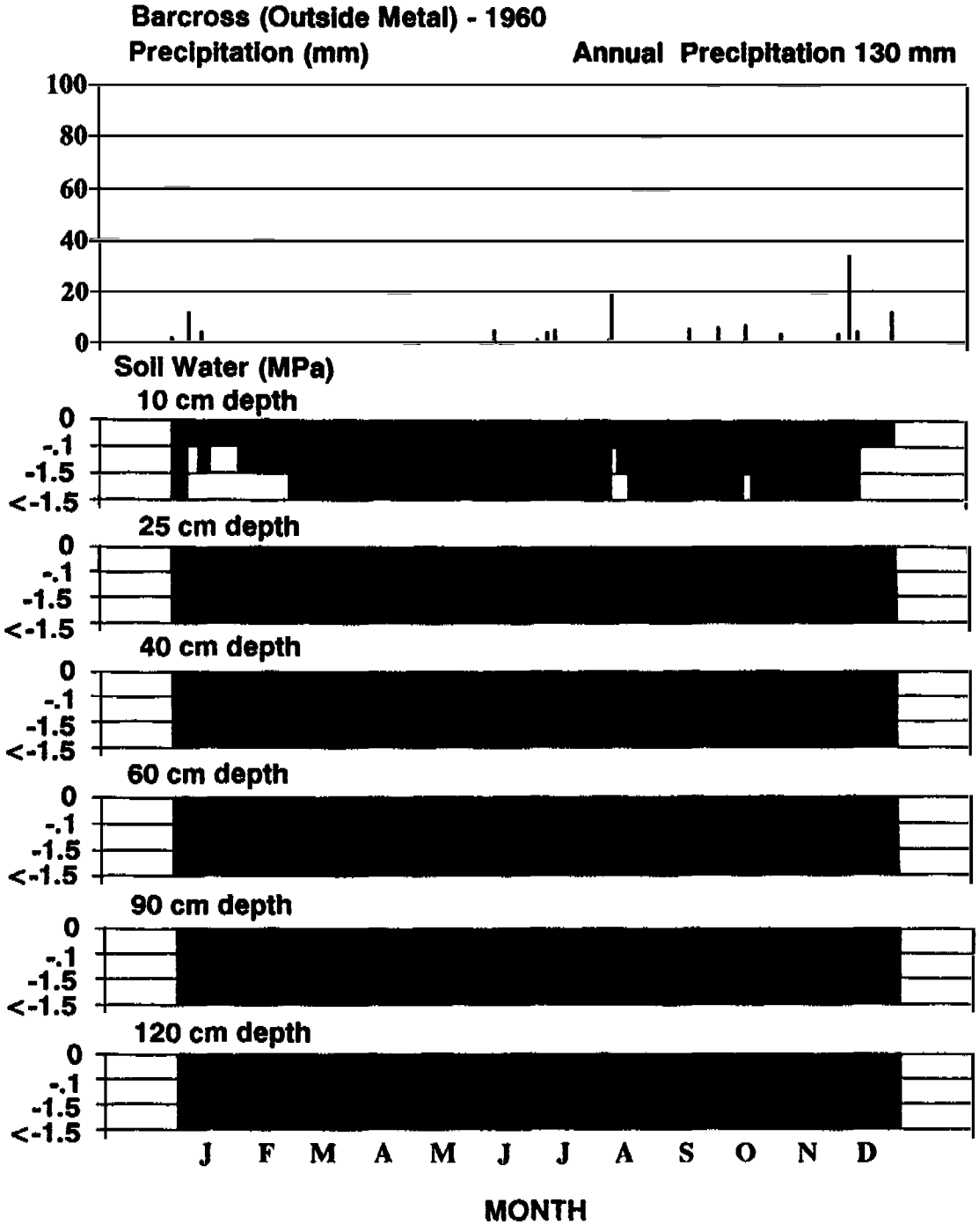


Figure 446. Annual precipitation (130 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1960.

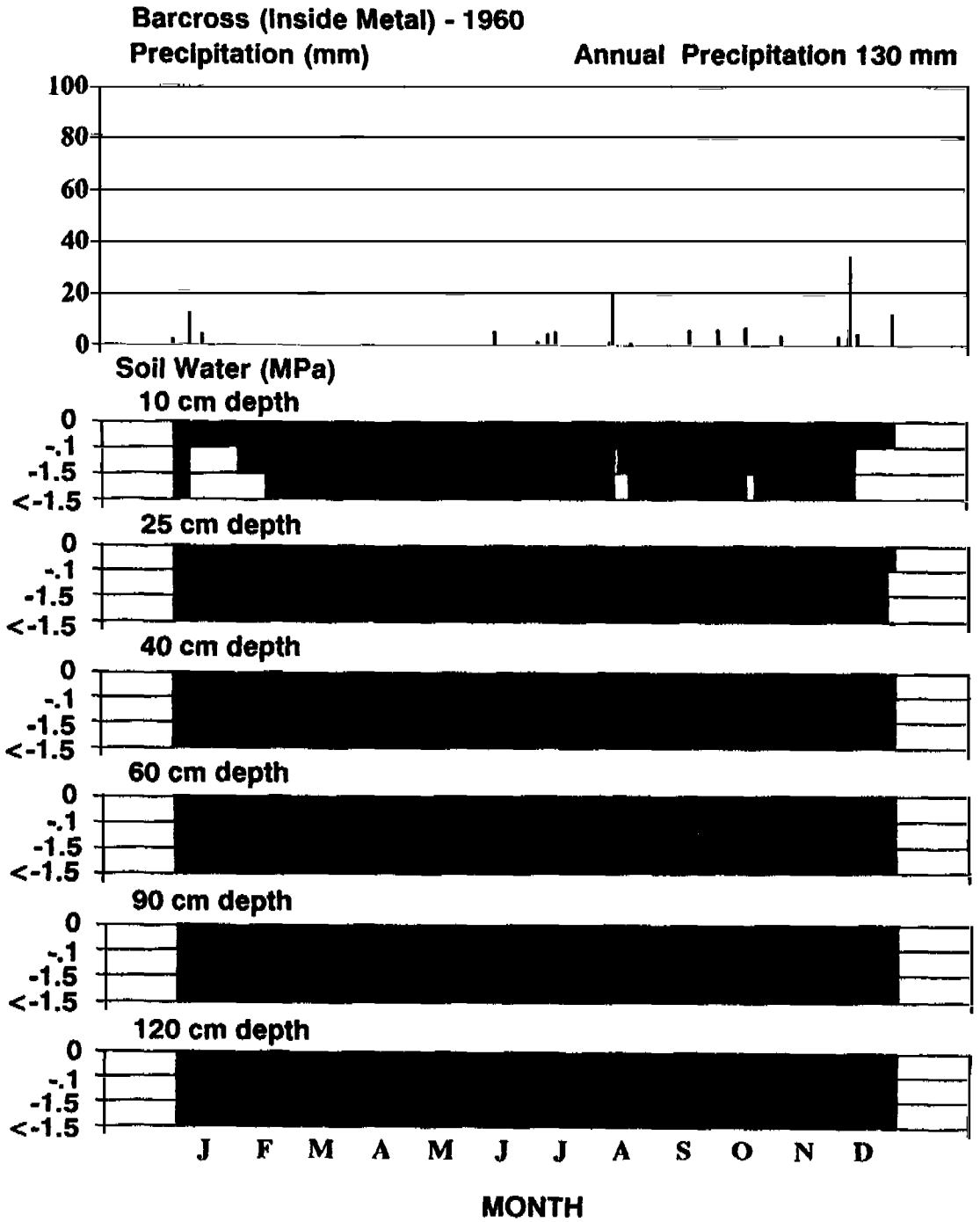


Figure 447. Annual precipitation (130 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1960.

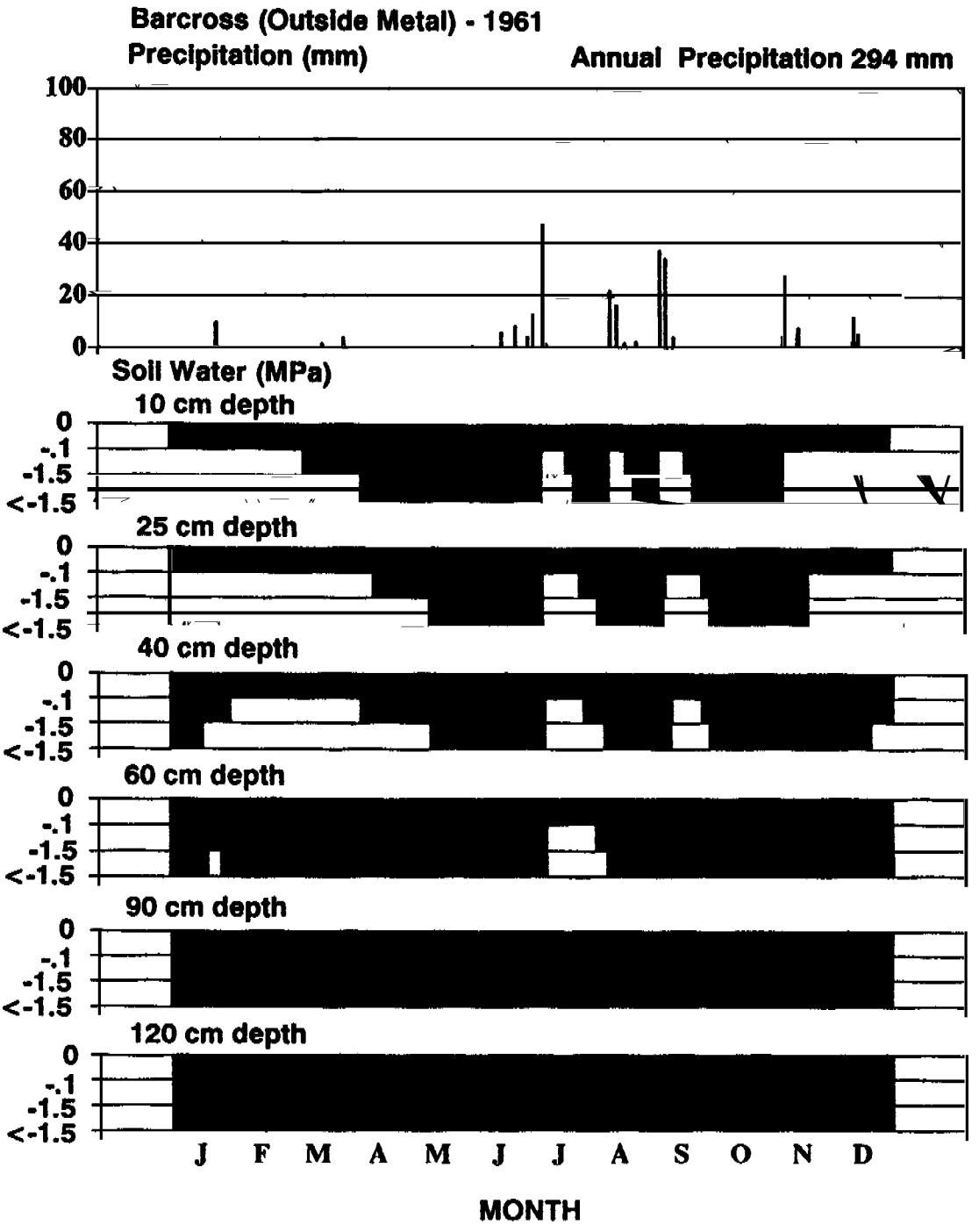


Figure 448. Annual precipitation (294 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1961.

April 14, 1963 (figs. 450, 452). Soil water at 25 cm inside the metal was >-1.5 MPa January 1, 1961-April 23 (fig. 449); July 9-22; September 7-29; November 15, 1961-April 7, 1962 (figs. 449, 451); July 29-August 11; September 26-November 5; and December 3, 1962-March 24, 1963 (figs. 451, 453). Run-in contributed 29 additional days to the soil water >-1.5 MPa at 25 cm in 1961 and 44 days in 1962. There was also more water >-1.5 MPa at the 40- and 60-cm depths outside the sheet metal cylinder in both years. Burrograss yields were 1944 kg/ha (n=25, s.e.=111 kg/ha) in 1961 and 1527 kg/ha (n=25, s.e.=96 kg/ha) in 1962. Tobosa production was 2803 kg/ha (n=25, s.e.=208 kg/ha) in 1961 and 1970 kg/ha (n=25, s.e.=127 kg/ha) in 1962. The additional production in 1961 is due to more soil water >-1.5 MPa during the growing season of 1961 than in 1962.

The annual precipitation for the next four years, 1963-66, was below average (figs. 452-459). Besides the soil water >-1.5 MPa recorded in the winter and early spring of 1963 none was recorded outside or inside the cylinder at 25 cm or deeper except for August 16-25, 1966 at 25 cm inside the cylinder (fig. 459). Burrograss yields for the four years were 150 kg/ha (n=25, s.e.=10 kg/ha), 326 kg/ha (n=25, s.e.=72 kg/ha), 41 kg/ha (n=25, s.e.=10 kg/ha), and 724 kg/ha (n=25, s.e.=48 kg/ha), respectively. Tobosa production for 1963-66 was 251 kg/ha (n=25, s.e.=31 kg/ha), 783 kg/ha (n=25, s.e.=120 kg/ha), 530 kg/ha (n=25, s.e.=85 kg/ha), and 3013 kg/ha (n=25, s.e.=268 kg/ha), respectively. Grass production was higher in 1966 because much of the meager precipitation was concentrated in late July and August (figs. 458, 459). The summer soil water >-1.5 MPa combined with the winter soil water >-1.5 MPa at 10 cm in 1966 resulted in greater grass yields than in 1963, 1964, or 1965 (figs. 452, 454, 456, 458). It was higher in 1964 than 1963 or 1965 because there was considerably more soil water >-1.5 MPa at 10 cm in July-September in 1964 (figs. 452, 454, 456). The 1967 production of burrograss was 289 kg/ha (n=25, s.e.=26 kg/ha) and tobosa was 549 kg/ha (n=25, s.e.=81 kg/ha). Even though 1967 precipitation was above average, the only soil water >-1.5 MPa at 25 cm was recorded in December (figs. 460, 461). The grass production was a result of sporadic soil water at shallow depths.

Annual precipitation in 1968 was 224 mm (figs. 462, 463). The soil water outside the sheet metal at 25 cm was >-1.5 MPa December 21, 1967-May 7, 1968 (figs. 460, 462) while inside the metal at 25 cm soil water was >-1.5 MPa December 21, 1967-May 6, 1968 (figs. 461, 463) and July 5-12, 1968. Burrograss yields were 374 kg/ha (n=25, s.e.=37 kg/ha) and tobosa yields averaged 709 kg/ha (n=25, s.e.=94 kg/ha).

Precipitation was 335 mm in 1969 (figs. 464, 465). Matric potential of the soil water at 25 cm outside the metal was >-1.5 MPa June 3-15, July 10-19, September 2-30, and December 7-31 (fig. 464). Inside the metal at 25 cm, the soil water was >-1.5 MPa June 4-14, September 3-October 1, and December 7-31 (fig. 465)

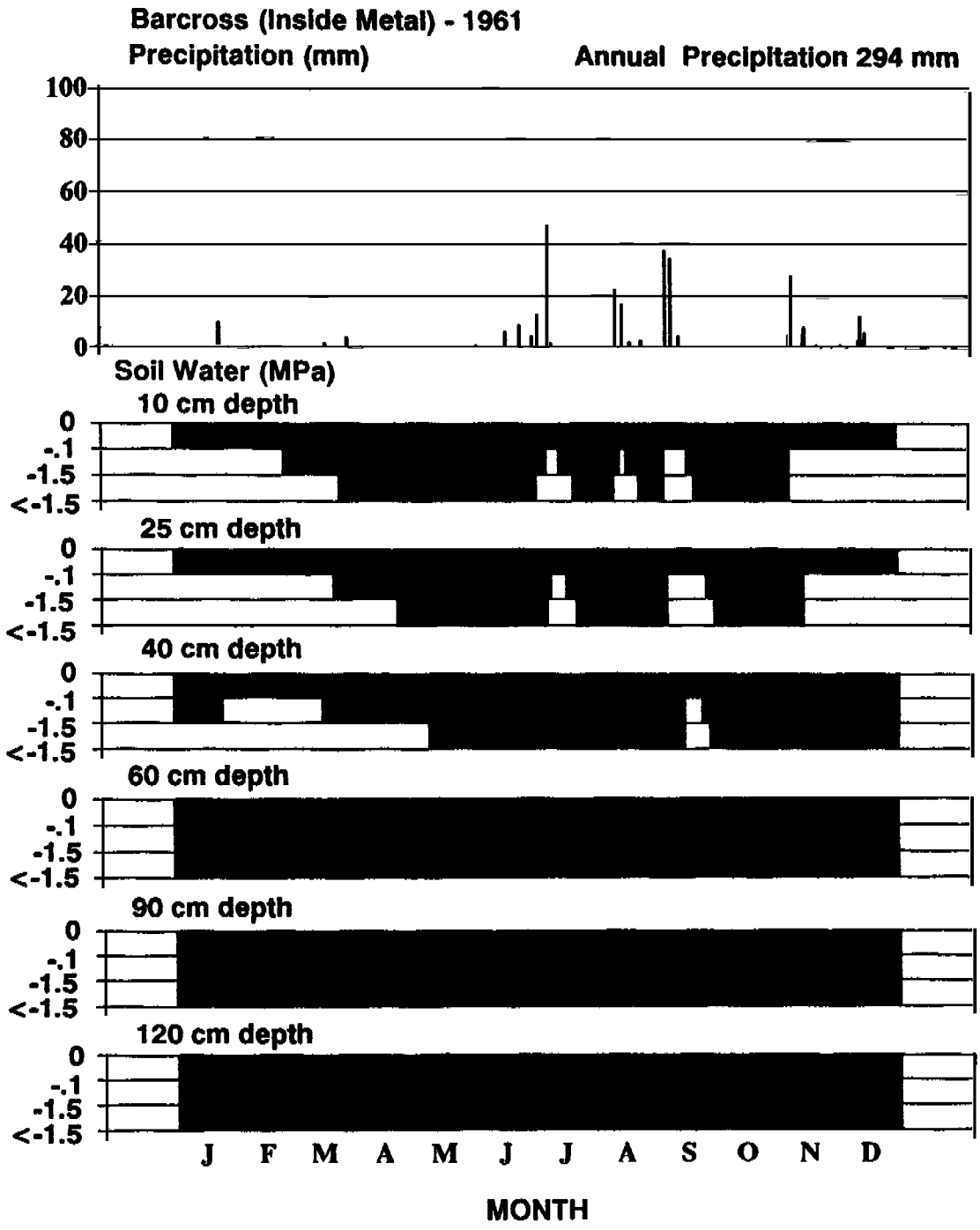


Figure 449. Annual precipitation (294 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylind r at the Barcross site for 1961.

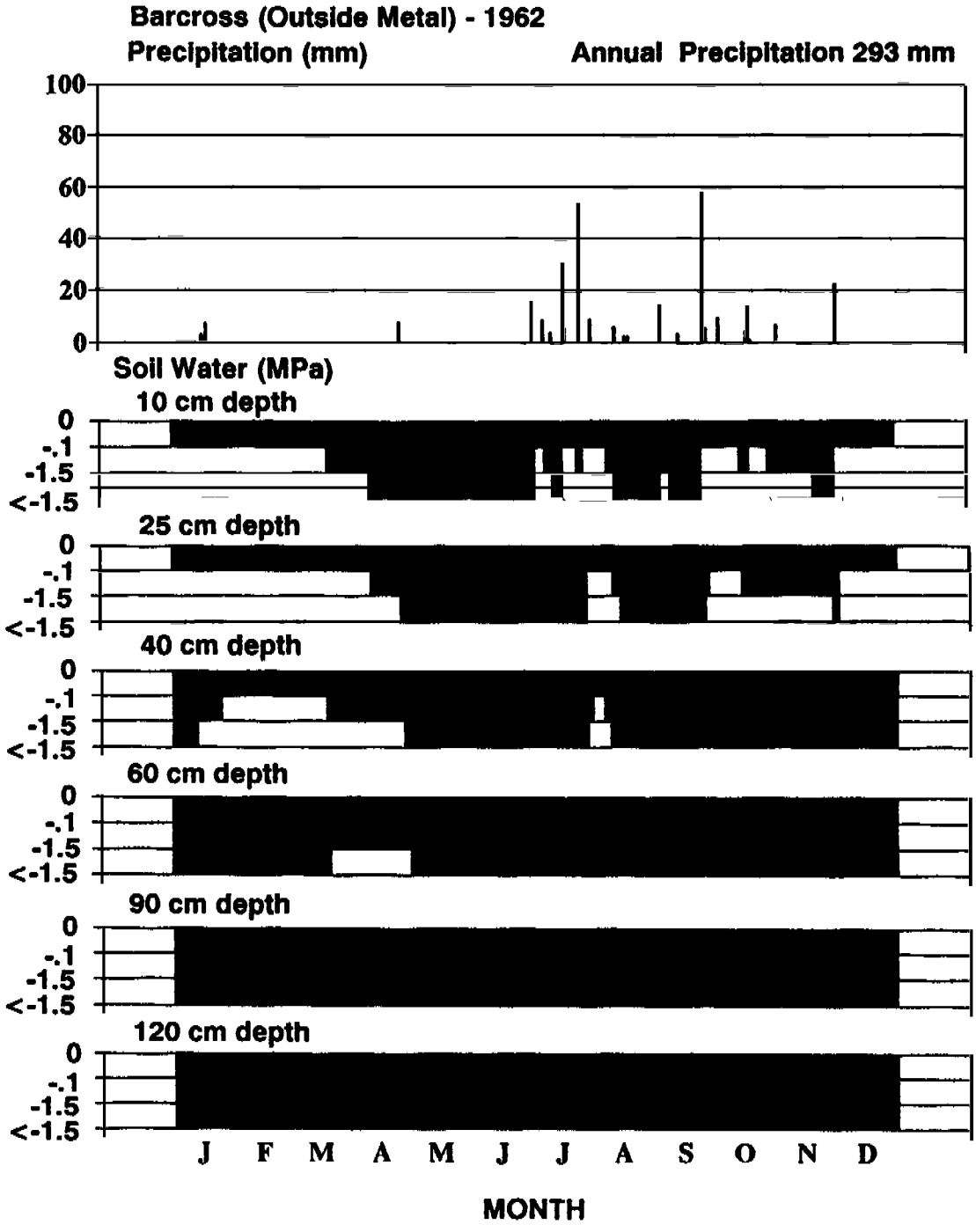


Figure 450. Annual precipitation (293 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1962.

