United States Department of Agriculture

FINAL STUDY REPORT

Los Lunas Plant Materials Center, Los Lunas, New Mexico

Bureau of Land Management "Seeds of Success"

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In 2010, the Natural Resources Conservation Service (NRCS) Los Lunas Plant Materials Center (LLPMC) entered into an Interagency Agreement with the Bureau of Land Management (BLM) "*Seeds of Success*" (SOS) Program to establish seed production fields of BLM selected native plant populations at the LLPMC in an effort to improve the commercial availability of seed adapted to the Colorado Plateau.

The Colorado Plateau is situated in the Four Corners region and includes portions of Arizona, Colorado, New Mexico, and Utah. It comprises approximately 130,000 square miles. This area terrain consists of high deserts with scattered high mountain forests and unique geological features including domes, reefs, river narrows, natural bridges, slot canyons and more. Historically this area has experienced severe land disturbances from heavy off-road vehicle use, livestock grazing, oil and gas exploration and production, mining activities, abandoned farmland, and noxious and invasive weed invasions. There is a limited amount of commercial plant materials adapted to this region available for restoration purposes.

The LLPMC has been producing seed of several forb species, some of which are rarely produced under agronomic conditions:

- *Oenothera pallida* – Pale evening primrose
- *Ipomopsis aggregata* – Scarlet gilia
- *Sphaeralcea parvifolia* – Smallflower globemallow
- *Ratibida columnifera* - Upright prairie coneflower

Oenothera pallida – Pale Evening Primrose (LLPMC # Number 9066884, BLM # W6-32619)

Only 0.3 grams of primrose seed was received from SOS in 2010; the seed packet indicated an approximate seed count of 2,000 seed. Seed vendors report from 500,000 to 700,000 seed /lb. which would equate to 330 to 460 seed in 0.3 grams. This seed was sown on the surface of peat/perlite mix, moistened, and then cold stratified for six weeks at 40°F (4°C). This primrose seed had very poor germination resulting in the production of 20 containerized transplants which transplanted into a raised bed at the LLPMC in spring of 2011. In the fall of 2011, a considerable amount of seed was harvested by hand from these plants.

There was enough seed from the 2011 harvest to sow six plug trays (341 cells each) with about 0.7 tsp. seed per tray. This seed was mixed with ¾ cup of sifted peat moss/perlite media for each tray. The seed mixture was dispensed through a soil sieve to evenly distribute the seed over each tray on April 13, 2012.

Each tray was watered daily until April 16, 2012. The trays were then put into clear plastic bags and placed in a walk-in cold room with minimal lighting (for species requiring light for germination) set at 40°F (4°C). On May 7, 2012, the trays were removed from cold stratification and placed in a greenhouse where the night temperature had a set-point of 55°F (13°C) and day temperature had a set-point of 70° F (21°C). The seedlings were transplanted into Deepot™ (D12) (2.5 inches x inches [12 cubic inches]) containers in mid-June 2012. After the seedlings were well established in the D12's, they were transferred to the nursery on July 31, 2012 to harden off.

Prior to transplanting the seedlings, Field 34S at the LLPMC was prepared by laser leveling and flood irrigating in early August 2012. The planting rows were ripped 18-inches deep with a straight shank subsoiler. Fertilizer was applied every 12-inches in the soil slits at a dose of 4 grams phosphorus (⅔ TBS. ammonium phosphate) and 10 grams potassium (1 TBS. potassium sulfate) using a Rainflo Model #1600 Series II Water Wheel Transplanter (WWT) to dibble holes where the fertilizer was placed. The soil slit was ripped again to distribute the fertilizer both vertically and horizontally. The field was flood irrigated again to optimize soil moisture before planting and to partially fill the soil slits.

The seedlings were transplanted on August 23, 2012 using the (WWT) to place the plants 12-inches apart with a between row spacing of 76-inches. Unlike the other rows, the eastern-most ¾- row of pale evening primrose was fertilized with 5grams of Osmocote Plus 15-9-12 (5-6 month release) controlled release fertilizer placed in the bottom of each planting hole. The final planting contained 2.75 rows in the central portion of Field 34S and comprised approximately 800 plants. Figures 1 and 2 show the planting in mid-October 2012.

