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## 652.0308 State Supplement

### (a) Critical Growth Periods

In general, plant stress caused by insufficient soil moisture will reduce yields. Most crops are more sensitive to water stress during some periods of their growing season. A critical period is defined as a period in which the crop is most sensitive to moisture stress. Moisture stress during this period causes an irreversible loss of yield. While this may occur at any time during the life cycle of many crops, critical periods are usually those where the affects of a water deficit are most detrimental to yield or quality. If there is enough moisture for germination and for the establishment of an adequate stand, the critical period often occurs later in the season during the pollination period or during the fruit development stage. Critical periods must be considered carefully since they will depend on plant species and variety.

A Summary of critical periods for commonly irrigated crops are shown in Table 3-1 on Pages 3-3 to 3-5. More detailed information is available under the discussion for individual crops in the Montana Irrigation Manual.

### Moisture Stress Indicators

For most crops, a change of leaf appearance to a more dull or dark outward showing of leaf color often precedes leaf wilting.

Corn leaves that begin to curl by mid-morning is an indicator of plant stress. Stress on spring grains appears as firing of lower leaves. Wilting is almost always an indicator of plant stress. One exception is maturing sugar beets which may show some wilting on hot days even when adequate soil moisture is present.

### For Fruit Trees:

During bloom, stress appears as a reduced set of fruit-bloom drop. During fruit development, fruit growth will decrease or stop. Pre-harvest fruit drop, or poor quality fruit often is the result of stress.

### (b) Management Allowed Deficit (MAD)

Determining when to irrigate requires the selection of a management allowed depletion (MAD). This is management determined allowed soil moisture depletion prior to irrigation. MAD can be expressed in one of three ways: (1) as a percent of the available water capacity (AWC) in the root zone, (2) as a soil water deficit (SWD) in inches, or, (3) as an allowable soil moisture tension level.

Different crops will tolerate different soil moisture depletion levels. The same crop will generally have critical periods during various stages of growth that require adjusting the MAD. Table 3-2 Adapted Irrigation Methods on Page 3-6, shows management depths for planning, and applicable irrigation methods. Table 3-3 on Page 3-7 lists recommended management allowed deficit values by crop development stages.

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### (c) Example Management Allowable Depletion (MAD) and Irrigation Frequency

Following, on the next page, is an example of how to select a Management Allowable Depletion (MAD) and use it to calculate net irrigation water requirement and irrigation frequency.

Given: The operator is growing potatoes on a sandy loam soil. The crop ET rate is .34 in/day.

Find: Select an appropriate MAD value and determine the net irrigation requirement and the irrigation frequency.

Solution:

Step 1.

Using procedures mentioned in Chapter 29 (AWC for texture, layer thickness and corrections), the available water capacity is estimated at 3.36 inches at 24". Table 3-4 shows typical rooting depths. For the purpose of this example, a rooting depth of 2 feet is selected. (In an actual situation never assume a plant root zone for management purposes, rather check actual root development pattern and depth.) From Table 3-3 select a MAD of 35%. Net irrigation can be calculated the following way:

$$\text{Net Irrigation} = \text{Available water capacity (AWC)} \times \frac{\text{MAD}\%}{100}$$

$$\text{Net Irrigation} = 3.3 \text{ inches} \times \frac{35\%}{100} = 1.15 \text{ inches}$$

AWC may be selected for the maximum seasonal depth or to a stage of root development during the season for a specific irrigation set.

Step 2.

The Irrigation frequency can be calculated as follows:

$$\text{Irrigation frequency} = \frac{\text{Net Irrigation}}{\text{Crop ET rate}} = \frac{1.15 \text{ inches}}{0.34 \text{ in/day}} = 3.4 \text{ days}$$

### (d) Irrigating with Limited Water Supplies

To accommodate limited water supplies, irrigation managers can do something other than purchase additional equipment or reduce irrigated acreage. By making the best use of water, irrigation managers can free up both water and equipment for use on other crops, other land parcels, or other resource needs. Well-timed irrigations may help managers irrigate more acres without lowering crop yields.