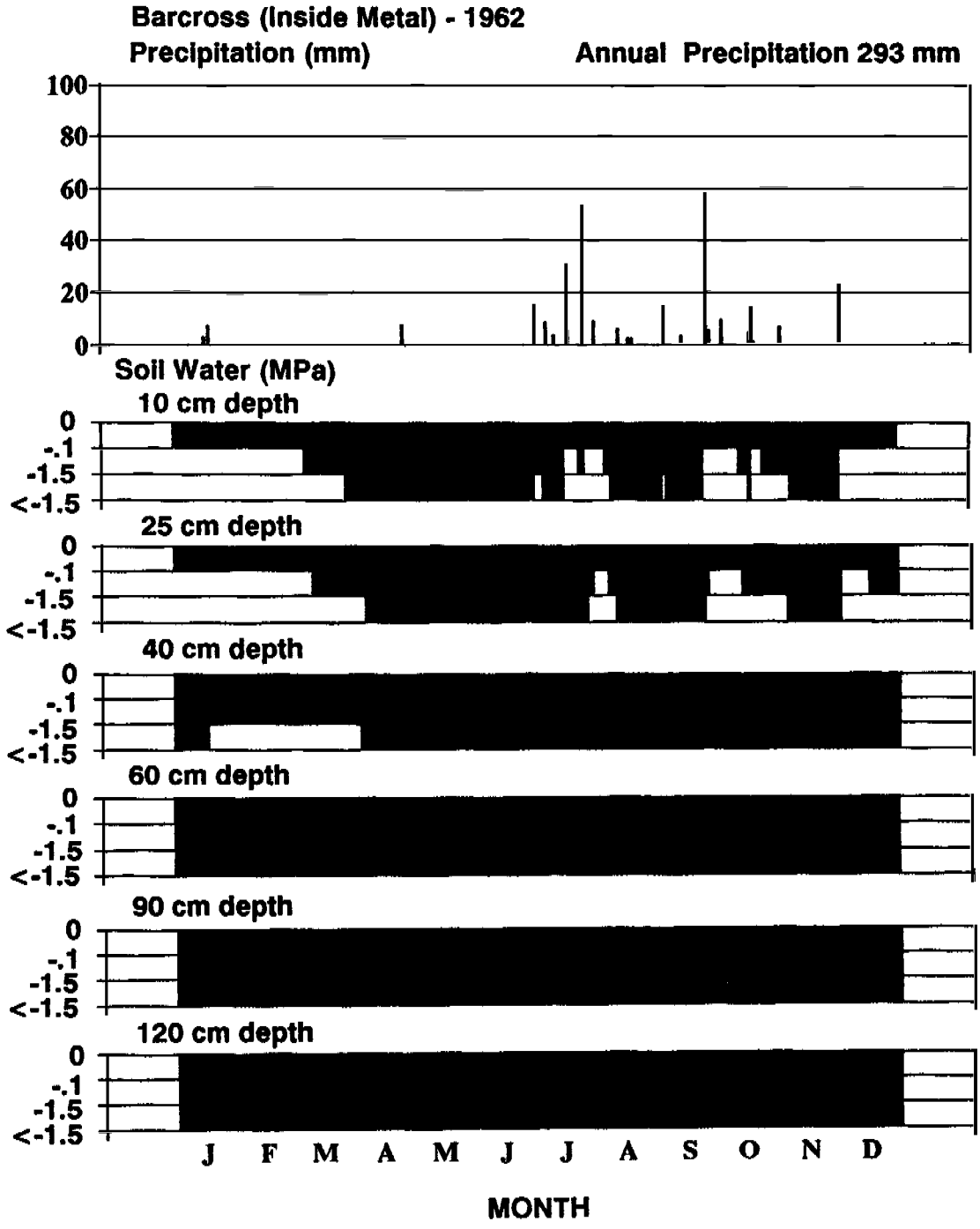


Figure 451. Annual precipitation (293 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1962.

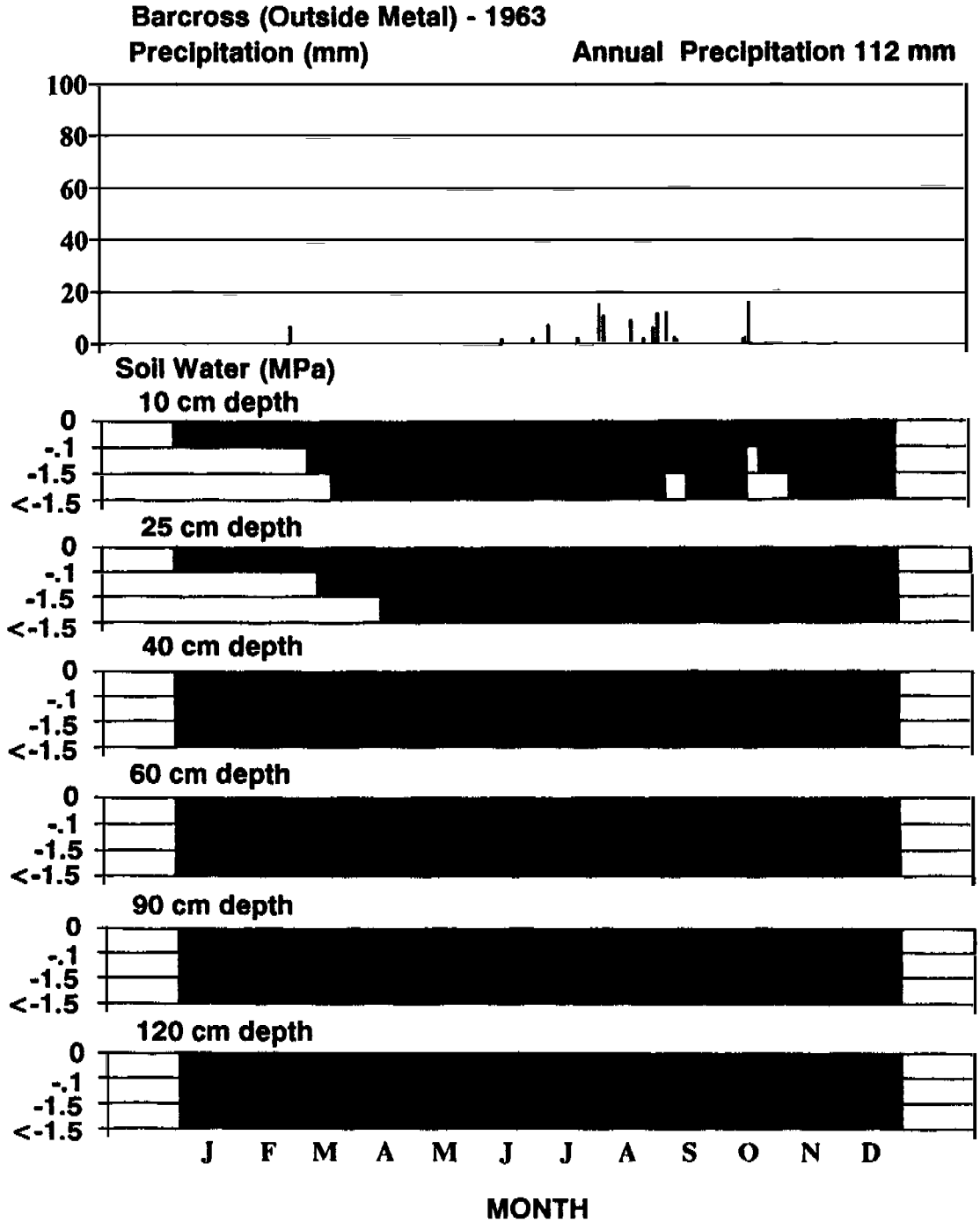


Figure 452. Annual precipitation (112 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1963.

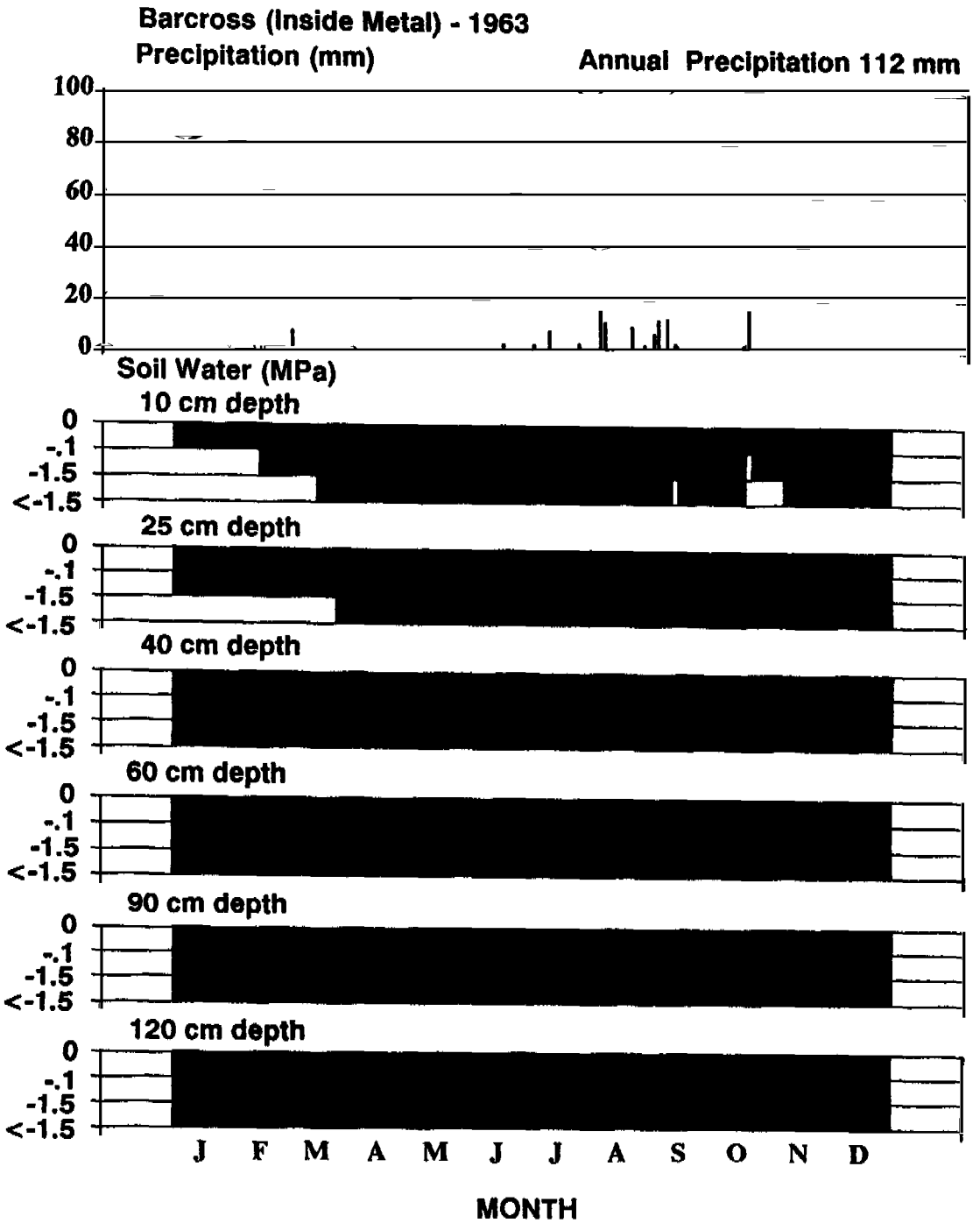


Figure 453. Annual precipitation (112 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1963.

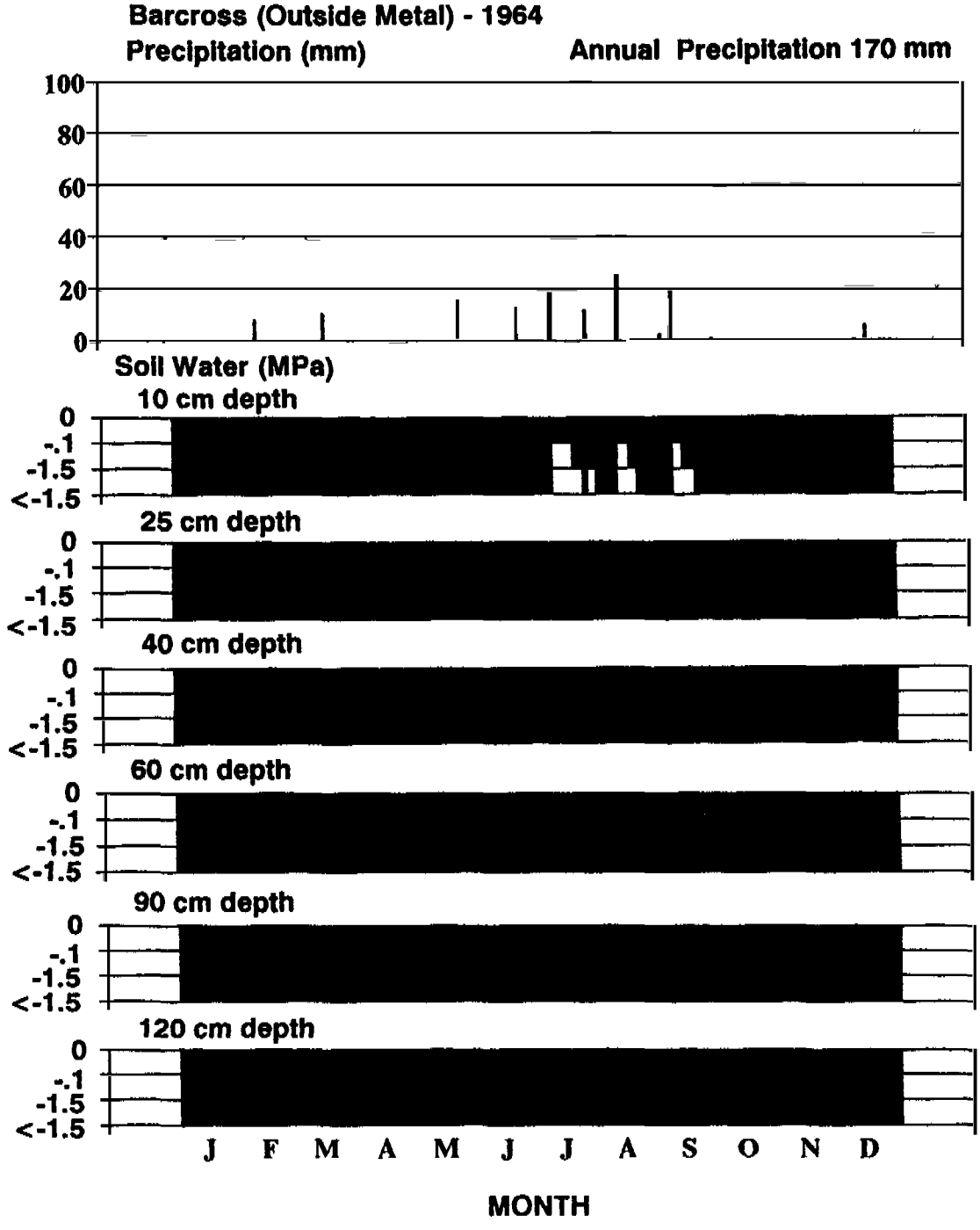


Figure 454. Annual precipitation (170 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1964.

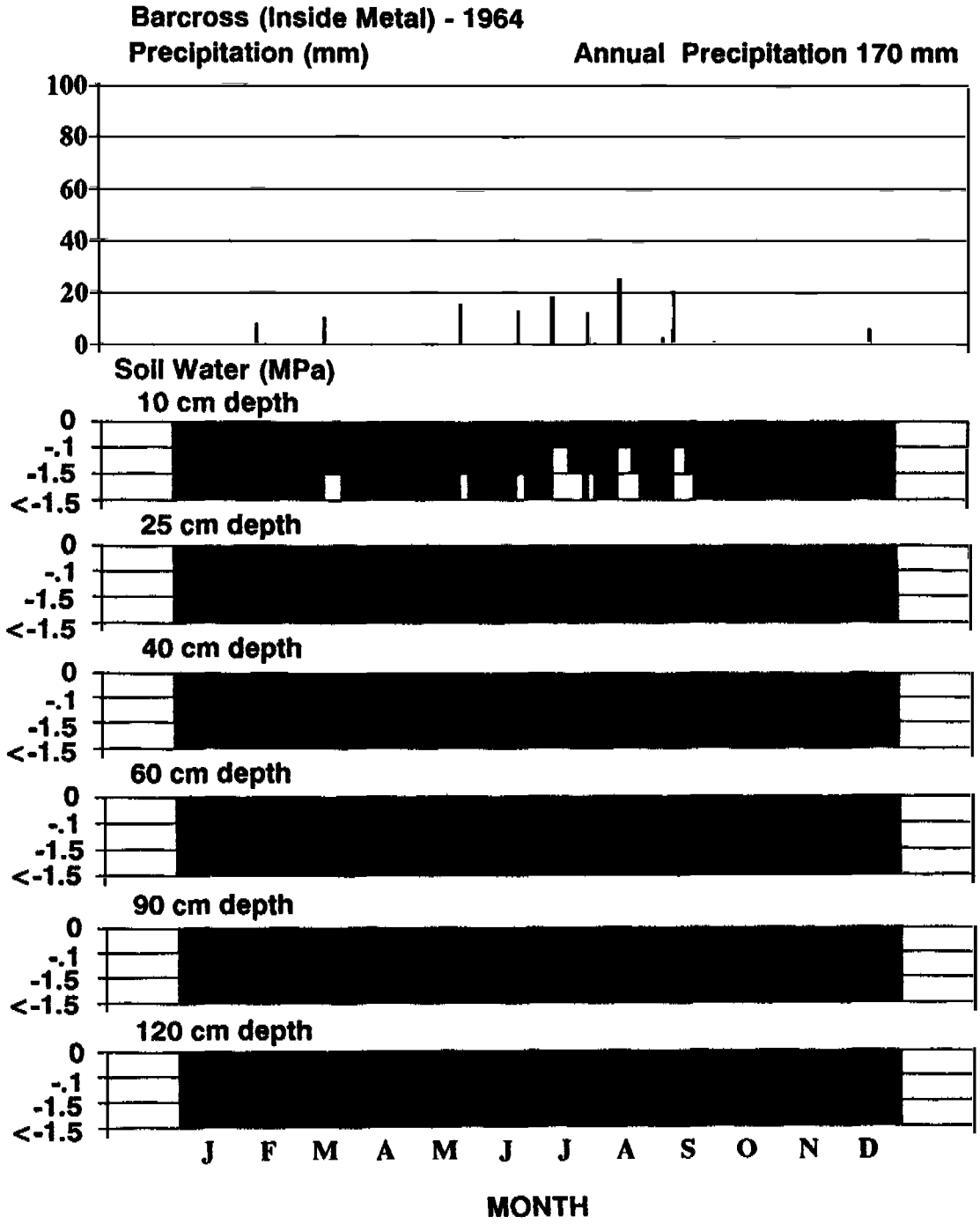


Figure 455. Annual precipitation (170 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1964.