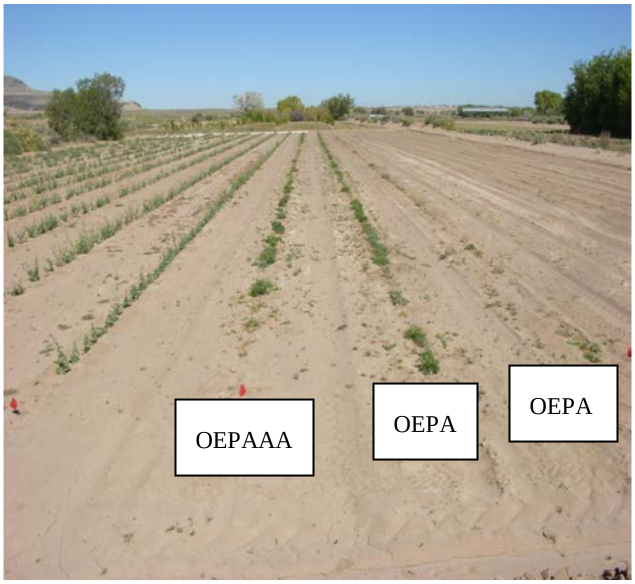

Figure 1. *Oenothera pallida* – Pale Evening Primrose planting comprising 2.75 rows in the central portion of Field 34S on October 15, 2012.

Figure 2. *Oenothera pallida* – Pale Evening Primrose plants on October 15, 2012.

In 2013, we initially tried to harvest the seed using the vacuum harvester (described in the section *Vacuum Harvester with Blower-Facilitated Seed Detachment*). The large distance (>3 ft.) between the vacuum intake and the blower outlet required by the width of plants resulted in negligible seed dispersal out of the seed capsules into the air stream. The small seed size, the vining nature of the species (see Figure 3 and 4), and the need to harvest green stems precluded the use of a combine harvester in its normal operating configuration. Therefore, the plot was harvested with a forage harvester in late August. The green material was spread on a tarp in a hot greenhouse to be dried before cleaning. This material yielded 4.5 lbs. (2.0 kilograms) of cleaned seed, a 7,000-fold increase from the initial seed weight.

Figure 3. *Oenothera pallida* – Pale Evening Primrose in early July 2013, seedlings planted in August 2012.

Figure 4. OEPA field mid-June 2014, planted in 2012

The seed harvested in 2013 was used to propagate 6,000 OEPA seedlings (Figure 5) to be planted into a new seed field and expand the existing field. During July 2014, we transplanted the 4,000 of the most vigorous seedlings with a WWT, and the remaining 2,000 seedlings were planted in August. This new field was planted into stubble from a winter wheat crop (Figure 5). The planting rows had been roto-tilled in a narrow strip to facilitate ripping and fertilizing. Before planting, the rows were ripped with a straight shank ripper to a depth of 22 inches and deep side-dressed (10-inch depth) with potassium sulfate and mono-ammonium phosphate at a rate of 50 lbs. K and P per acre (Figure 5).

Figure 5. Deep side dressing P and K (6/30/14)

Figure 6. OEPA seedlings (1350 per bench) (6/30/14)

In 2014, the total harvest from both of the new fields (harvested 10/30/14) and the old field (harvested 8/21/14) was 25.70 bulk lbs. (13.05 PLS lbs.). The low PLS percentage in 2014 was due to a large fraction (45%) of dead seed. We interpreted this as immature seed collected from the newly-planted field which was still in bloom when harvested on 10/30/14. The new field was harvested with a collection trailer pulled behind the combine to create, in effect, a high-powered forage harvester by manipulating the concave opening, threshing speed, and air flow of the combine (Figure 7).

In 2015 the two primrose fields totaling 0.9 acre were harvested with combine/collection trailer. The massive amount of biomass collected required us to stagger harvests in the period between 9/1/15 and 9/16/15 to allow the earliest harvested matter to dry before the final harvest was conducted. The approximate volume of material harvested after drying was 630 $ft.^3$ (23 $yd.^3$). The total bulk seed harvested was 43.80 lbs. (22.24 PLS lbs.).

Figure 7. Combine with collection trailer to perform as a high-power forage harvester.

Ipomopsis aggregata – Scarlet gilia (LLPMC# 9066883, BLM # W6 32589)

6.1 grams of *Ipomopsis aggregata* (scarlet gilia) seed was received from SOS in 2010; the seed packet indicated an approximate seed count of 2,000 seed. The 6.1 grams of seed was sown on the surface of peat/perlite mix, moistened, and then cold stratified for six weeks at 40°F (4° C). A 0.25 acre field of scarlet gilia (*Ipomopsis aggregata)* was established from transplants in August 2010. The scarlet gilia field was drenched on September 24, 2010 with the fungicide Subdue Maxx® to control root-rot which had infected most of the plants. The drenching seemed to control the disease since few uninfected plants were lost after the treatment. These biennial plants did not flower in 2010, so there was no seed production until 2011. The surviving plants were harvested in 2011 and yielded very little viable seed.