Seed-producing crops such as corn, barley, sunflowers, wheat, and beans, respond more to irrigations during one particular stage of

development than during other stages. Yields of storage and forage crops--sugar beets, potatoes, alfalfa, and grasses--are more directly related to climatic demand and cumulative water use during the season than to stress during any particular growth stage.

#### Sugar Beets

Sugar beets are quite drought tolerant. They can withstand extended periods, without rainfall or irrigation water, by using water stored in the soil. Limited water can even increase the efficiency of sucrose production. Simply by cutting off irrigations 3 to 4 weeks before harvest operations,

sucrose yield per unit of water use can be increased above that where maximum water use is allowed.

Sugar beets are only moderately sensitive to plant stress, except during the early growth stages. Afternoon leaf wilting during hot, dry, windy conditions has negligible effects on total sugar production. Water can be used more efficiently on sugar beets by applying one last significant irrigation to recharge the entire soil profile at the onset of the major stress period which is approximately the first of August.

Sugar beets adapt to limited irrigations both by using deeply stored soil water, and by quickly recovering when water is made available following major stress periods. Normal irrigations of sugar beets could be reduced after the middle of July. Sucrose yield is likely to be reduced very little when such a practice is used with a final heavy irrigation applied in early August.

### **Corn**

Corn is very sensitive to drought stress, especially during the flowering and reproductive stages. Stress during the early vegetative stage is not nearly as serious as stress during flowering, pollination, and early seed filling. Grain corn is most sensitive to drought stress between the 12-leaf and blister kernel stages. This period includes flowering, pollination, and initial seed filling. Stress during any part of the cropping season limits grain corn production. To maximize water use efficiency in grain corn, it is best to limit irrigations during the vegetative stage. In contrast, the vegetative stage is important for silage corn. The period from emergence to 12-leaf was least sensitive to stress.

### **Barley**

Barley responds to drought stress much like corn and other cereal crops. Yield is likely to be reduced very little when drought stress occurs during the vegetative period. However, a major disadvantage

of early drought stress is the tendency for plants to tiller more than usual. Although the increased tillering is desirable, often the tillers never produce grain-yielding heads if water is not adequate in that stage. Barley is most sensitive to stress during jointing, booting, and heading. Considering drought stress before, during, and after heading, yield is reduced the most by drought before heading. Flowering and pollination appear to be the most sensitive periods.

### **Wheat**

Several studies have been conducted with spring wheat and winter wheat to evaluate the effect of limited irrigations on crop quality and production.

Stress was most critical during and after heading. This response is similar to that for barley. There is little or no measurable benefit from irrigating spring grains before the boot stage, unless moisture stress is evident. Stress is likely to occur when the plants appear wilted and the leaves curl. The period between grain filling and maturity is critical. Yield is reduced most when stress starts during soft dough or during or following heading. Stress during the maturing process results in approximately a 10 percent lower yield.

Moderate stress during the early vegetative period has essentially no effect on yield. Irrigation managers can use water most efficiently on spring-planted grains by reducing early season irrigations and by minimizing crop stress during flowering, pollination, and seed filling.

Drought stress on winter wheat production during early spring regrowth results in head development approximately 7 to 10 days prematurely. The consequence of early heading is early maturity and a shortened growth period. Thus, yield is reduced. Early stress results in development of more heads than usual. However, many of the heads fail to produce grain. Winter wheat is most sensitive to drought stress during shooting and booting. It is

essential to avoid even slight water stress at joining. Withholding water to increase tillering may lead to premature heading and grain maturity.

### **Potatoes**

High-quality potato yields can be achieved only by maintaining a uniformly high level of available water throughout the crop season. Short 4- to 5-day stress periods do not lower yields significantly or deteriorate the quality of potatoes compared to unstressed crops. Potato production is directly related to crop water use between emergence and defoliation. Potatoes are not susceptible to severe yield reductions from short periods of moderate stress during any single period of production.

### **Alfalfa**

Alfalfa forage yield is directly related to available water and actual plant water use. Alfalfa is not nearly as sensitive to plant water stress at different times of the season as are most of the grain-producing crops. Forage increases of one-sixth to one-fifth ton per acre per year for each inch of applied water have been obtained.