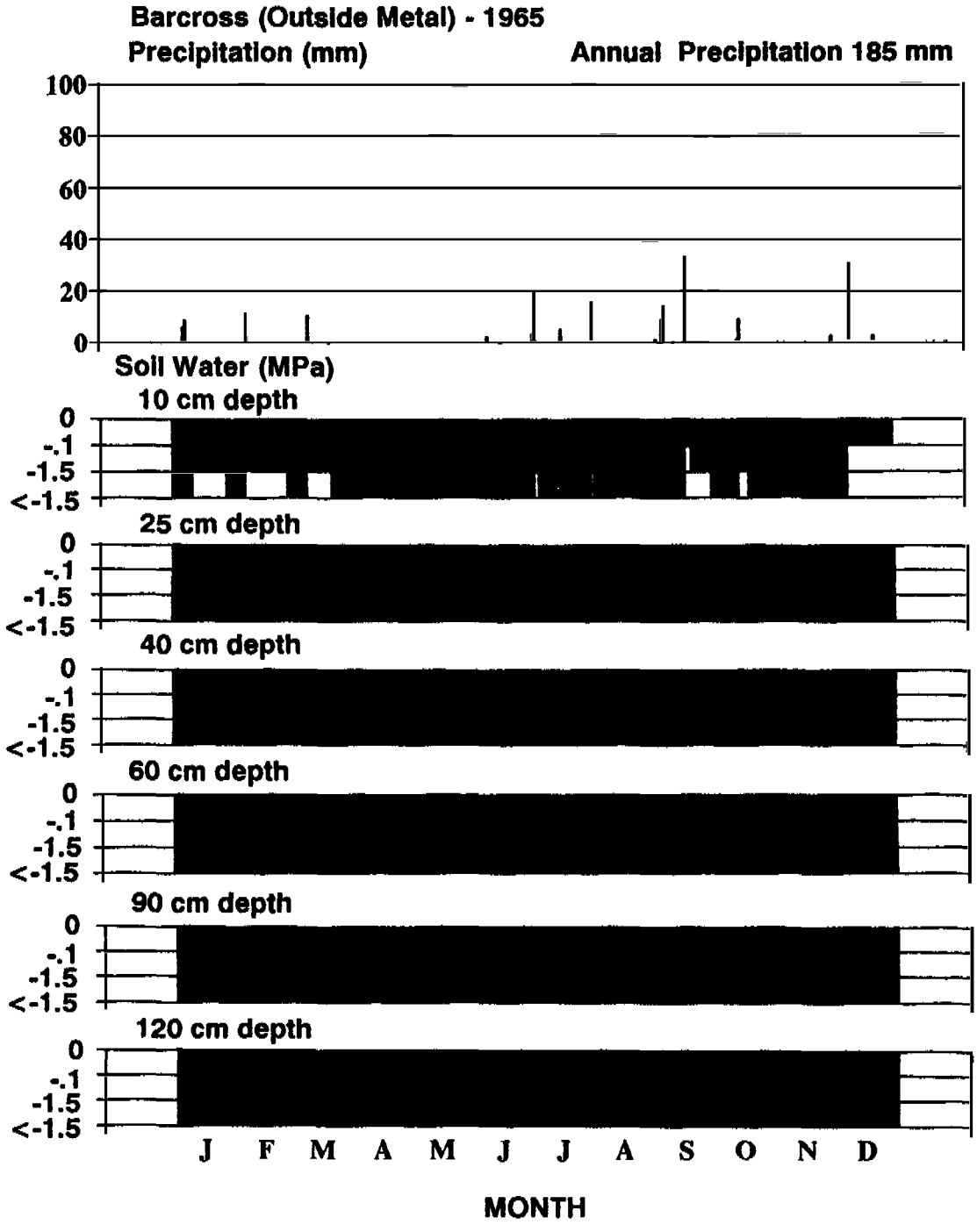


Figure 456. Annual precipitation (185 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside ths sheet metal cylinder at the Barcross site for 1965.

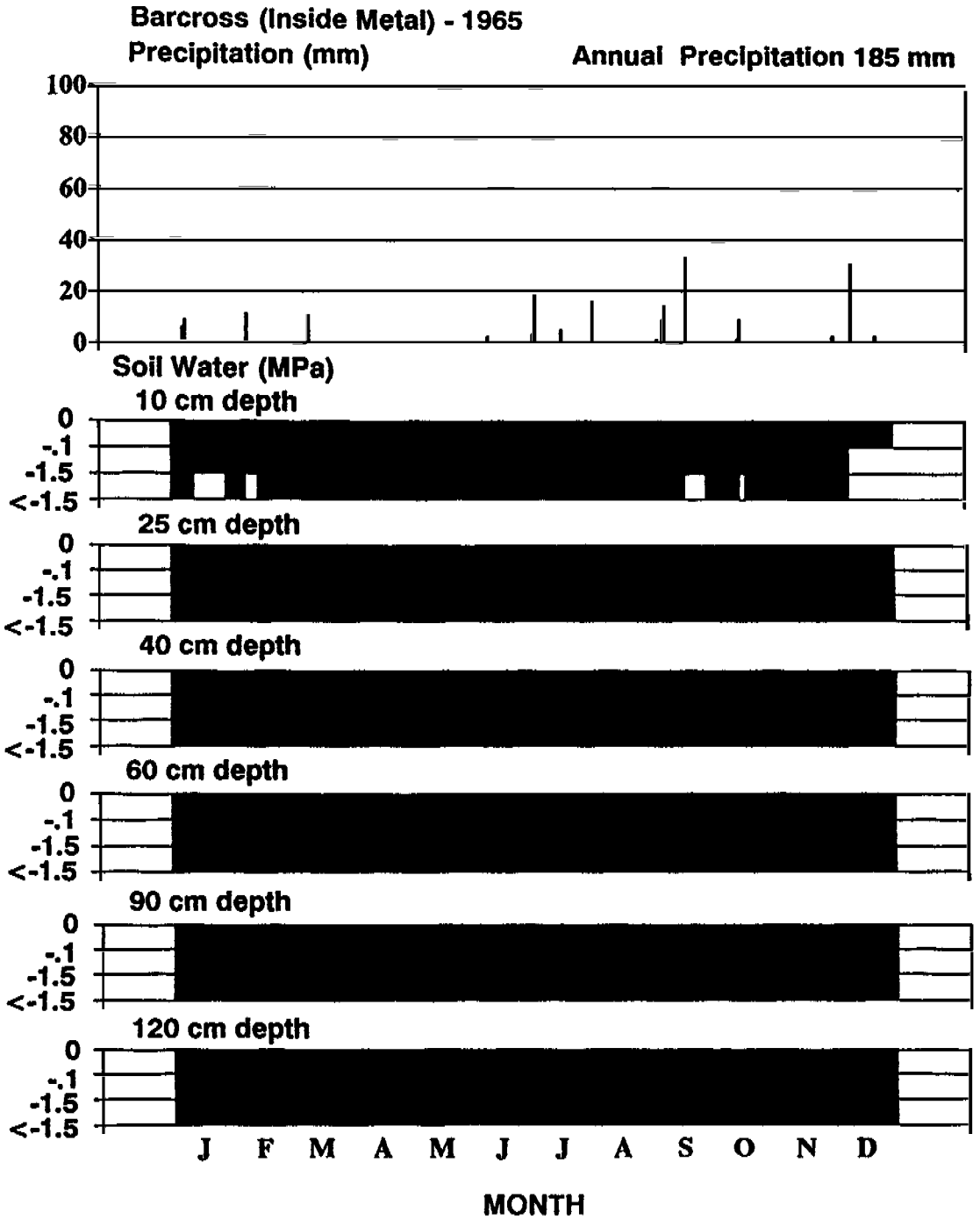


Figure 457. Annual precipitation (185 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1965.

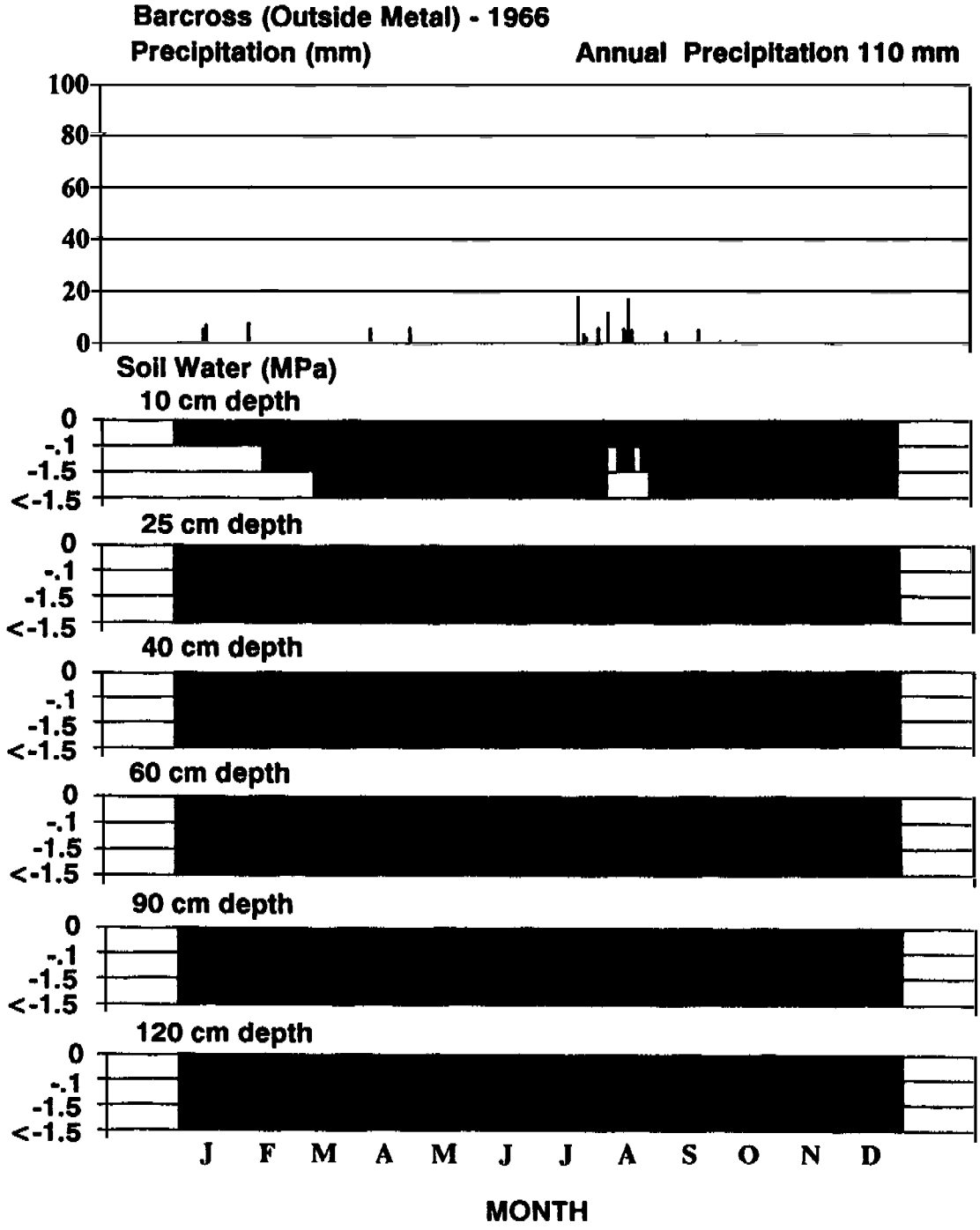


Figure 458. Annual precipitation (110 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1966.

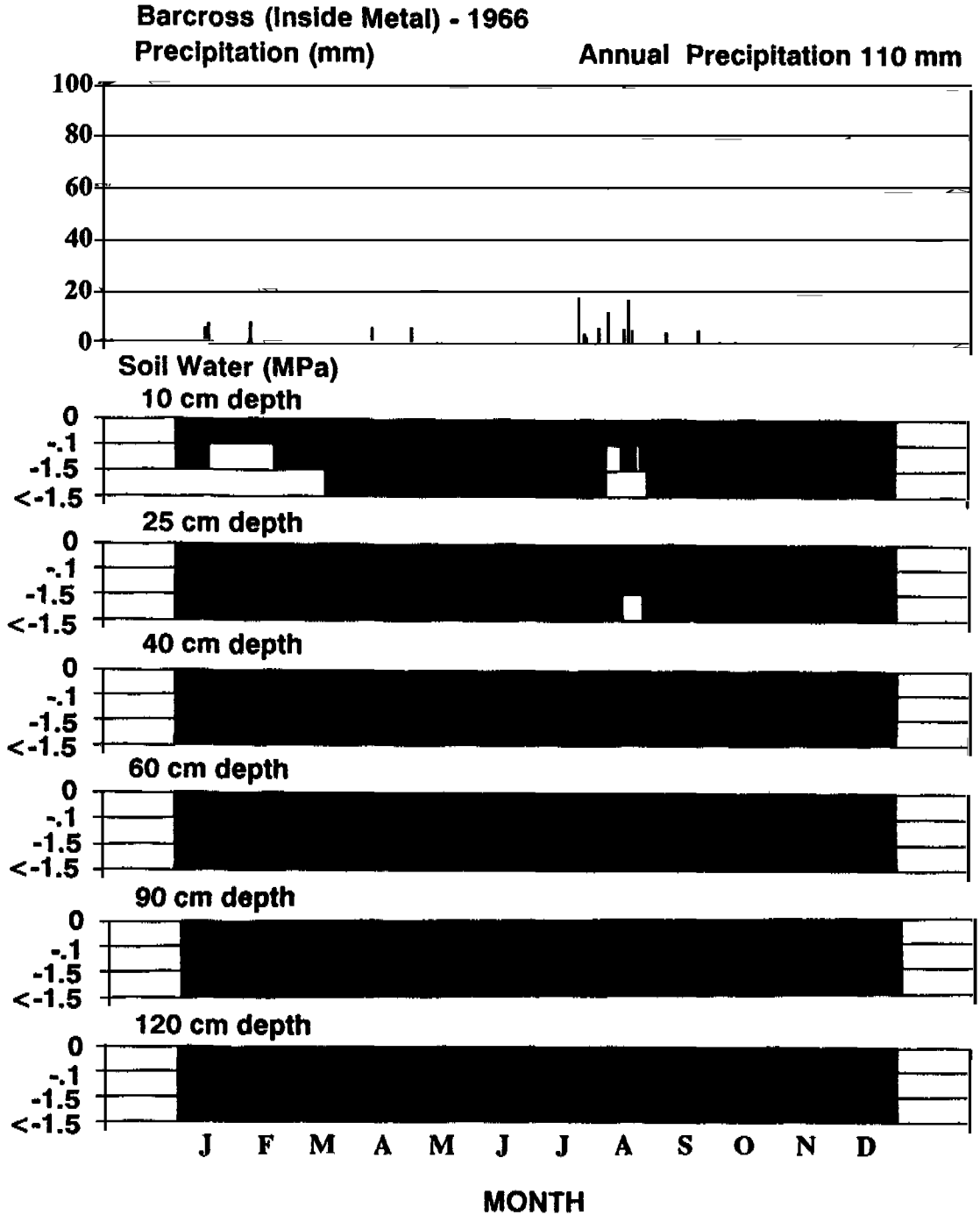


Figure 459. Annual precipitation (110 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1966.

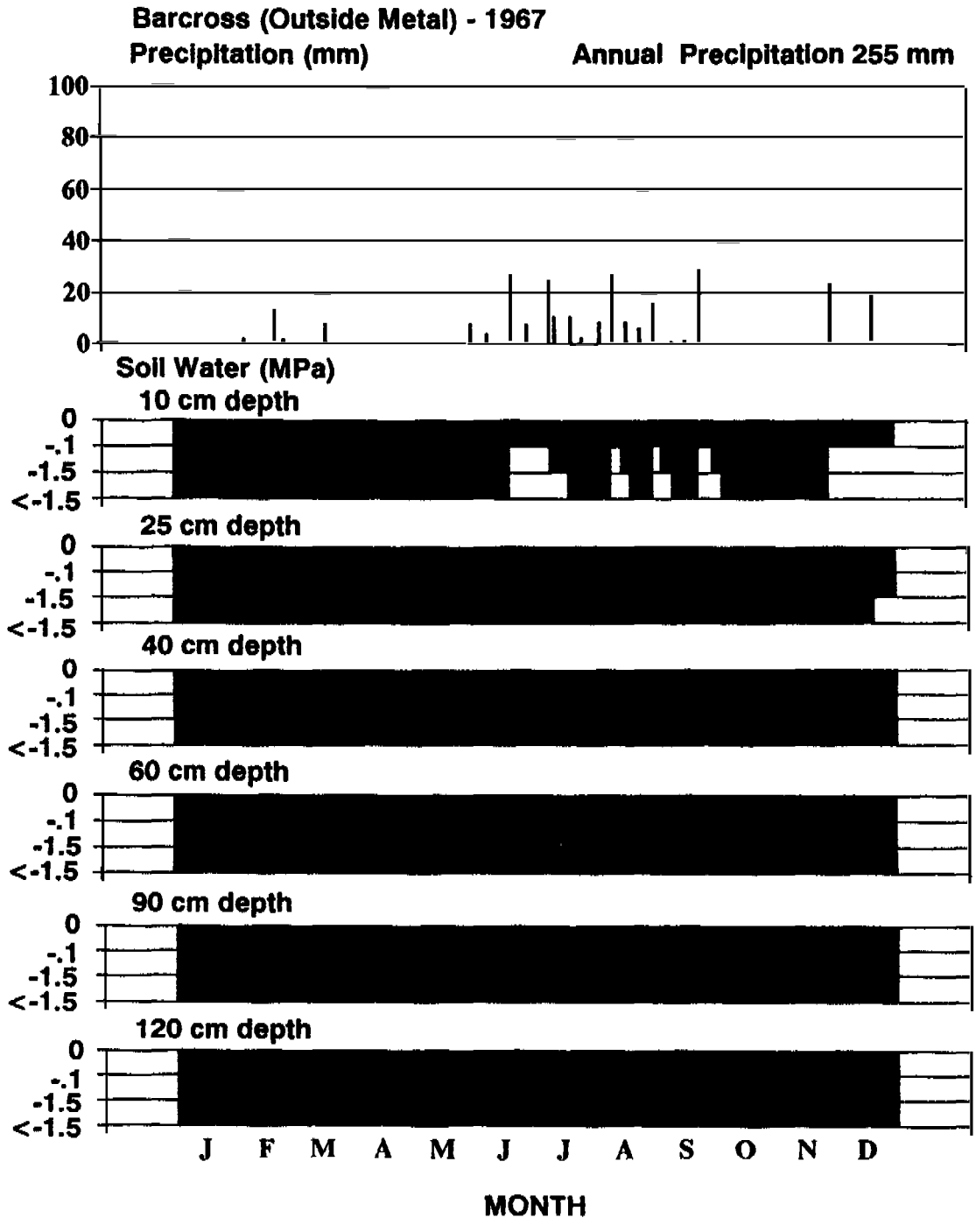


Figure 460. Annual precipitation (255 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1967.

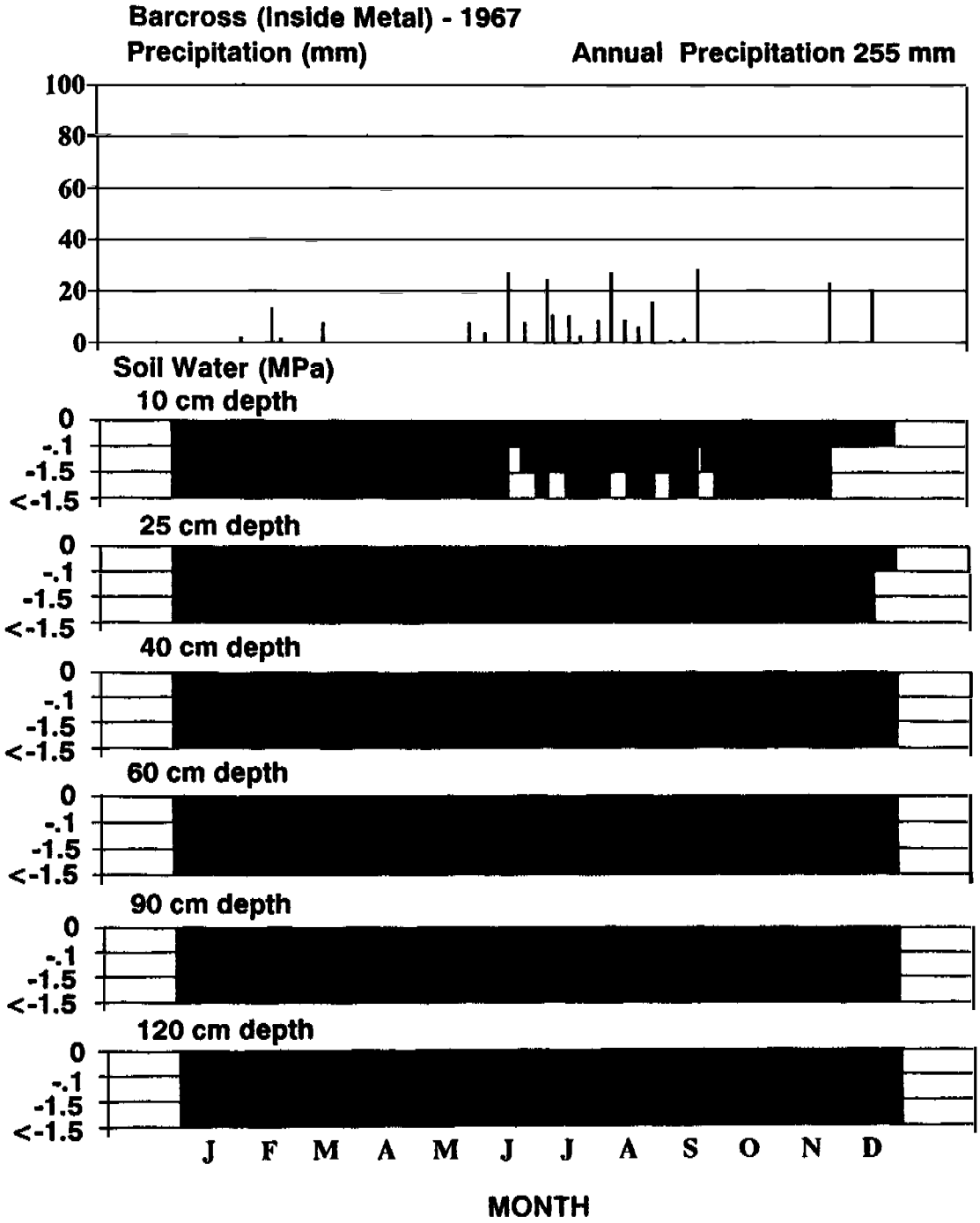


Figure 461. Annual precipitation (255 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1967.