We decided to attempt to grow the next crop of scarlet gilia using drip irrigation and fungicide treatments because we felt that flood irrigation might have exacerbated the root-rot diseases, and that preventative fungicide applications soon after planting might be required.

On February 22, 2012, the seed was sown into a single 341 cell plug tray (each cell measuring 0.75 inches x 0.75 inches x 2.5 inches) at rate of two-to-five seeds per cell. The seed was covered lightly with fine grit (0.02 inches to 0.03 inches [0.5–0.8 millimeters]) and the tray was moistened. On February 23, 2012, the tray was placed into a clear plastic bag which was then placed into a walk-in cold room with minimal lighting (for species requiring light for germination) set at 40° F (4° C). The tray was removed from cold stratification and placed in a greenhouse on April 12, 2012; the greenhouse had a night temperature set-point of 55° F (13° C) and day temperature set-point of 70° F (21° C). The seedlings were transplanted into Deepot^{TM} 19 (D19) (2.5 inches x 5 inches [19 cubic inches]) containers between May 21 and 28, 2012. After the seedlings were well established in the D19's, they were transferred to the nursery to harden-off on June 27, 2012. The seedlings were transplanted into a Weed Guard Plus Heavy Weight Creped Organic paper mulch on July 19, 2012. Holes were cut into the mulch with a 3-inch diameter sharpened steel pipe in two parallel rows with plant spacing 16-inches between rows and within rows. The holes were dug with a miniature clam shell post-hole digger, and 1 tsp. (5 grams) of 'Osmocote' Plus 15-9-12 (5- to 6-month release) controlled release fertilizer was placed in the bottom of each hole. A row of T-tape (15 mil, 8-inch emitter spacing, 0.22 gpm/100 ft.) drip tape was placed adjacent to each row. The transplants were drenched with 'Subdue' fungicide on July 23, 2012, and with 'Banrot' fungicide on July 30, 2012 with approximately 6 oz. of drench solution per plant at the labeled rate for preventative care. The planting was irrigated every seven days.

The planting and an individual plant are shown in Figures 8 and 9 as of October 10, 2012. As of March 1, 2013, 135 out of the 155 plants (87%) were still alive. This biennial species sent up flowering stems in 2013 which reached heights of up to 6 ft. and produced numerous flowers and appreciable activity from hummingbirds for pollination (Figure 10).

Figure 8. *Ipomopsis aggregata* – Scarlet gilia planting in Field 7 at the LLPMC on October 10, 2012.

Figure 9. *Ipomopsis aggregata* – Scarlet Gilia plant in Field 7 at the LLPMC on October 10, 2012.

Entire stems were hand harvested on October 23, 2103 and placed in woven polyethylene bulk bags for drying. These approximate 100 plants yielded 0.4 lbs. of cleaned seed with an estimated PLS percentage of 30%.

1,500 scarlet gilia seedlings were propagated from the seed harvested in 2013 from the drip-irrigated, 100-foot row (Figure 10). These seedlings propagated in the spring of 2014 (Figure 11) were planted in early July 2014 using the WWT. The seedlings were planted on five (5) beds to try to reduce root-rot development. These beds were formed using a border disc followed by ripping and fertilizing. Prior to transplanting, the beds were shaped and smoothed using an 18-inch wide bed shaper.

Figure 10. *Ipomopsis aggregata* – scarlet gilia test plot October 1, 2013

Figure 11. Scarlet gilia seedlings (1350 per bench) on 6/30/14

After planting, the seedlings were drenched once with the following fungicides and then one week apart to prevent root- and stem-rot:

a. Banrot® (etridiozole and thiophanate-methyl, Groups 14 and 1 fungicides)

b. Subdue Maxx® (metalaxyl–M, Group 4 fungicide)

After a rainy July in the summer of 2015, symptoms of root-rot were observed in the scarlet gilia planting. The plants were drenched first with a tank-mix of Banrot® (etridiozole and thiophanate-methyl, Groups 14 and 1 fungicides) and Subdue Maxx® (metalaxyl–M, Group 4 fungicide). Approximately one week later they were drenched with Alliette® (aluminum-tris, Group 33 fungicide). These fungicide applications did not aid in preventing the additional mortality of the flowering plants.