Maximum water use by alfalfa is not likely to exceed 24 inches between late April and the later part of August. Most alfalfa varieties, when subjected to plant water stress, will go into dormancy, thereby dramatically reducing both water use and production. When irrigation reduces stress, the crop resumes growth. Alfalfa is much less sensitive to plant water stress, regardless of when it occurs during the growing season.

### **Summary**

Essentially two types of response occur when irrigated crops are subjected to drought stress.

**Determinate** crops, which are grown primarily for the harvest of mature seed, are most sensitive to drought stress during the seed formation period.

This period includes heading, flowering, and pollination. These crops are also dependant on day length and season length. Crops most affected by stress during this period include small grains, other cereal crops, and oilseed crops. Drought stress that occurs between seed development and maturity also limits yield, but to a lesser degree. These same crops are relatively insensitive to drought stress during the early vegetative period.

**Indeterminate** crops, such as tuber and root crops that are grown primarily for the harvest of storage organisms, are relatively insensitive to moderate drought stress for short intervals throughout the entire crop growing season. Crops, like potatoes, sugar beets, alfalfa, and pasture, quickly recover from short stress periods and little reduction in yield occurs.

Irrigation managers confronted with limited irrigation water should consider making the most efficient use of water by their crops. For seed crops, this means cutting back on early season irrigations and ensuring minimum stress conditions between seed development and maturity. For root, tuber, and forage crops, irrigation managers should minimize the number of early season irrigations and reduce or eliminate late-season irrigations.

### **Reference Material**

For individuals wishing to read more about irrigated crops and irrigated crop management, some of the following reference might provide answers to your questions.

“Irrigating with limited water supplies” 1985. An (out of print) Extension Circular, 1262, written by Jim Bauder in response to the 1985 drought. Single copies can be obtained from Jim Bauder, jbauder@montana.edu or by calling (406) 994-5685 and leaving a voice mail message with mailing address. Request Circular 1262, Limited Water Supplies. This note is part of the Agronomy Notes series, a weekly news release and

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fact sheet series prepared by: James W. Bauder, Soil and Water Specialist Montana State University, Land Resources, and Environmental Sciences, Bozeman, MT 59717, ph. (406) 994-5685, fax 406/994-3933 jbauder@montanai.edu

### **Crop Nutrient Content**

A tool on the web has been developed by NRCS to approximate the amount of nitrogen, phosphorus, and potassium that is removed by the harvest of agricultural crops.

This site can be found at:

[http://npk.nrcs.usda.gov/nutrient\\_body.html](http://npk.nrcs.usda.gov/nutrient_body.html)

### **Salinity**

The Agriculture Research Service has developed a web site for salt, boron and chloride tolerance in crops. This site is:

<http://www.ussl.ars.usda.gov/databases.htm>

## **CROPS**

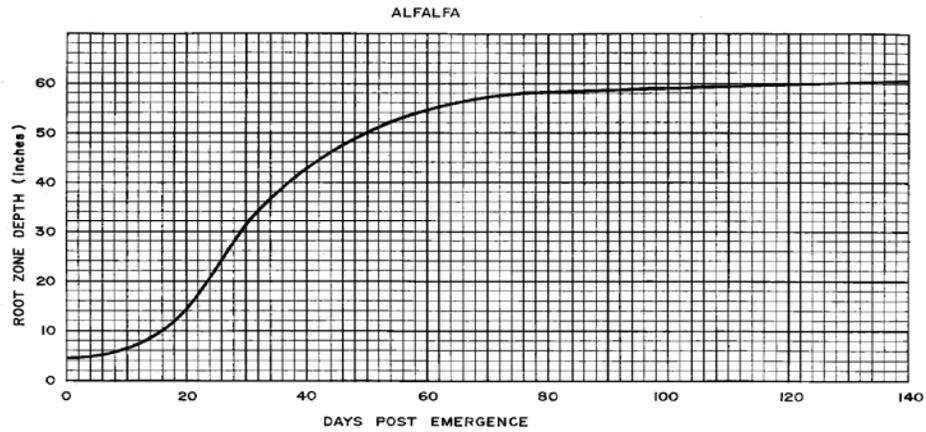
### **Rooting Depth**

Effective rooting depth at the time of irrigation is one factor in determining how much water must be replaced by an irrigation. Effective root depth is that portion of the soil profile where the effective root zone is lost to deep percolation or is not immediately used by the plant.