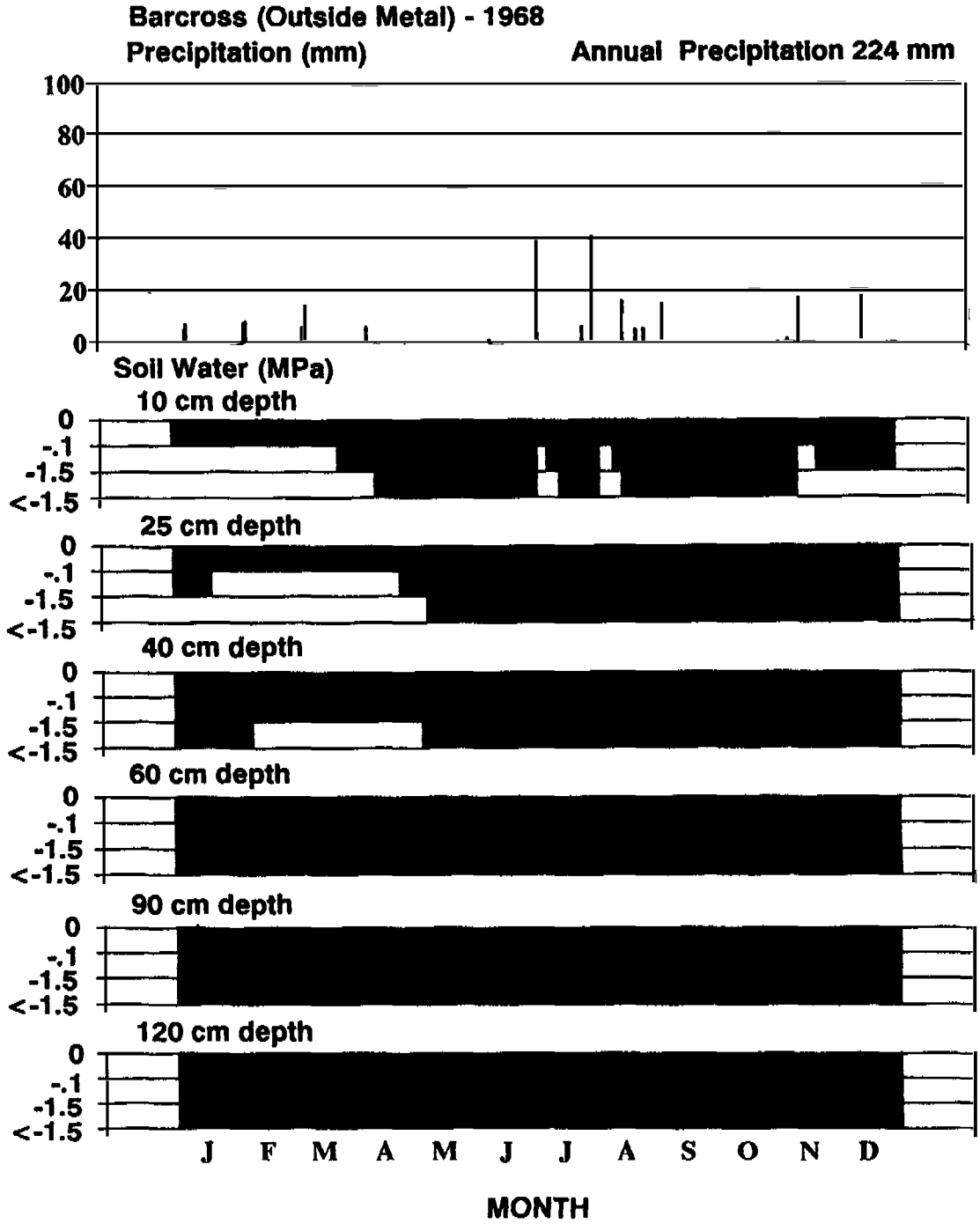


Figure 462. Annual precipitation (224 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1968.

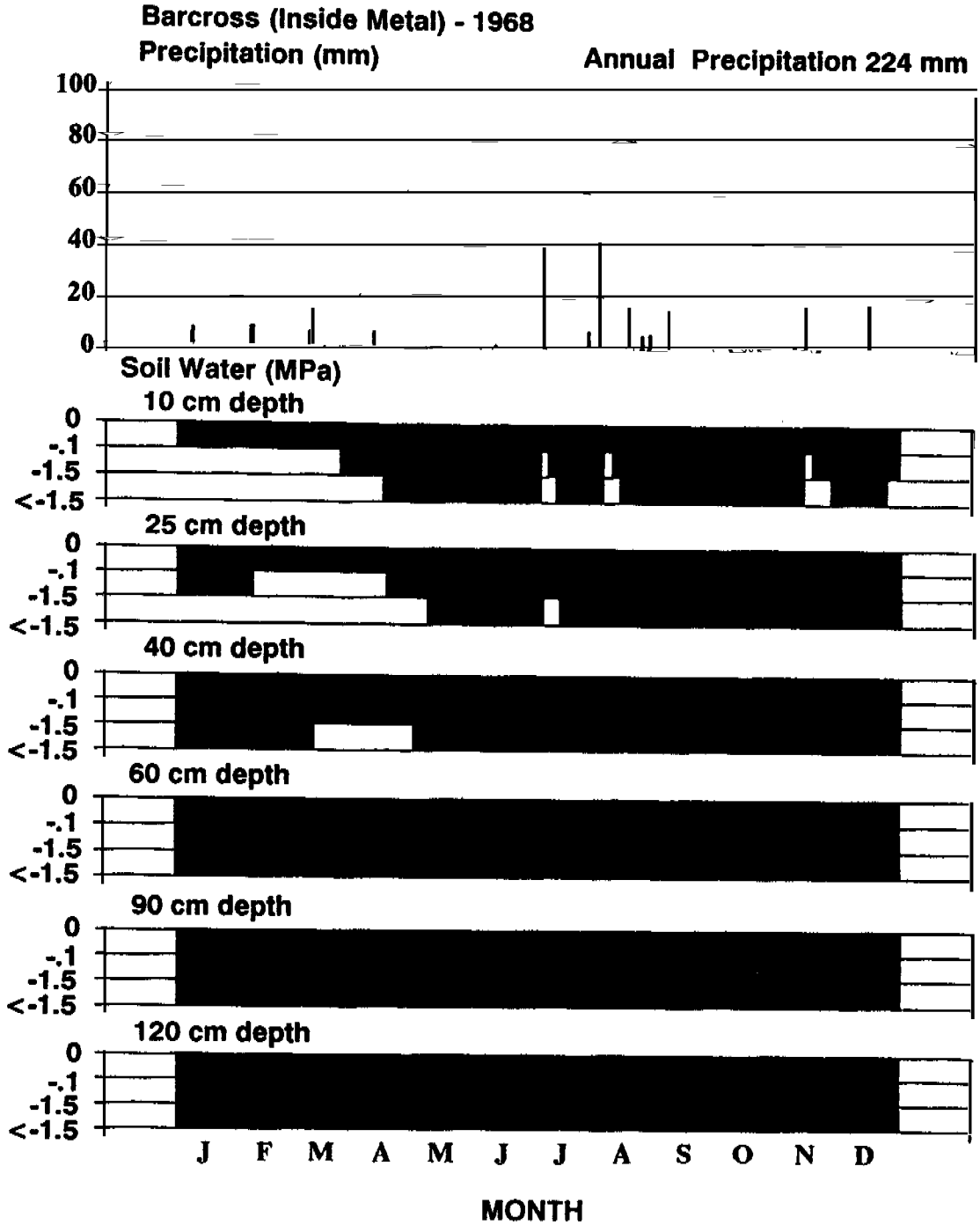


Figure 463. Annual precipitation (224 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60,90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1968.

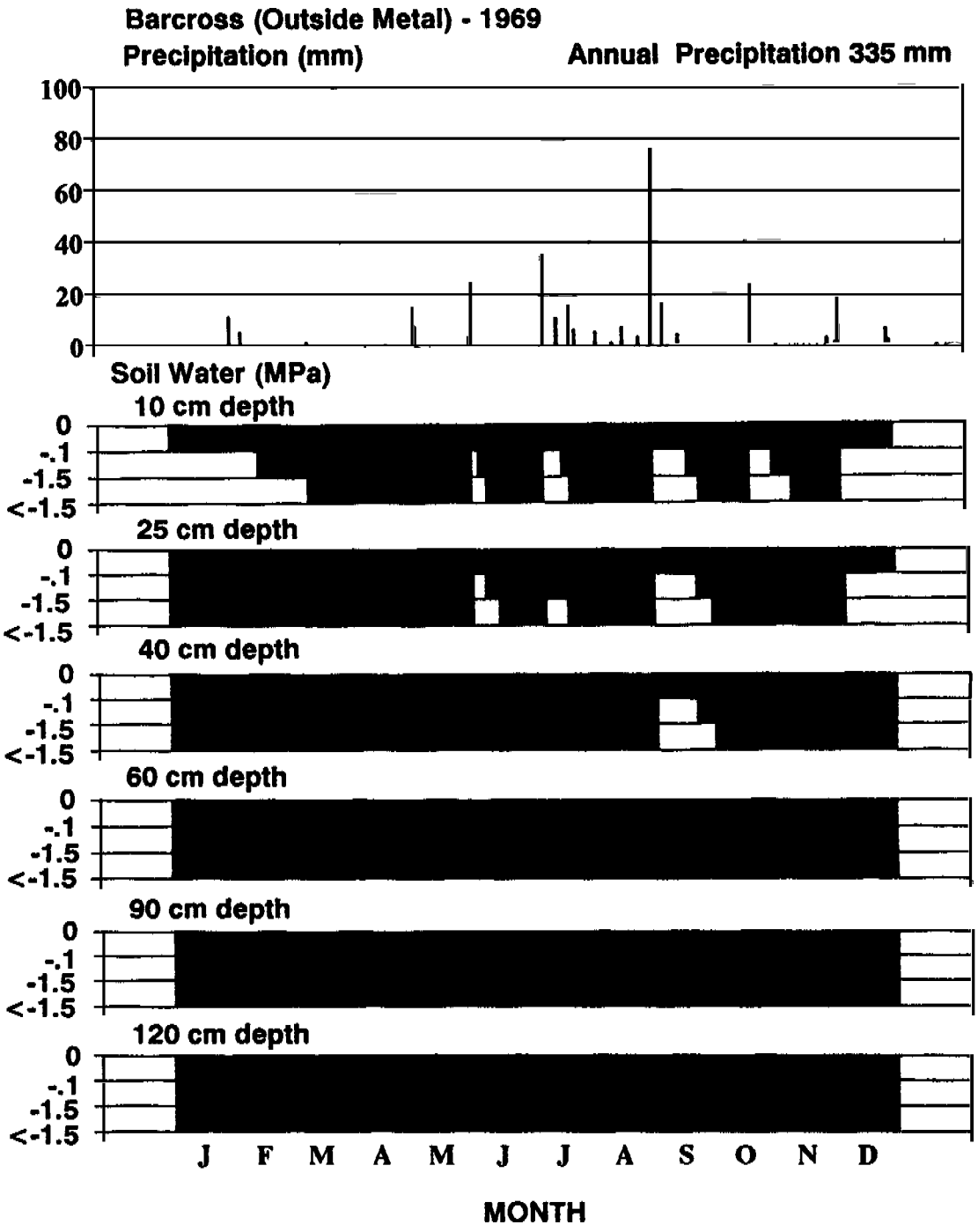


Figure 464. Annual precipitation (335 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1969.

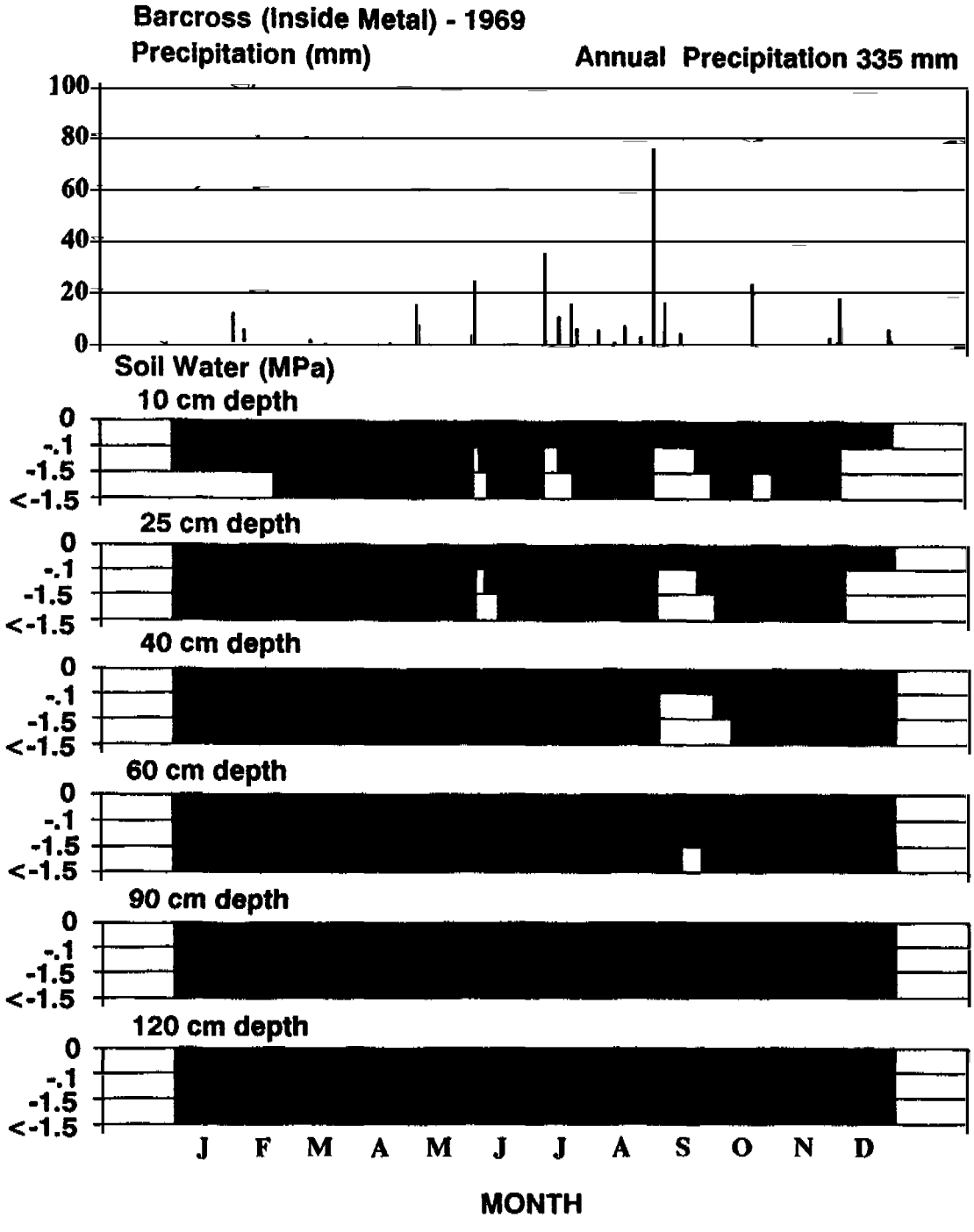


Figure 465. Annual precipitation (335 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1969.

or a total of 12 days less than that observed outside the metal. The average burrograss production was 1252 kg/ha (n=25, s.e.=99 kg/ha) and tobosa produced 2950 kg/ha (n=25, s.e.=141 kg/ha).

Estimated yields of burrograss were 369 kg/ha (n=25, s.e.=34 kg/ha) for 1970 and 118 kg/ha (n=25, s.e.=19 kg/ha) for 1971 whil tobosa averaged 637 kg/ha (n=25, s.e.=56 kg/ha) and 151 kg/ha (n=25, s.e.=16 kg/ha) for the same years. Annual precipitation was below average for both years but the matric potential of the soil water at 25 cm was >-1.5 MPa outside the cylinder January 1, 1970-April 17 (fig. 466); July 25-August 11, 1970; and October 25-December 31, 1971 (fig. 468). Inside the metal, the soil water at 25 cm was >-1.5 MPa January 1, 1970-March 31 (fig. 467); July 26-August 9, 1970, and October 26, 1971-December 31 (fig. 469).

Annual precipitation in 1972 was 305 mm (figs. 470, 471) but no soil water estimates were taken after July 31. The matric potential of the soil water at 25 cm was >-1.5 MPa January 1-March 20 outside the metal (fig. 470) and January 1-February 29 inside the metal (fig. 471). The yields of burrograss were estimated at 1710 kg/ha (n=25, s.e.=119 kg/ha) and tobosa yields were estimated at 2359 kg/ha (n=25, s.e.=155 kg/ha).

Precipitation in 1973 was only 193 mm (figs. 472, 473) but burrograss yielded 728 kg/ha (n=25, s.e.=57 kg/ha) and tobosa yielded 1732 kg/ha (n=25, s.e.=125 kg/ha). At the 25-cm depth the soil water was >-1.5 MPa January 8-April 23 inside the metal (fig. 473) and January 7-April 30, June 15-29, July 19-August 3, and August 30-September 5 outside the metal (fig. 472). Run-in contributed to 46 days of soil water at the 25-cm depth. This additional soil water was particularly evident in the summer.

Annual precipitation was above average 1974-76 (figs. 474-479). Inside the metal, soil water at 25 cm was >-1.5 MPa July 15, 1974-August 14 (fig. 475); September 22, 1974-April 2, 1975 (figs. 475, 477); September 1-4; September 13-October 10, 1975; and September 18, 1976-October 14 (fig. 479). Outside the metal, soil water at 25 cm was >-1.5 MPa January 10, 1974-February 10 (fig. 474); July 15-August 14; September 21, 1974-March 21, 1975 (figs. 474, 476); September 13-October 10, 1975; July 29-31, 1976 (fig. 478); September 7-10; September 17-October 16; and October 31-November 3, 1976. Run-in contributed an additional 32 days to the soil water >-1.5 MPa at the 25-cm depth in 1974 and 14 days in 1976. Burrograss yields for the three years were 410 kg/ha (n=25, s.e.=24 kg/ha), 1045 kg/ha (n=25, s.e.=65 kg/ha), and 942 kg/ha (n=25, s.e.=130 kg/ha), respectively. Tobosa yields for 1974, 1975, and 1976 were 1645 kg/ha (n=25, s.e.=128 kg/ha), 2920 kg/ha (n=25, s.e.=206 kg/ha), and 1006 kg/ha (n=25, s.e.=79 kg/ha), respectively.

Annual precipitation for 1958-76 averaged 231 mm. Precipitation was above average for nine years and below average for 10 years. The probability of the matric potential of the soil water >-1.5 MPa at the 25-cm depth outside the metal cylinder averaged 40.8% for December-April, 4.9% for May-June, 19.3% for July-September, and 20.1% for October-November (fig. 480). Inside the metal cylinder the probability averaged 36.0% for December-

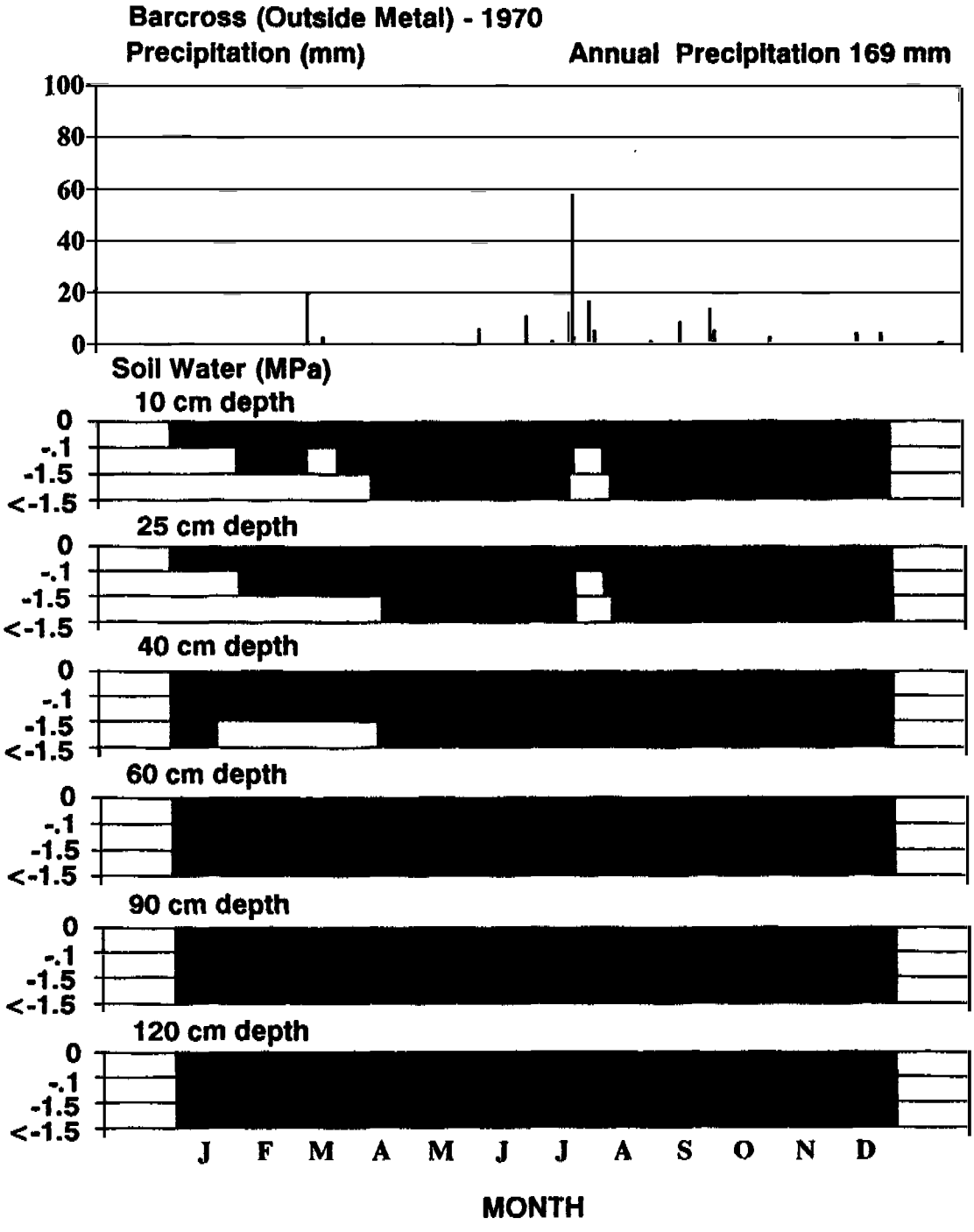


Figure 466. Annual precipitation (169 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1970.

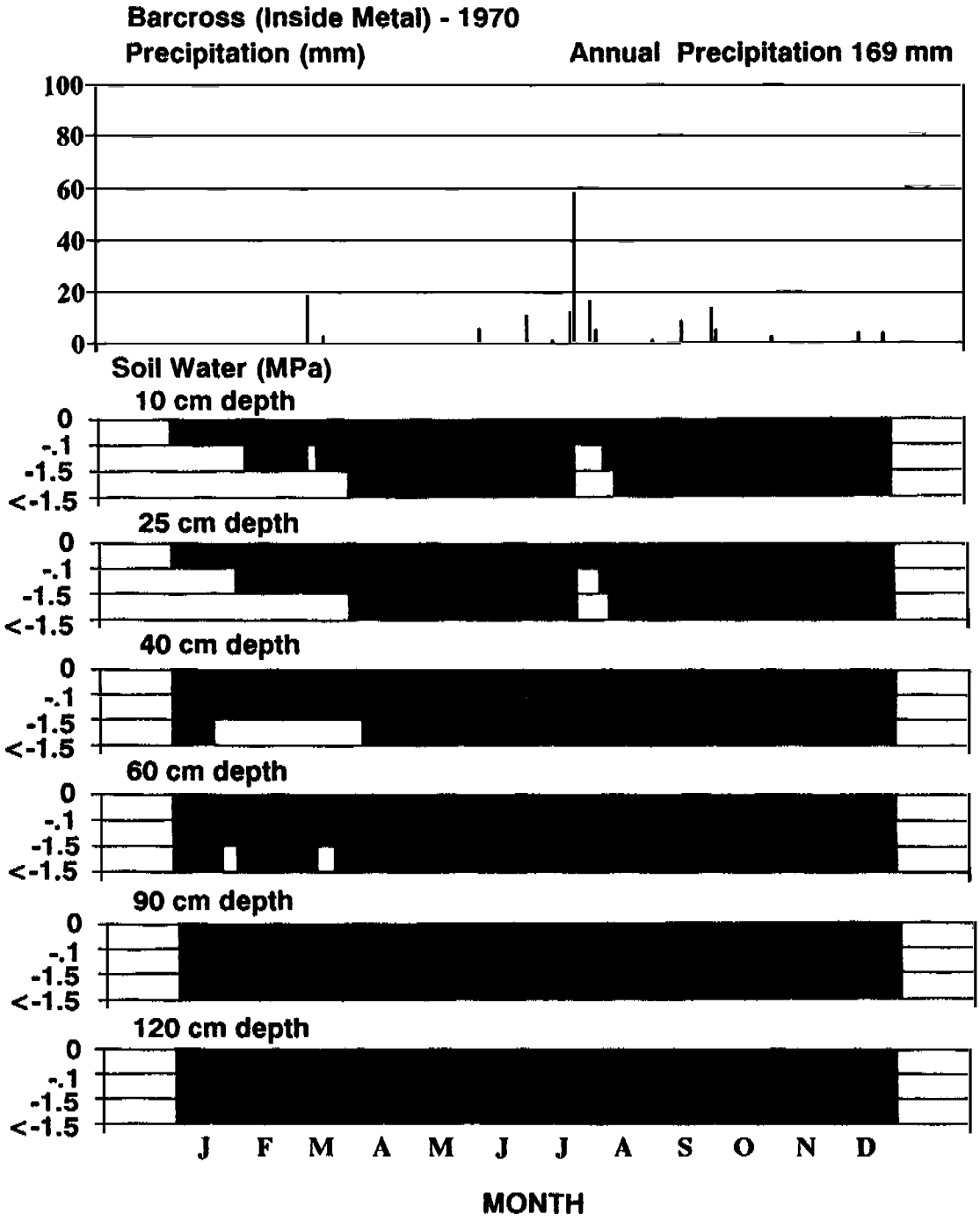


Figure 467. Annual precipitation (169 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1970.

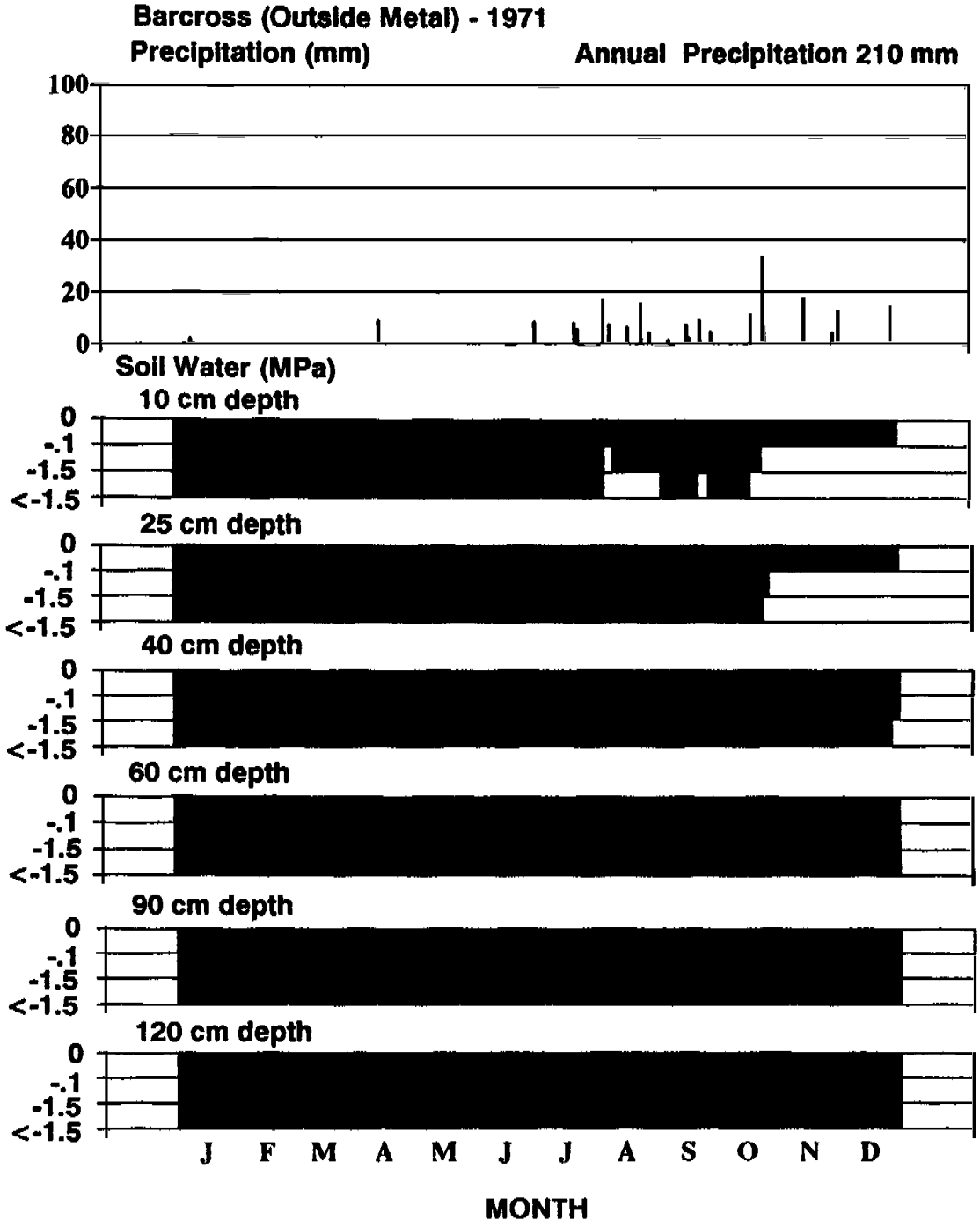


Figure 468. Annual precipitation (210 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1971.

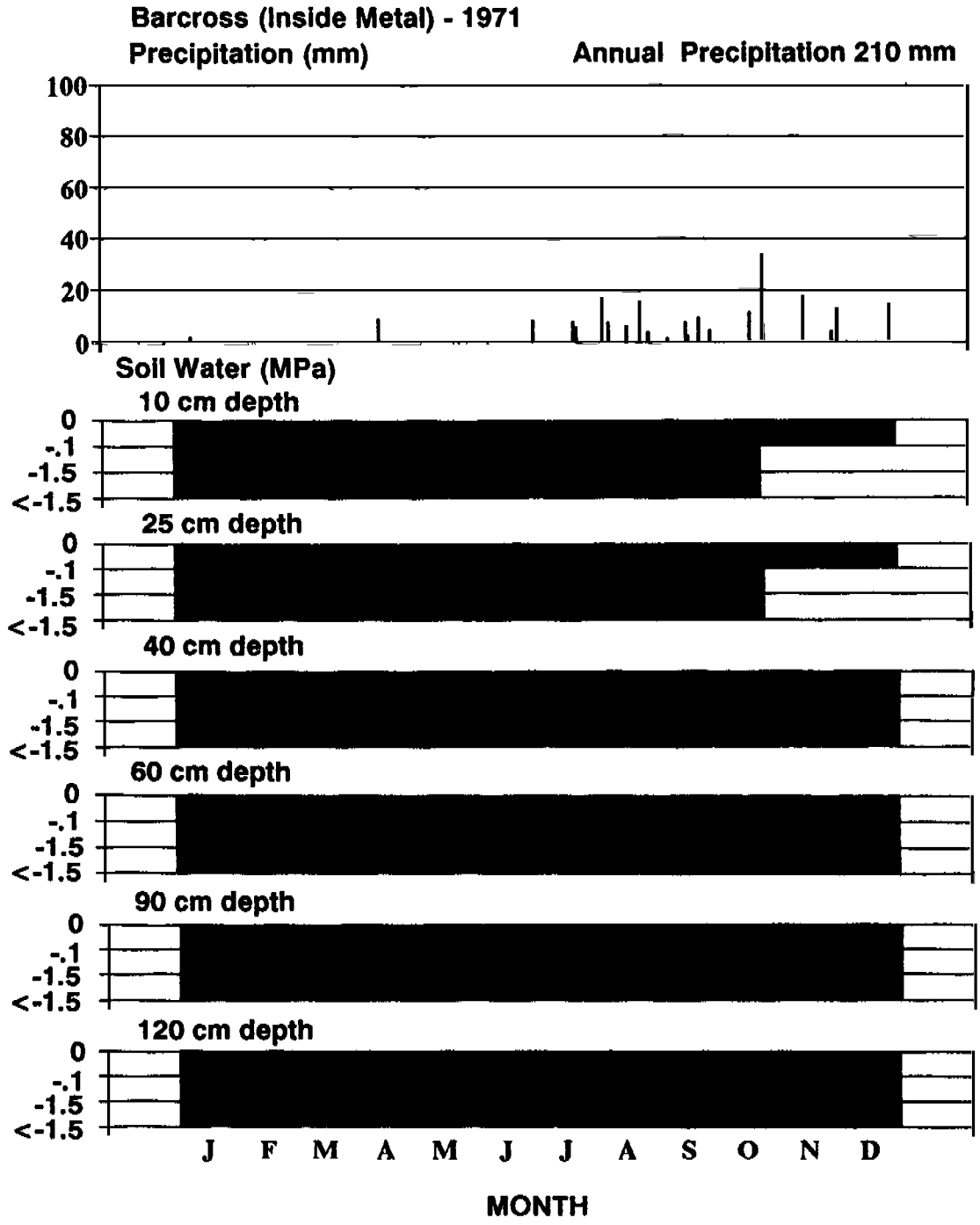


Figure 469. Annual precipitation (210 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1971.

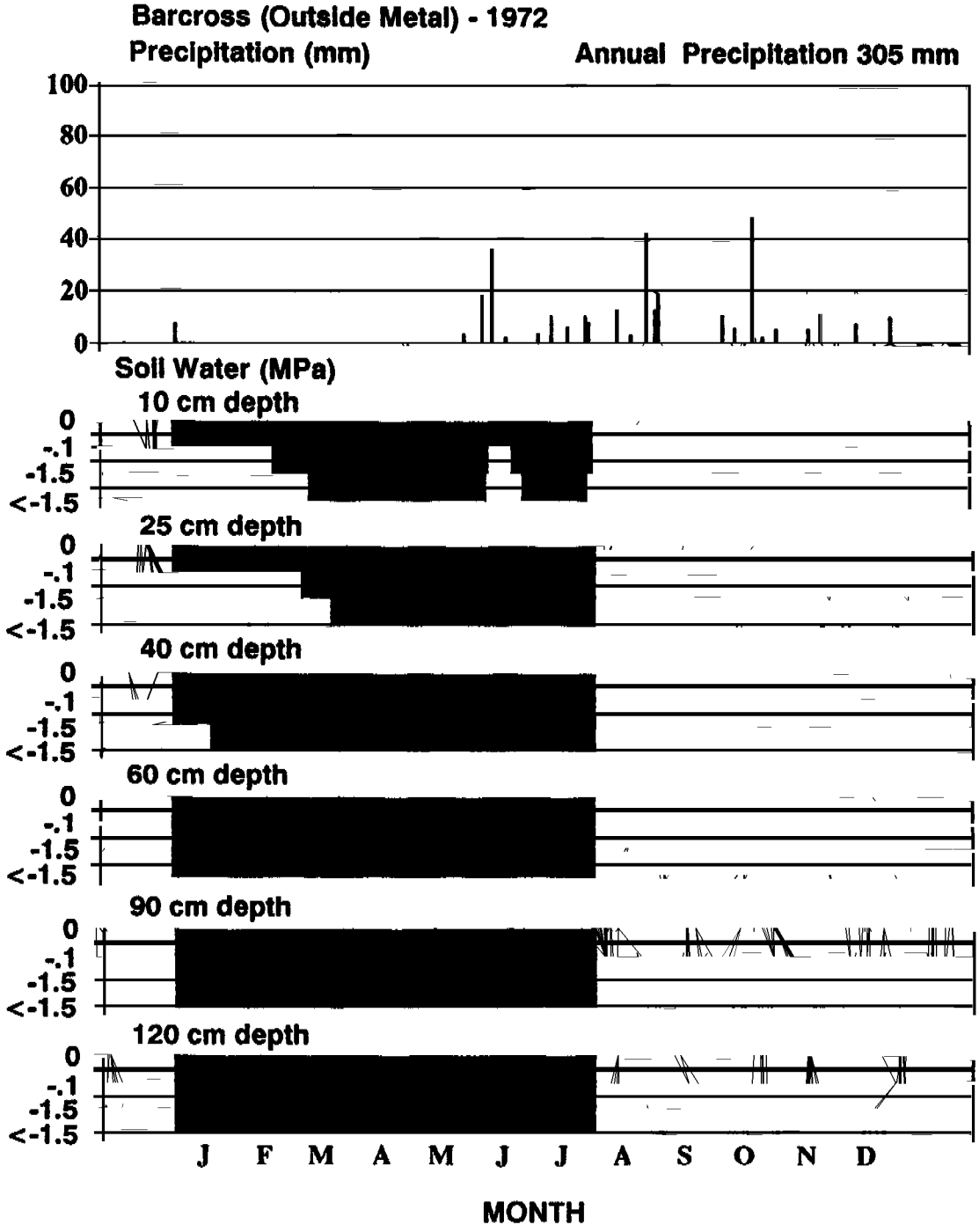


Figure 470. Annual precipitation (305 mm) and daily precipitation (mm) for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside a metal cylinder for January 1-July 31, 1972 at the Barcross site.

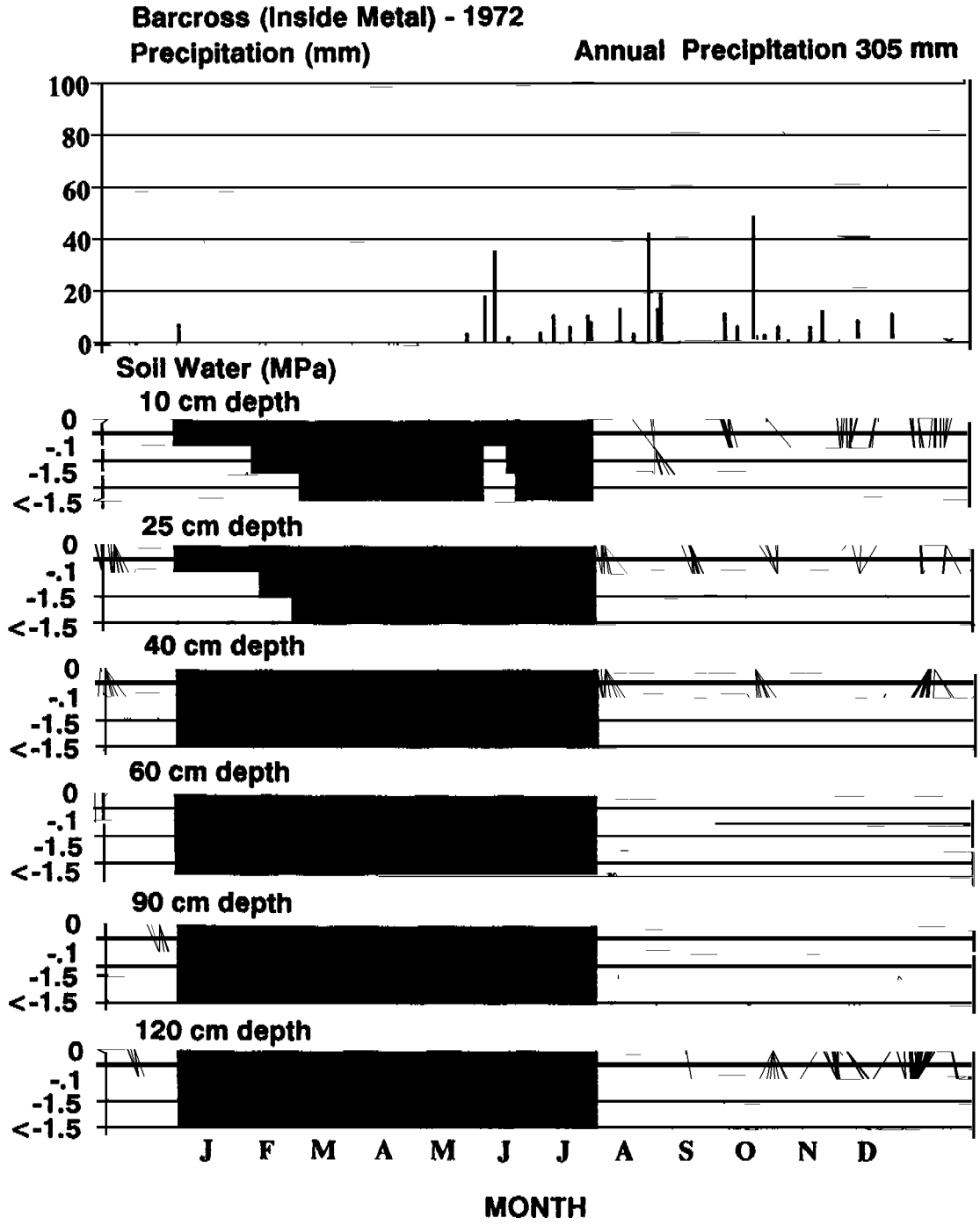


Figure 471. Annual precipitation (305 mm) and daily precipitation (mm) for 1972, and the matric potential of the soil water (MPa) at depths of 10, 25, 40,60, 90, and 120 cm inside a metal cylinder for January 1-July 31, 1972 at the Barcross site.