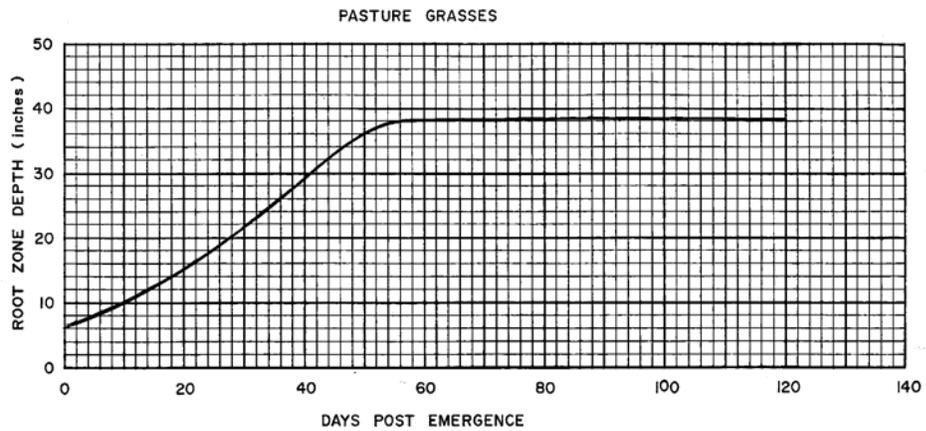
Rooting depths are often modified by soil compaction, stratification, or other factors. Since roots do not penetrate dry soil, a layer of dry soil below the surface can control rooting depth. A high water table also limits root growth, or may kill roots that have previously grown below the rising water surface. Salinity concentrations may also restrict root development. Because of many factors affecting root depths, effective root depth should be determined in the field whenever possible.

Rooting depth varies by stage of growth for annual crops and should be considered in determining the water available for plant use. Figures MT-3.1 through MT-3.9 (See the following pages) illustrates rooting depths by stage of development for various crops.

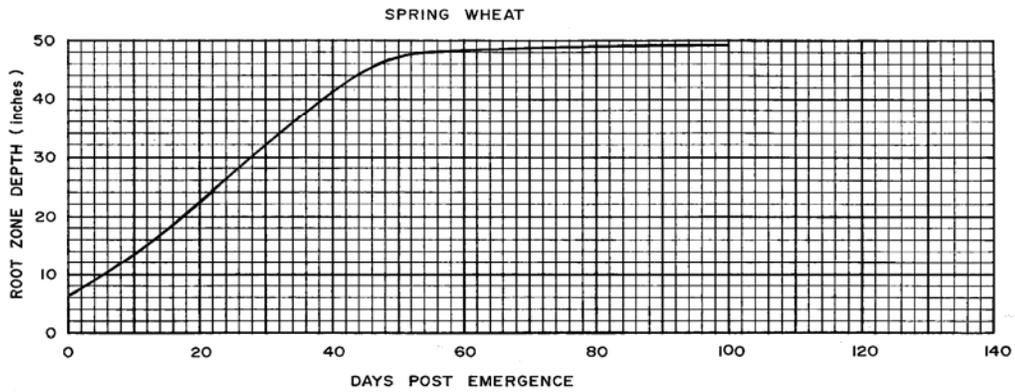
**Figure MT-3.1**  
Rooting Depth by Stage of Development for Alfalfa