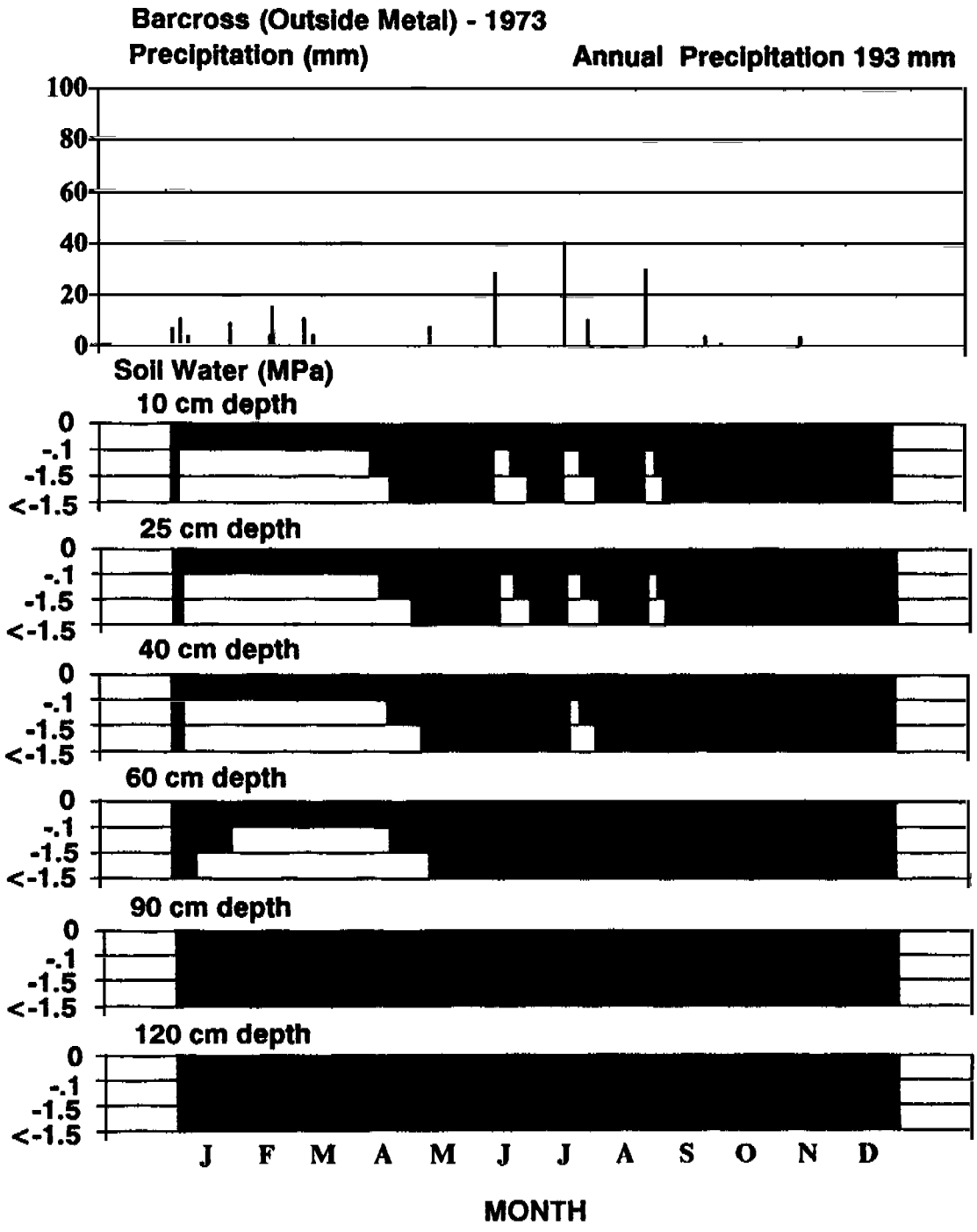


Figure 472. Annual precipitation (193 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1973.

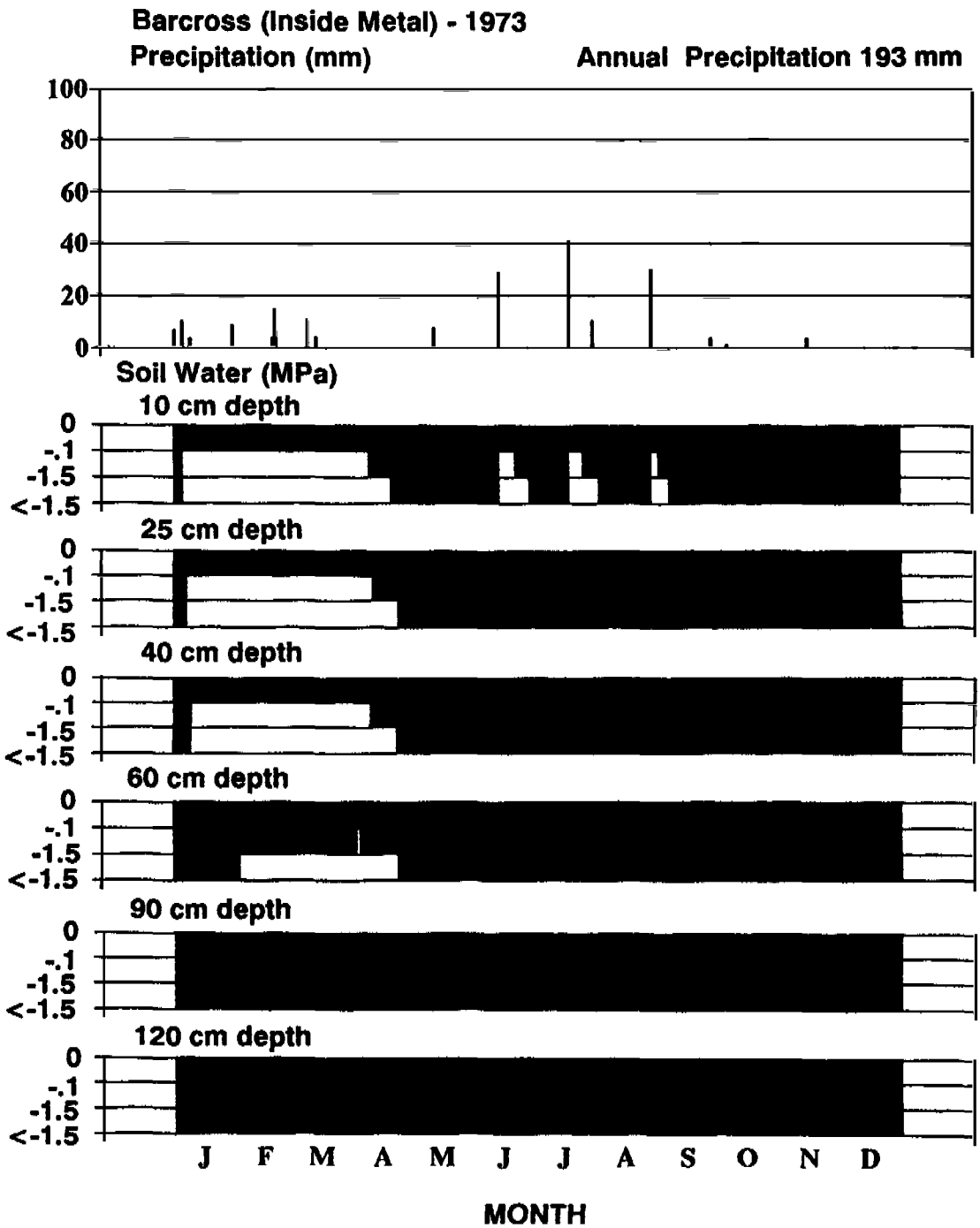


Figure 473. Annual precipitation (193 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1973.

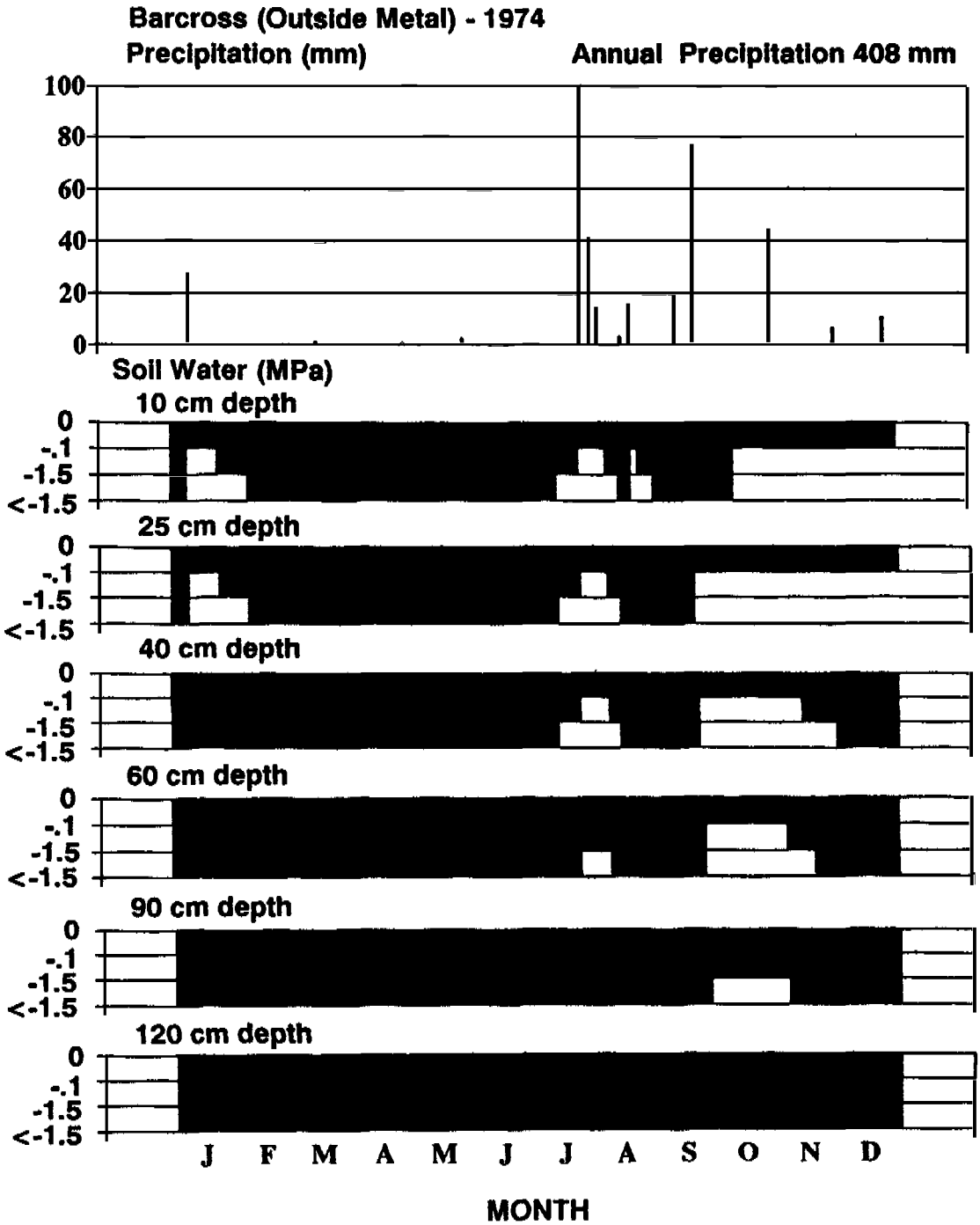


Figure 474. Annual precipitation (408 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1974.

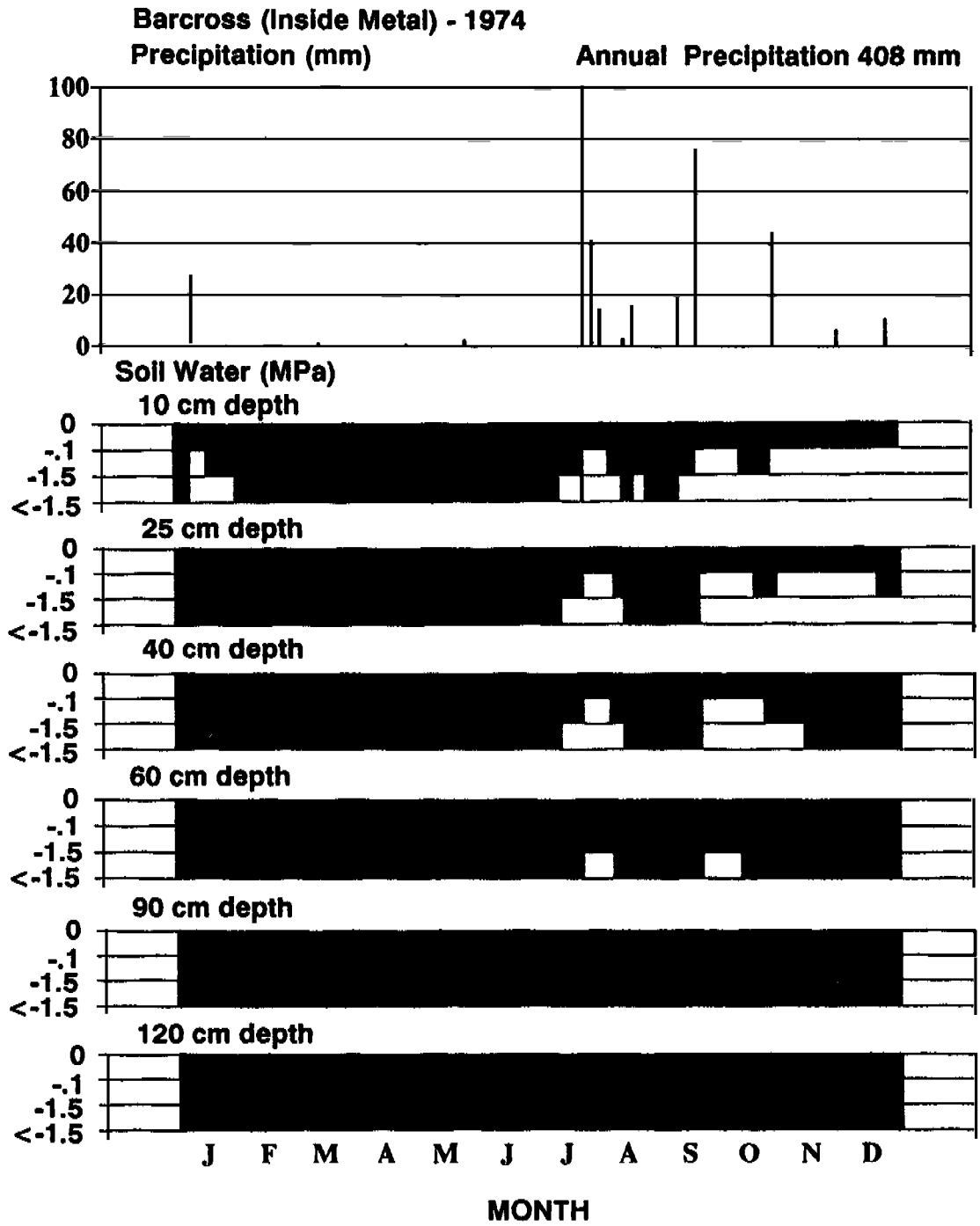
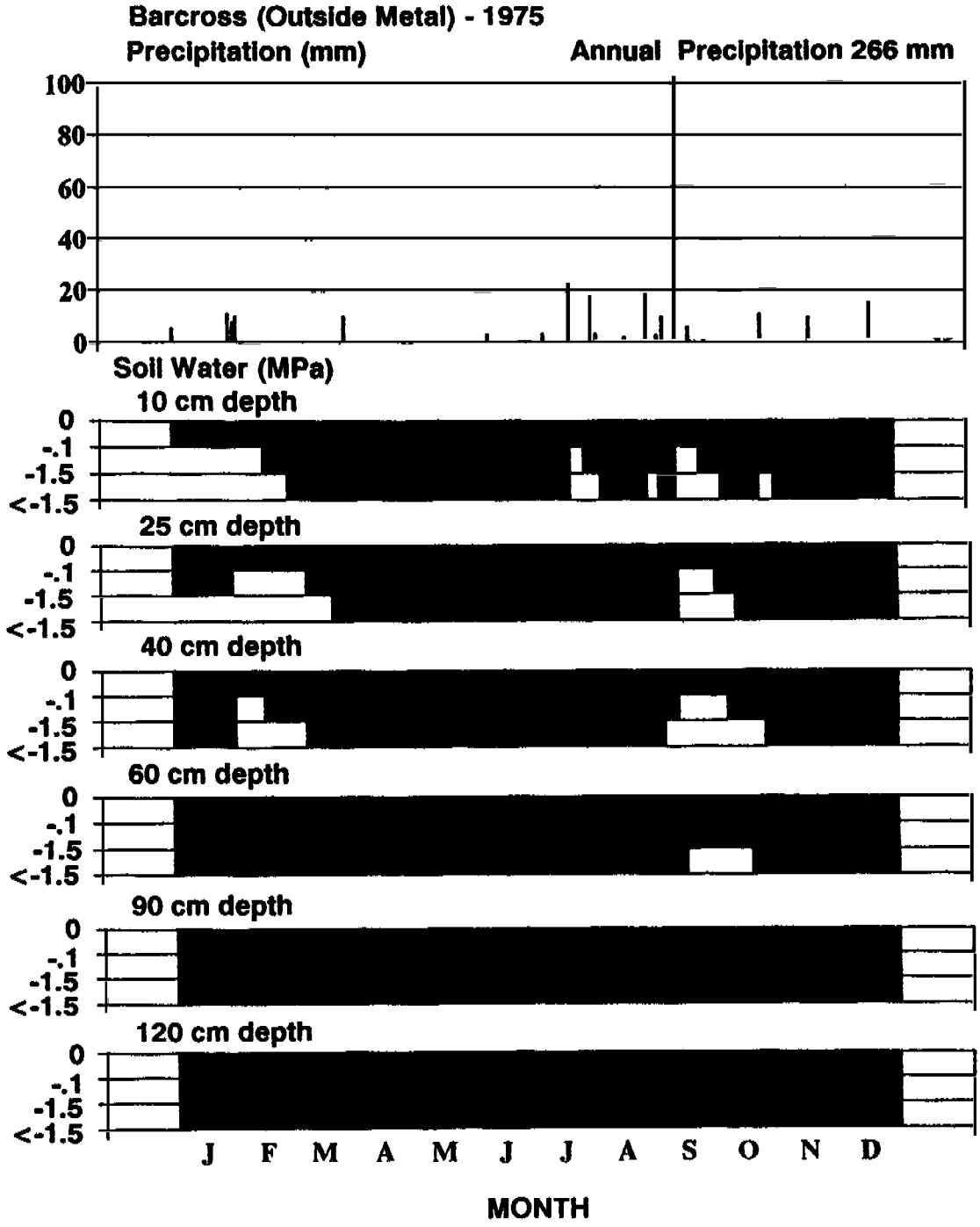


Figure 475. Annual precipitation (408 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1974.



Figrue 476. Annual precipitation (266 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1975.

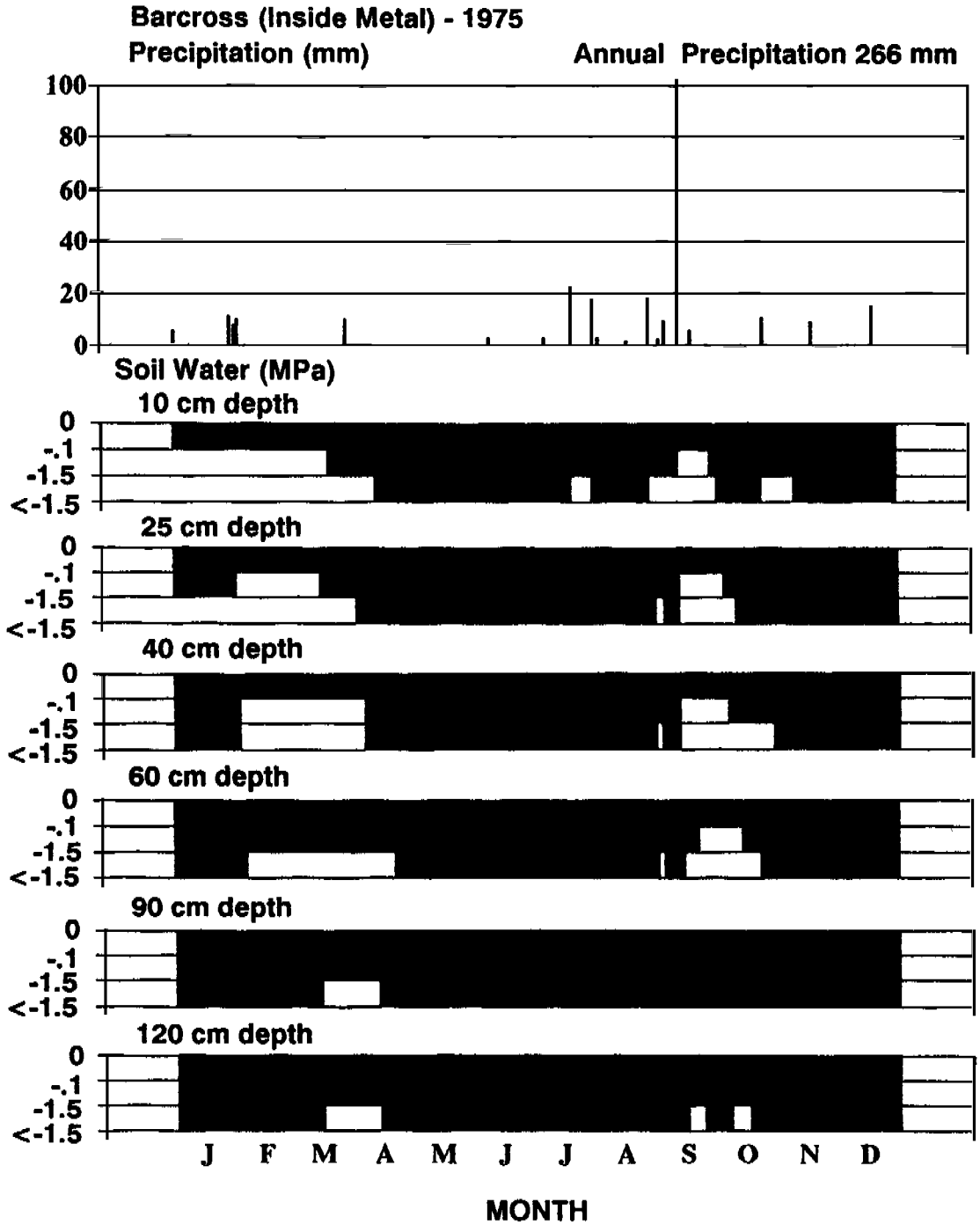


Figure 477. Annual precipitation (266 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1975.

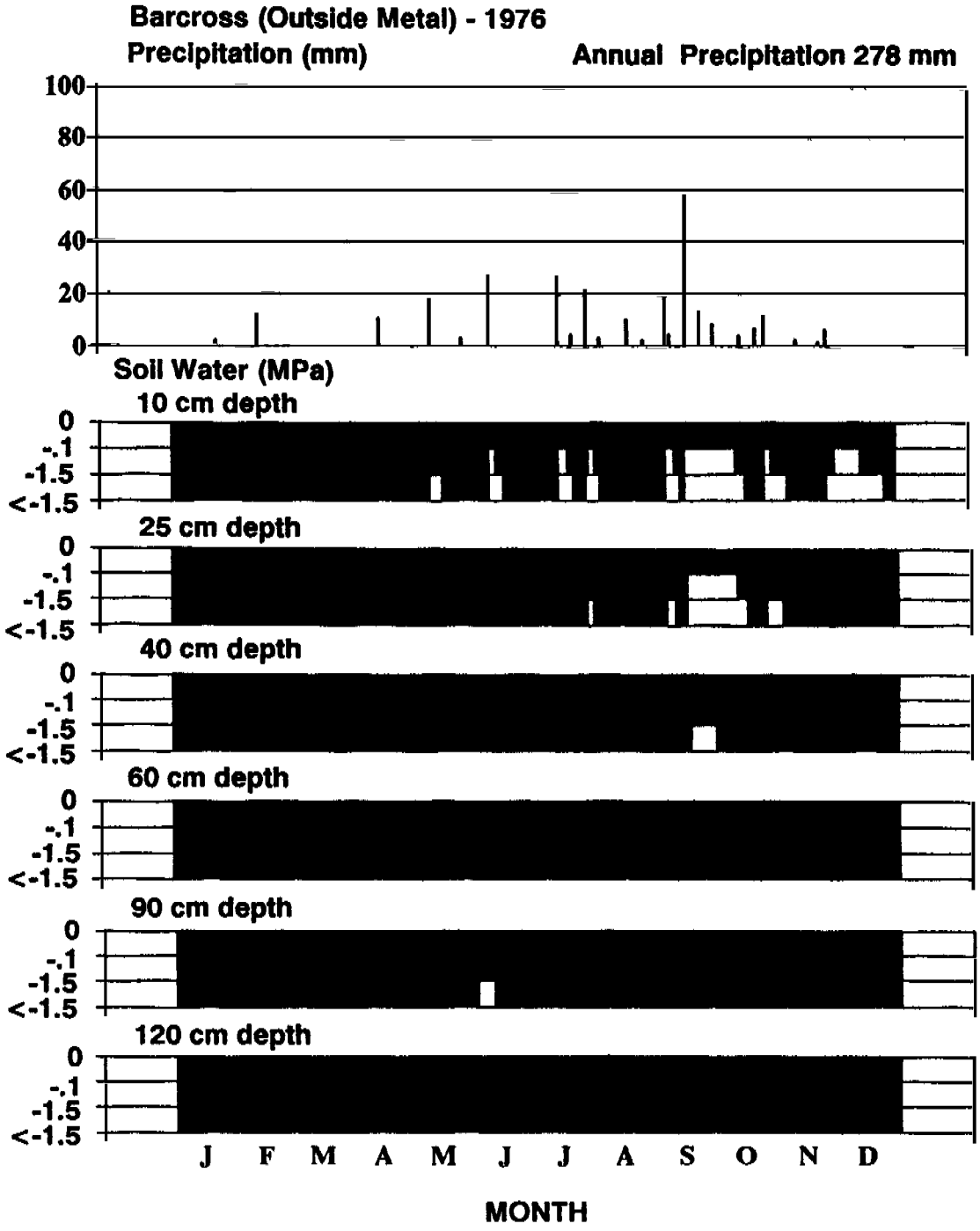


Figure 478. Annual precipitation (278 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm outside the sheet metal cylinder at the Barcross site for 1976.

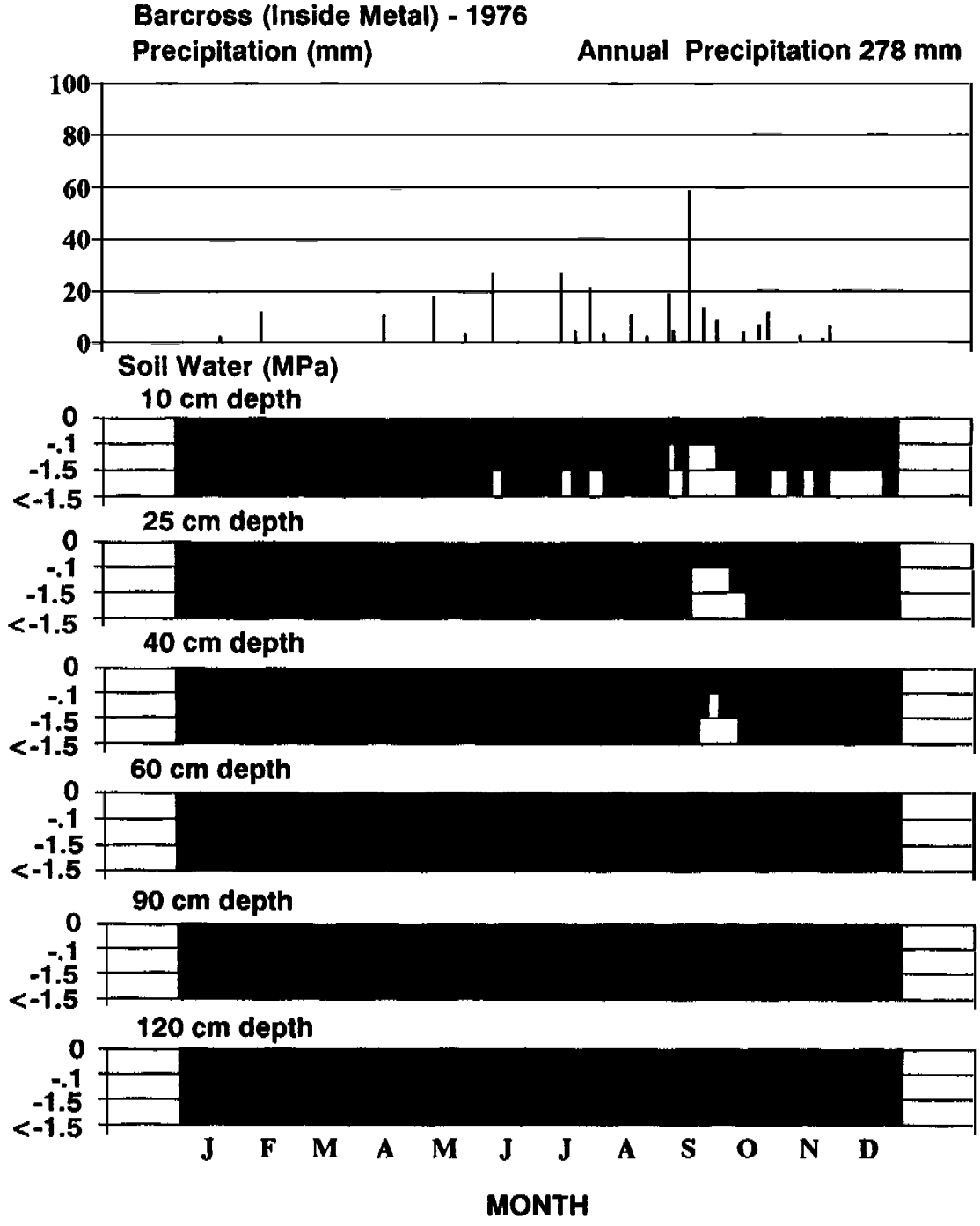


Figure 479. Annual precipitation (278 mm), daily precipitation (mm), and the matric potential of the soil water (MPa) at depths of 10, 25, 40, 60, 90, and 120 cm inside the sheet metal cylinder at the Barcross site for 1976.

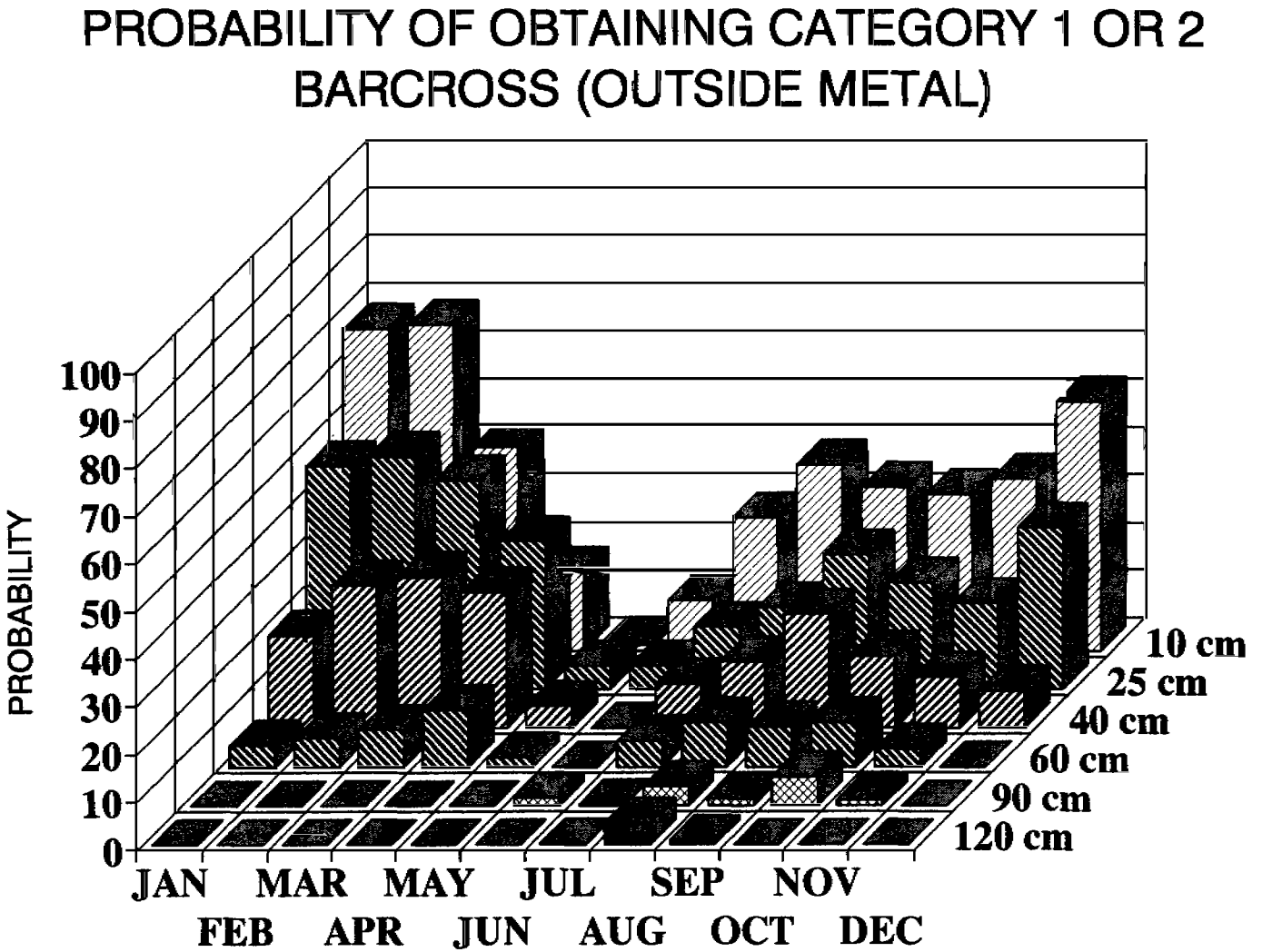


Figure 480. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm outside a sheet metal cylinder at the Barcross site.

April, 1.7% for May-June, 14.6% for July-September, and 16.9% for October-November (fig. 481). An average of about 16% of the soil water >-1.5 MPa at 25 cm was due to run-in. Burrograss yields for 1957-76 averaged 888 kg/ha and tobosa yields averaged 1688 kg/ha.

Tests of Definitions of the Soil Moisture Regimes. For the aridic (torric) moisture regime, 16 of 20 years had soil water <-1.5 MPa outside the metal cylinder more than half the time at a depth of 10 cm and 17 of 20 years at a soil depth of 25 cm while all of the years had soil water <-1.5 MPa more than half the time at depths of 40, 60, 90, and 120 cm. Fourteen of 20 years had soil water <-1.5 MPa for >90 consecutive days at 10 cm; 12 of 20 years at 25 cm; 16 of 20 years at 40 cm; and 17 of 18 years at a soil depth of 60 cm. All of the years had soil water <-1.5 MPa for more than 90 consecutive days at depths of 90 and 120 cm.

For the bordering ustic moisture regime, there were >60 consecutive days of soil water >-1.5 MPa in the moisture control section, 25-cm depth, 10 of 18 years and >30 consecutive days in the four months after June 21, 4 of 18 years when the soil water data were complete for the entire year. Soil water data were incomplete in 1957 and 1972 but the 60-day criterion was met in 1972 and the 30-day criterion was met in 1957.

CONCLUSIONS

Much of the precipitation in this arid region occurs as torrential rainstorms during the warm season and runoff rates are high on slopes. Precipitation tends to be gentler during the cool season. In addition, soil texture, depth to petrocalcic horizon, soil structure, landscape position, run-in, vegetational cover, pipes, and microrelief can have a marked effect on soil water.

SOIL TEXTURE AND DEPTH TO PETROCALCIC HORIZON

Table 15 presents the average annual precipitation and the average annual probability of days/year (%) when water was available to plants (matric potential >-1.5 MPa) during the period of study, which was mostly between 1957 and 1976 as previously discussed. In most of the soils, available water decreases with depth. Exceptions to this (table 15) are Sonoita, Stellar #2, Stellar #3 dominated by tobosa, and both Veatch soils, in which moisture first decreases with depth but then increases. These soils, as well as additional Stellar soils that do not show the decrease-increase pattern with depth, also have substantially more available water at the deeper depths (90 and 120 cm) than the other soils. Reasons for these differences are discussed in this and subsequent sections.

Soil texture is an important factor because surficial horizons of sandy texture have the greatest infiltration rates. This is shown by the water data from the soils of the broad, level or nearly level basin floor (table 15). About 50% of the days during

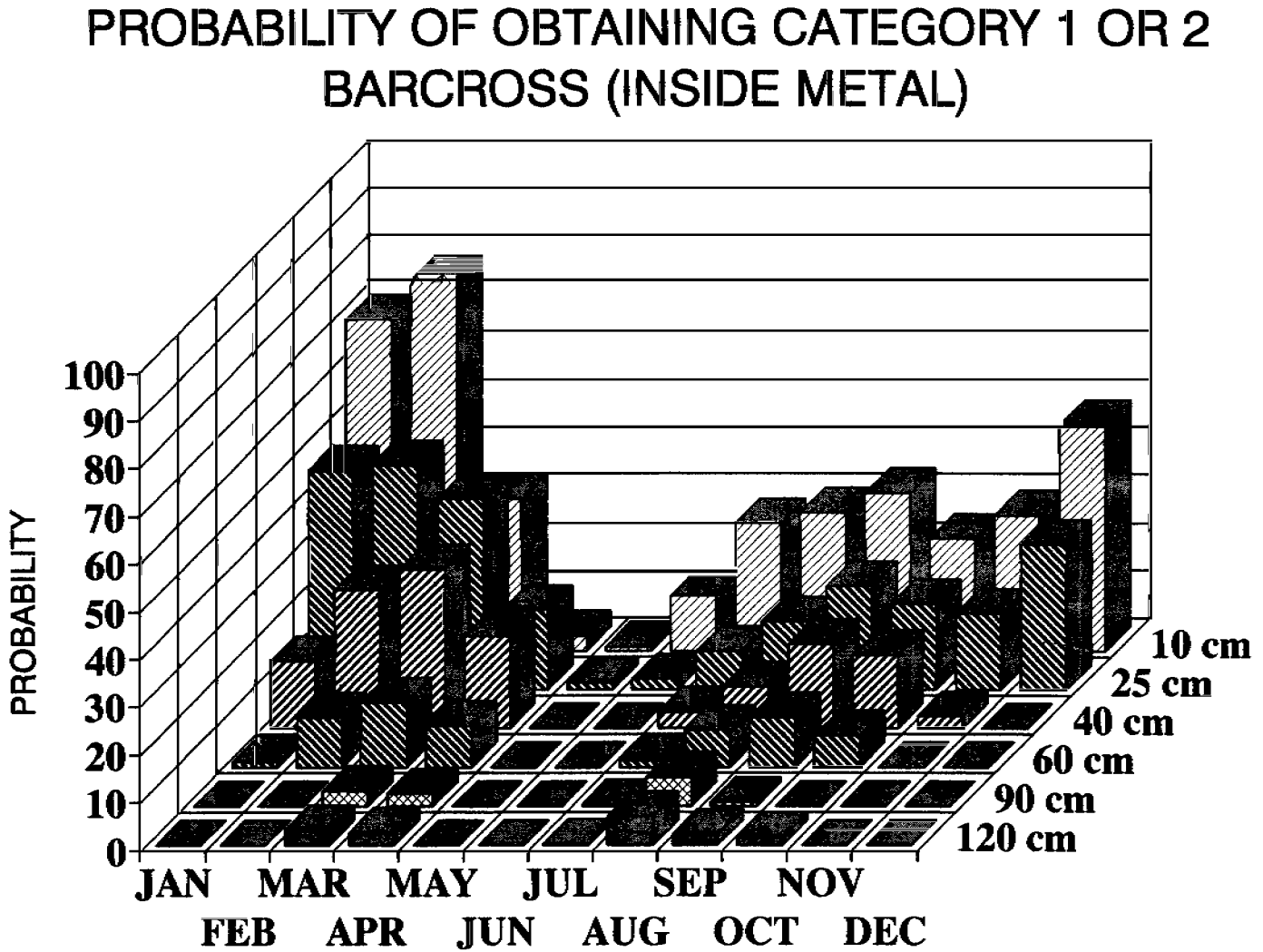


Figure 481. The probability (% days/month) of obtaining the matric potential of the soil water >-1.5 MPa at depths of 10, 25, 40, 60, 90, and 120 cm inside a sheet metal cylinder at the Barcross site.

Table 15. The average annual precipitation (mm) and the average annual probability of days/year (%) when the matric potential of the soil water was >-1.5 MPa (available to plants) during the study period.