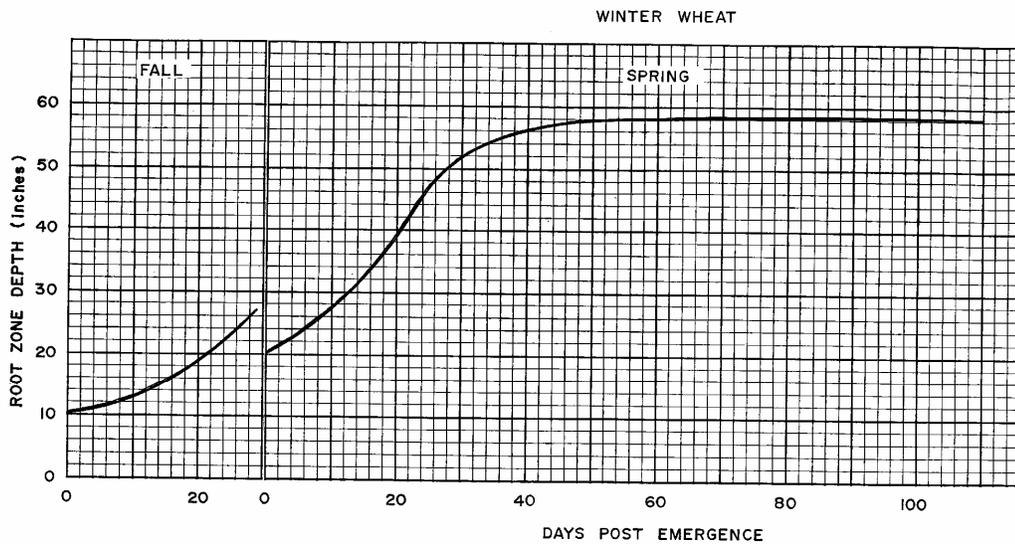
**Figure MT-3.2**  
Rooting Depth by Stage of Development for Pasture Grasses



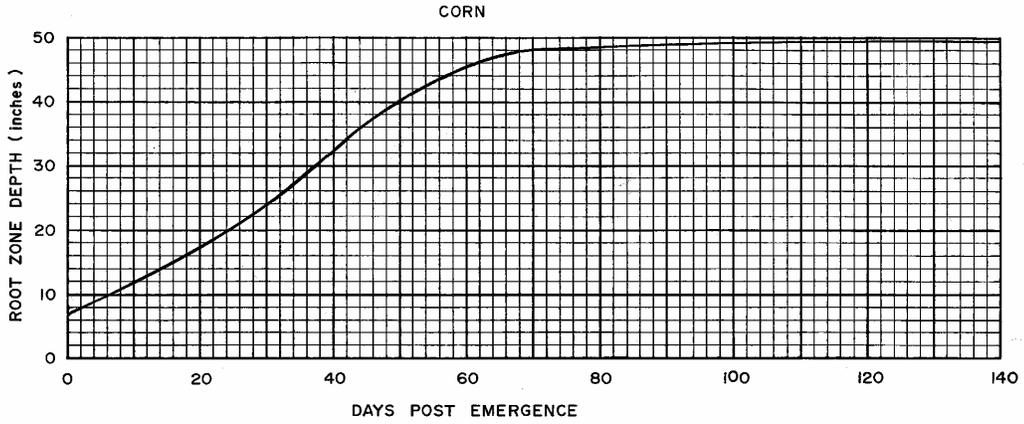
**Figure MT-3.3**  
Rooting Depth by Stage of Development for Spring Wheat



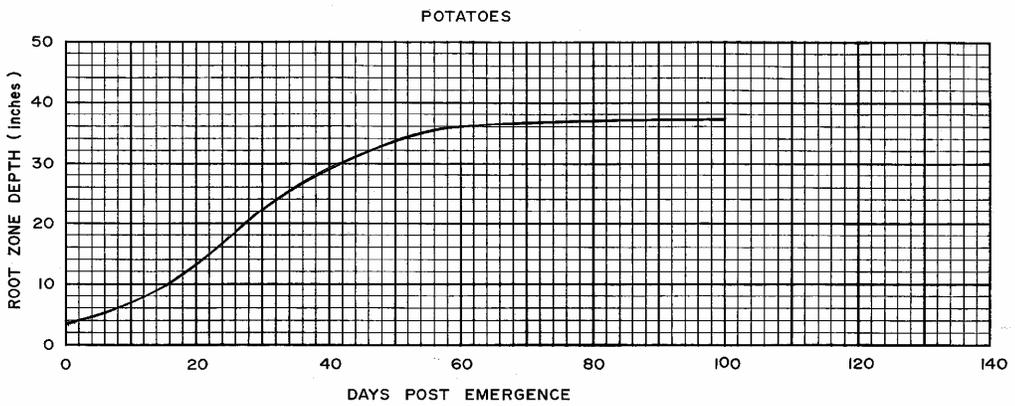
**Figure MT-3.4**  
Rooting Depth by Stage of Development for Winter Wheat