Site	Precipitation (mm)	Probability of water >-1.5 MPa at soil depths (%) 10 cm	25 cm	40 cm	60 cm	90 cm	120 cm
Soils of the broad, level or nearly level basin floor.							
Onite	238	50.8	49.5	34.5	22.7	11.2	-
Yucca	242	56.7	51.2	37.7	19.7	14.4	-
Hueco #1	218	53.3	45.5	41.9	28.9	23.5[1]	-
Hueco #2	222	52.6	51.8	43.5	31.0	29.5	-
Hueco #3	230	58.6	58.5	48.0	35.4[2]	28.3[3]	-
Hueco #4	258	48.9	47.4	50.7	45.0	-	-
Cruces	229	47.4	35.2	29.0	-	-	-
Sonoita	238	55.8	67.2	65.2	50.9	41.8	54.8
Wink	236	50.9	47.0	39.8	37.4	23.0	-
Turney	269	46.6	38.2	30.4	21.4	15.8	-
Soils of a narrow, level basin floor and adjacent fan-piedmont.							
Herbel	251	39.5	32.5	20.6	18.3	7.5	-
Stellar #1-O[4]	244	41.3	30.9	23.9	20.7	23.4	22.4
-I[5]	244	27.8	13.7	12.7	9.2	8.5	12.2
Reagan - O	244	30.6	20.7	17.7	15.1	12.6	13.7
- I	244	22.4	12.0	7.6	7.1	6.9	7.2
Stellar #2	273	52.1	45.8	37.8	42.3	51.6	53.3
Stellar #3-T[6]	273	45.9	45.4	53.1	50.4	40.7	39.2
-B[7]	273	30.2	23.9	21.0	15.8	11.1	16.0
Veatch (S)	273	62.4	80.2	79.7	81.2	73.6	61.5
Veatch	273	51.5	67.2	69.3	63.7	50.0	73.0
A soil in a small playa.							
Barcross - O	230	35.6	26.0	16.1	5.6	1.1	0.4
- I	230	31.8	21.7	11.9	4.9	1.0	1.3

[1]81-cm soil depth.
[2]53-cm soil depth.
[3]69-cm soil depth.
[4]O=outside a sheet metal cylinder.
[5]I=inside a sheet metal cylinder.
[6]T=site dominated by tobosa.
[7]B=site dominated by burrograss

this study period had a matric potential of the soil water >-1.5 MPa at 10 cm. The Petrocalcic Paleargid Cruces had a low probability of days when the soil water was >-1.5 MPa at 25 and 40 cm because the petrocalcic horizon is nearer the surface than at other study sites. Thus horizons above the petrocalcic horizon are more subject to surface evaporation. On the other hand, in level, stable areas with occasional slight depressions and with shallow petrocalcic horizons, vegetative density indicates that soil moisture conditions (although not measured in this study) would be good because there is no runoff and the petrocalcic horizon traps soil water for plant use.

The probabilities of soil water >-1.5 MPa at 40, 60, and 90 cm were lower at Typic Calciorthid Turney, Typic Haplargid Onite, and Typic Haplargid Yucca than at Typic Calciorthid Wink and Petrocalcic Paleargids Hueco #1-4 (table 15). This is attributed primarily to finer textures at about these depths at these three sites. Historical erosion at the Onite site may be an additional factor because the A horizon is absent and the finer, harder Bt horizon is at the surface.

Low infiltration rates occur in soil horizons with high clay content where wetting is accomplished by infiltration through upper horizons. Examples of the latter are Typic Calciorthid Barcross, Ustollic Calciorthid Reagan, and Ustollic Haplargid Stellar #1, where the runoff was excluded with a sheet metal cylinder. At the 25-cm depth, the fine Haplargid at Stellar #1 (wetted by precipitation only) had only 26% of the days of soil water >-1.5 MPa that the coarse-loamy Paleargid had at Hueco #2.

Platy structure of the A and E horizons is also important because it tends to "seal" when wetted. This phenomenon was particularly evident in the finer-textured soils of a narrow, level basin floor and adjacent fan-piedmont and the soil in a small playa (table 15).

LANDSCAPE POSITION

Runoff on a fan-piedmont sloping 2% reduces the number of days of soil water >-1.5 MPa compared to gentler slopes on the fan-piedmont below. For example, the probability of soil water >-1.5 MPa at 10 cm is 40% at Herbel (2% slopes) vs 52% and 46%, r spectively, for Stellar #2 (1% slope) and Stellar #3 dominated by tobosa (1/2% slope; table 15). The differences between these soils continue to widen with depth until at 90 cm the probabilities are 8% for Herbel, 52% for Stellar #2, and 41% for Stellar #3 dominated by tobosa (table 15). However, part of the increase of the probabilities of >-1.5 MPa is due to the thick stand of tobosa at Stellars #2 and #3, which would slow water movement on the surface as compared to the sparse stand of shrubs at Herbel. Microrelief at Stellar #2 and #3 is also important as discussed later.

Runoff from higher areas can markedly increase days of soil water >-1.5 MPa in topographic depressions. For example, Stellar #1 and Reagan occur in a basin floor near a fan-piedmont, and

Barcross occurs in a small playa with contributing drainageways that lead to the mountains. Runoff provided 92% more days when the soil water was >-1.5 MPa when the study depths were combined at Stellar #1, 24% at Barcross, and 75% more days at Reagan (table 15). The Reagan site had higher probabilities of soil water >-1.5 MPa than the Barcross site at depths of 60, 90, and 120 cm, reflecting the increased run-in at the Reagan site.

Run-in can also be important to long, grassy sloping areas near depressions in determining the number of days when the soil water was >-1.5 MPa, e.g., Stellar #1 (level basin floor) vs Stellar #2 (fan-piedmont sloping 1%, table 15). Stellar #2 had 75% more days when the soil water was >-1.5 MPa than Stellar #1 at the depths studied.

MICRORELIEF

Microrelief can greatly affect soil water. The four soils Stellar #2, Stellar #3 dominated by tobosa, Veatch (S), and Veatch, had a higher probability of days when the matric potential of the soil water was >-1.5 MPa at depths of 40, 60, 90, and 120 cm (table 15). The microrelief and the soil morphology indicate the soil water at these sites was increased considerably by small depressions and holes in the soil surface and by cracks in soil horizons connected to the holes. The Ustollic Haplargid Veatch (S) had a higher probability of days when the matric potential of the soil water was >-1.5 MPa at depths of 10, 25, 40, 60, and 90 cm than any other study site even though the soil water blocks were within a metal cylinder that prevented surface run-in (table 15). The depressions and holes at the Veatch sites also contributed soil water to Stellar #3 dominated by tobosa, particularly at the 40- and 60-cm depths. Conversely, absence of depressions and holes can greatly decrease soil water only a few meters away as demonstrated by Stellar #3 dominated by burrograss.

PIPES

Except for the Veatch soils, the Typic Haplargid Sonoita had the highest probability of soil water >-1.5 MPa at depths of 25, 40, 60, and 90 cm because the gypsum blocks were in a huge pipe (table 15). Sonoita also has the thickest noncalcareous zone in this study, probably because of the increased soil water in the pipe. Free water at the top of the adjacent petrocalcic horizon moves into the pipe and supplements the soil water supplied by vertical infiltration from the surface.

VEGETATIONAL COVER

Cover of vegetation is another factor affecting soil water. The Ustollic Haplargid Stellar #3 dominated by tobosa and the one dominated by burrograss are only about 5 m apart but the site dominated by tobosa had more than twice the probability of soil water >-1.5 MPa at the measured depths than the site dominated by burrograss (table 15). This difference in soil water between these two sites is due to the presence of depressions and holes in the nearby Veatch soil, and the difference in vegetation cover. Another effect of vegetation is the thick stand of tobosa on Veatch and Stellars #2 and #3 vs the sparse stand of shrubs on Herbel as discussed in the section on effect of landscape position.

PERCENTAGE OF DAYS DRY AS A TAXONOMIC CRITERION

Table 16 shows the percentage of days dry at different depths in the soil. It should be noted that Aridisols in the Desert Project occur at higher elevations and are wetter than many Aridisols. Thus the expected range in percentage of days dry for Aridisols would be wider than suggested by the data shown in table 16. As would be expected, the percentage of days dry gradually increases with depth for most soils except for the Veatch and some of the Stellar soils as previously discussed.

Data for the four Hueco pedons (table 16) show these ranges in percentage of days dry at the 25, 40, and 60 cm depths: 41-54, 49-58, and 55-71. There is less variation at the 40 cm depth. Tentatively using that depth for discussion purposes, the Cruces soils, which are similar to Hueco but have a shallow petrocalcic horizon, have 71% dry days at 40 cm depth. This is substantially greater than for the deeper Hueco soils. Other soils also show considerable variation at the 40 cm depth (table 16; reasons for the variations have been discussed in previous sections). There is so much variation that specific ranges in the percentage of days dry may ultimately be found best as taxonomic criteria for specific landscape positions, textures, microrelief, vegetation, and/or combinations of these.

SEASONAL PATTERNS OF SOIL WATER

Substantial parts of the soils are moist for surprisingly long periods in many years because of seasonal patterns of precipitation, precipitation intensity, plant growth, and evapotranspiration. Most of the precipitation in the summer occurs as rains of high intensity associated with thunderstorms. In contrast, fall and winter precipitation tends to be gentler, causing much less runoff and increased infiltration. In addition most plant growth takes place in the summer months when evapotranspiration is high. Because of lower evapotranspiration

Table 16. The average annual precipitation (mm) and the average annual probability of days/year (%) when the matric potential of the soil water was <-1.5 MPa (dry) during the study period.

Site	Precipitation (mm)	Probability of water <-1.5 MPa at soil depths (%)					
		10 cm	25 cm	40 cm	60 cm	90 cm	120 cm
Soils of the broad, level or nearly level basin floor.							
Onite	238	49.2	50.5	65.5	77.3	88.8	--
Yucca	242	43.3	48.8	62.3	80.3	85.6	-
Hueco #1	218	46.7	54.5	58.1	71.1	76.5[1]	-
Hueco #2	222	47.4	48.2	56.5	69.0	70.5	-
Hueco #3	230	41.4	41.5	52.0	64.6[2]	71.7[3]	-
Hueco #4	258	51.1	52.6	49.3	55.0	--	-
Cruces	229	52.6	64.8	71.0	--	--	-
Sonoita	238	44.2	32.8	34.8	49.1	58.2	45.2
Wink	236	49.1	53.0	60.2	62.6	77.0	-
Turney	269	53.4	61.8	69.6	78.6	84.2	-
Soils of a narrow, level basin floor and adjacent fan-piedmont.							
Herbel	251	60.5	67.5	79.4	81.7	92.5	-
Stellar #1-O[4]	244	58.7	69.1	76.1	79.3	76.6	77.6
-I[5]	244	72.2	86.3	87.3	90.8	91.5	87.8
Reagan-O	244	69.4	79.3	82.3	84.9	87.4	86.3
-I	244	77.6	88.0	92.4	92.9	93.1	92.8
Stellar #2	273	47.9	54.2	62.2	57.7	48.4	46.7
Stellar #3-T[6]	273	54.1	54.6	46.9	49.6	59.3	60.8
-B[7]	273	69.8	76.1	79.0	84.2	88.9	84.0
Veatch (S)	273	37.6	19.8	20.3	18.8	26.4	38.5
Veatch	273	48.5	32.8	30.7	36.3	50.0	27.0
A soil in a small playa.							
Barcross-O	230	64.4	74.0	83.9	94.4	98.9	99.6
-I	230	68.2	78.3	88.1	95.1	99.0	98.7

[1]81-cm soil depth.
[2]53-cm soil depth.
[3]69-cm soil depth.
[4]O=outside a sheet metal cylinder.
[5]I=inside a sheet metal cylinder.
[6]T=site dominated by tobosa.
[7]B=site dominated by burrograss.

and virtual lack of plant growth in the fall and winter months, soil water from precipitation during these times tends to stay in the soil.

Table 17 shows the probability of the matric potential of the soil water >-1.5 MPa at 25 cm for the 4 seasons of the year. Precipitation during fall and early winter is generally responsible for the high probability of soil water >-1.5 MPa during the winter.

The coarser textured soils of the broad, level or nearly level basin floor had an average probability of 48% more soil water >-1.5 MPa at 25 cm in the winter than the summer (table 17). The Herbel and Barcross soils also had a higher probability of soil water >-1.5 MPa at 25 cm in the winter than in the summer. The Stellar, Reagan, and Veatch soils had similar probabilities of soil water >-1.5 MPa at 25 cm in winter and summer (table 17). These data suggest a higher proportion of C3 plants in the flora can increase use of the soil water >-1.5 MPa.

SOIL WATER WITHOUT RUNOFF OR RUN-IN

In stable areas where runoff and run-in are not involved, most favorable soil water conditions occur in soils and landscapes that have the following characteristics: (1) level or nearly level areas of a stable landscape that show little or no evidence of erosion, (2) a thin surficial horizon, about 5-10 cm thick, of sand or loamy sand to allow maximum infiltration of water and to reduce rapid water loss by evaporation, and (3) a slightly finer-textured horizon (e.g., medium or heavy sandy loam) at least 25-45 cm thick, to capture most of the water that has penetrated and to keep it in the root zone of most herbaceous plants. Indurated horizons can also slow the downward percolation of soil water. The Petrocalcic Paleargid Hueco #3 is an example of such a soil.

PRECIPITATION, SOIL WATER, AND HERBAGE DYNAMICS

There is often a poor relationship among precipitation, soil water, and herbage dynamics. For example, examine the 1975 and 1976 data for the following sites: Hueco #1, Hueco #2, Hueco #3, Cruces, Sonoita, Turney, Stellar #1, Reagan, and Barcross. These data show large differences in production of perennial grasses but small differences in annual precipitation. There are numerous other examples. Undoubtedly, the factors discussed previously must also be considered in evaluating soil water of arid rangelands.

TESTS OF DEFINITIONS OF THE SOIL MOISTURE REGIMES

The data of this study provide tests of definitions of the aridic (torric) moisture regimes used in soil classification, and of a proposed definition for bordering ustic. Data from gypsum blocks at the 25-cm depth have been used because this depth lies

Table 17. The average probability (%) of the matric potential of the soil water >-1.5 MPa at 25 cm for 4 periods during the year.

Site	Winter[1]	Spring[2]	Summer[3]	Fall[4]
Soils of the broad, level or nearly level basin floor.				
Onite	65.6	28.9	43.2	39.4
Yucca	69.9	16.0	49.0	42.6
Hueco #1	58.9	16.3	44.8	42.3
Hueco #2	68.5	21.7	47.2	46.8
Hueco #3	74.2	37.4	49.6	53.5
Hueco #4	67.5	20.1	36.5	41.0
Cruces	47.1	20.6	36.5	17.9
Sonoita	86.1	52.0	54.3	54.5
Wink	70.0	26.5	33.1	31.1
Turney	54.2	13.3	33.5	29.9
Soils of a narrow, level basin floor and adjacent fan-piedmont.				
Herbel	53.9	7.9	20.3	22.0
Stellar #1-O[5]	36.1	3.4	33.5	41.4
-I[6]	16.0	0.9	17.8	14.5
Reagan-O	21.4	1.9	30.6	22.9
-I	18.7	0.6	11.9	6.8
Stellar #2	57.2	16.6	48.3	42.6
Stellar #3-T[7]	54.6	15.6	46.5	50.7
-B[8]	26.6	6.4	29.8	25.8
Veatch (S)	82.4	62.5	87.5	81.4
Veatch	72.6	43.3	73.3	68.5
A soil in a small playa.				
Barcross-O	40.8	4.9	19.3	20.1
-I	36.0	1.7	14.6	16.9

[1]Winter=December-April.
[2]Spring=May-June.
[3]Summer=July-September.
[4]Fall=October-November.
[5]O=outside a metal cylinder (run-in).
[6]I=inside a metal cylinder (no run-in).
[7]T=site dominated by tobosa.
[8]B=site dominated by burrograss.

within the soil moisture control sections of all soils of the study. Table 18 gives definitions for both the aridic (torric) and the bordering ustic soil moisture regimes, the total years of measurement at each site, and the total years that the set(s) of blocks at each site met the criteria for the moisture regime using the 25-cm depth.

The definition of the bordering ustic moisture regime, criterion #1, "the soil moisture control section is moist (>-1.5 MPa) for >60 consecutive days per year," was superior to criterion 2 at 12 of 19 sites (Onite; Yucca; Huecos # 1-4; Sonoita; Wink; both Veatches; Stellar #2; Stellar #3 dominated by tobosa; table 18). The definition of the aridic (torric) moisture regime, criterion a, "the moisture control section is dry (<-1.5 MPa) in all parts more than half the time," was superior to criterion b at the sites that tended to have less days of soil water >-1.5 MPa than the sites mentioned above (Cruces, Stellar #1, Stellar #3 dominated by burrograss, Reagan, and Barcross; table 18). The latter definition for aridic "a" and the definition for the bordering ustic moisture regime, criterion #2, "the moisture control section is not moist in any part for more than 30 consecutive days in the 4 months following the summer solstice (June 21)," were equally useful in describing the soil water regimes at two sites, Herbel and Turney (table 18). Even at the Cruces, Turney, and Herbel sites, the soil moisture definition for bordering ustic criterion #1 nearly described the soil water r gimes.

The definition of the bordering ustic moisture regime criterion #1 described the situation 84% of the years at all sites xcept Barcross, Reagan, Stellar #1, and Stellar #3 dominated by burrograss (table 18). These four sites have less soil water >-1.5 MPa than the other sites. The definition of the aridic (torric) moisture regime criterion "a" described 90% of the years at these latter four sites.

Table 18 shows that criterion b in the aridic (torric) moisture regime definition and criterion 2 of the bordering ustic moisture regime definition are a poor fit for most soils in this study. On the other hand, criteria a and 1 of the aridic (torric) and bordering ustic moisture regime definitions, respectively, do fit most of the soils in most years.

Table 18. Tests of the aridic (torric) and bordering ustic moisture regimes at the 25-cm soil depth.

Site	Soil series, phase or taxadjunct	Classification	The aridic (torric) moisture regime: years of measurement/years that qualify Criterion[a]	Criterion[b]	The bordering ustic moisture regime: years of measurement/years that qualify Criterion#1[c]	Criterion#2[c]
Soils of the broad, level or nearly level basin floor. All soils have sandy surface horizons except for the soil at site O, which has fine sandy loam.						
O	Onite, buried soil phase	Typic Haplargid, coarse-loamy	20/10	20/7	20/18	20/7
Y	Yucca	Typic Haplargid, coarse-loamy	20/11	20/6	20/18	20/8
H1	Hueco	Petrocalcic Paleargid, coarse-loamy	20/10	20/7	20/16	20/9
H2	Hueco	Petrocalcic Paleargid, coarse-loamy	20/11	20/5	20/17	20/8
H3	Hueco	Petrocalcic Paleargid, coarse-loamy	17/9	17/5	17/13	17/9
H4	Hueco	Petrocalcic Paleargid, coarse-loamy	20/12	20/7	20/16	20/10
C	Cruces	Petrocalcic Paleargid, loamy, shallow	13/11	13/6	13/10	13/7
S	Sonoita	Typic Haplargid, coarse-loamy	20/5	20/3	20/19	20/3
W	Wink, deep *gypsum phase*	Typic Calciorthid, coarse-loamy	17/9	17/5	17/14	17/9
T	Turney taxadjunct	Typic Calciorthid, fine-loamy	20/14	20/9	20/13	20/14
Soils of a narrow, level basin floor and adjacent fan-piedmont. All soils have clay loam or loam surface horizons except for the soil at site H, which has fine sandy loam.						
H	Herbel	Typic Torriorthent, coarse-loamy	19/15	19/10	19/14	19/15
S1	Stellar	Ustollic Haplargid, fine	20/17	20/11	20/13	20/10
R	Reagan	Ustollic Calciorthid, fine-silty	20/19	20/15	20/7	20/13
S2	Stellar	Ustollic Haplargid, fine	20/11	20/7	20/18	20/5
VS3	Veatch (S)	Ustollic Haplargid, fine	18/3	18/2	18/17	18/3
	Veatch	Ustollic Haplargid fine	18/6	18/2	18/17	18/1
	Stellar-T[d]	Ustollic Haplargid, fine	19/11	19/6	19/17	19/7
	Stellar-B[e]	Ustollic Haplargid, fine	18/17	18/13	18/9	18/13
A soil in a small playa. This soil has a fine sandy loam surface horizon.						
B	Barcross	Typic Calciorthid, fine-loamy	20/17	20/12	20/11	20/15

[a]The moisture control section in most years is dry in all parts more than half the time (cumulative) that the soil temperature at a depth at 50 cm is above 5 degree C.

[b]The moisture control section in most years is never moist in some or all parts for as long as 90 consecutive days when the soil temperature at 50 cm is above 8 degrees C.

[c]The soil moisture control section is (1) moist in some part for 60 to 90 consecutive days per year when the soil temperature at 50 cm is more than 8 degrees C but (2) not moist in may part for more than 30 consecutive days in the 4 months following the summer solstice.

[d]Stellar soil dominated by tobosa.

[e]Stellar soil dominated by burrograss.

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