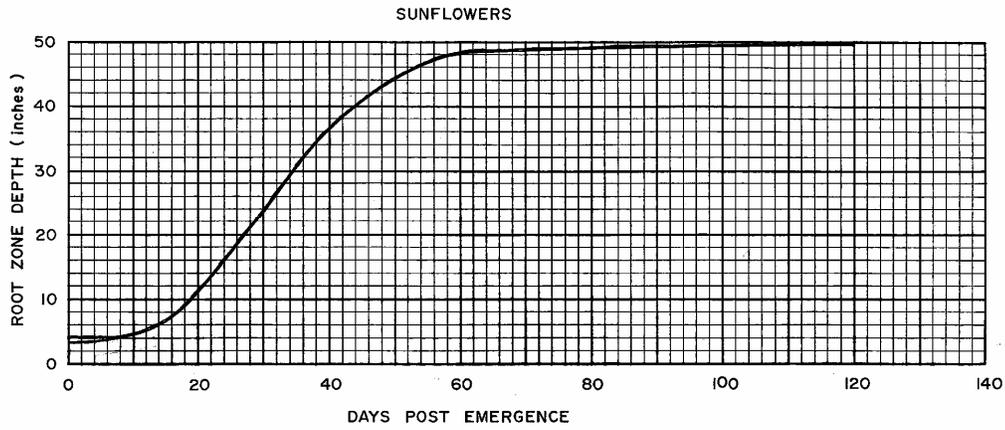
**Figure MT-3.5**  
Rooting Depth by Stage of Development for Corn



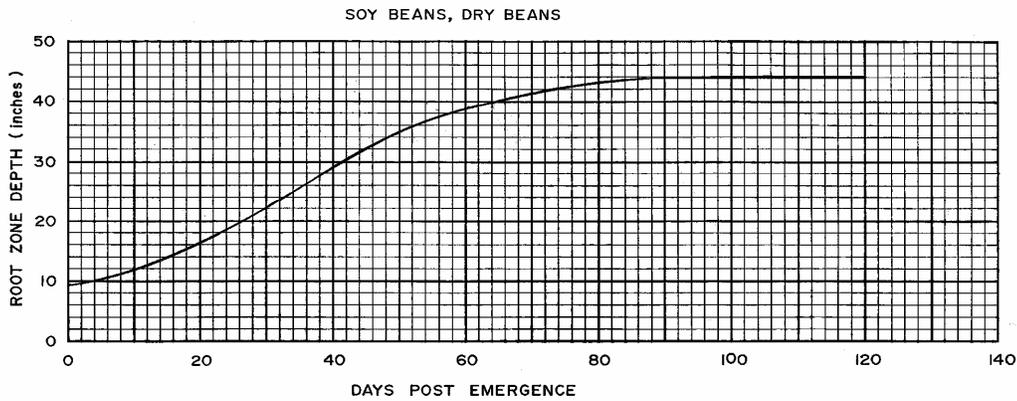
**Figure MT-3.6**  
Rooting Depth by Stage of Development for Potatoes



**Figure MT-3.7**  
Rooting Depth by Stage of Development for Sun Flowers



**Figure MT-3.8**  
Rooting Depth by Stage of Development for Soy Beans, Dry Beans



**Figure MT-3.9**  
Rooting Depth by Stage of Development for Sugar Beets