Ratibida columnifera – Upright prairie coneflower (LLPMC# 9066882, BLM# W6-32619)

1.9 grams of *Ratibida columnifera* was received from SOS in 2010; the packet indicated an approximate 2,000 seed count. Prairie coneflower seed was covered with 2 mm of peat/perlite mix and germinated in a warm greenhouse at the LLPMC. The seedlings propagated in 2010 were used to establish a 0.5 acre field in August 2010 which yielded 0.44 lbs. of cleaned seed. The harvested seed was used to grow additional seedlings in 2011 to establish another 0.55 acre of seed production.

The older planting in Field 23S was harvested in December of 2011 using a Kincad XP 2-row plot combine. This field yielded 29.4 PLS/lbs. The seed had a purity of 85% and total viability of 75% for a PLS of 64%. The newly established field did not produce seed in 2011. Figures 12, 13, and 14 show the plantings in mid-October 2012. In November of 2012, seed was harvested from both fields for a combined weight of 215 PLS lbs.

Figure 12. *Ratibida columnifera* - Upright prairie coneflower planting in Field 8 on October 15, 2012

Figure 14. *Ratibida columnifera* - Upright Prairie Coneflower plant in Field 8 on October 15, 2012.

Figure 13. *Ratibida columnifera* – Upright prairie coneflower planting in Field 23S on October 15, 2012

Routine maintenance of the fields included:

- Flood irrigation monthly from October through April, biweekly from June through September
- Fertilization of nitrogen in three applications (50lbs each); phosphorous at three applications (50 lbs. each)
- Mechanical cultivation monthly from March through November
- Hand hoeing biweekly from March to November

These same fields were harvested in late October 2013 with a Gleaner K2 combine. The harvesting head was modified with crop lifting snouts to lift the spreading stems to allow more seed heads to be swathed which was a problem with previous harvests of prairie coneflower. The PLS yield from the two fields for 2013 was 130 lbs.

The newer 0.55 acre seed field continued to produce flowers and seed in 2014. The older field which had declining seed yield, was plowed under in the spring of 2014. The seed yield from the 0.55 acre field in 2014 was 107 PLS lbs.

The 0.55 acre field declined rapidly during the winter of 2014-2015, and few plants emerged in the spring of 2015. Obtaining any appreciable seed was unlikely, so the field was plowed under in the early summer of 2015.

Sphaeralcea parvifolia – Small-leaf globemallow (Accession Number 9066885)

The 0.6 grams of seed that was originally obtained from SOS in 2010 was labelled to contain about 1,000 seed. Literature has seed counts for this species ranging from 500,000 to 850,000 seed per lb., which equates to 660 to 1,100 seed in 0.6 grams. This seed was scarified with a MAT-OSU pneumatic seed scarifier for 10 seconds at 20 psi, sown on surface of peat/perlite mix, moistened, and then cold stratified for six weeks at 40°F (4°C). Eighty (80) transplants were produced in 2011 and installed in a two-row planting in the LLPMC Field 23N. Seed was collected off of the plants in the late summer and early fall of 2011. Several collections were made because of the continuous flowering and seed maturation of the species. The seed was collected using a battery-powered shop vacuum with a mesh screen made from a paint strainer bag attached to the inlet inside the tank. The yield was 14.8 grams of cleaned seed.

Prior to propagation, the harvested globemallow seed was scarified in a MAT-OSU pneumatic scarifier for 60 seconds at 20 psi in batches of 1 tsp. per run. We had sufficient seed to sow 23 plug trays (341 cells each) with about 0.4 tsp. seed per tray; this seed was mixed with 4 tsp. of grit (0.03 inches to 0.08 inches [0.8– 2 millemeters]) for seed dispersed in each tray. On February 6, 2012, the mixture was applied through a soil sieve to evenly distribute the seed over each tray. Each tray was covered with one-third cup of grit (>0.08 inches [>2 millemeters]) and watered daily. On February 13, 2012, the trays were put into clear plastic bags and placed into a walk-in cold room with minimal lighting (for species requiring light for germination) set at 40°F (4°C). The trays were removed from cold stratification and placed in a greenhouse on April 5, 2012; the greenhouse had a night temperature set-point of 55°F (13°C) and day set-point of 70°F (21°C). The seedlings were transplanted D12 containers between May 21 and 28, 2012. After the seedlings were well-established in the D12's, they were transferred into the nursery to harden off on July 31, 2012.

Before planting the seedlings, Field 34S at the LLPMC was prepared by laser leveling and flood irrigating in early August 2012. The planting rows were ripped 18-inches deep with a straight shank sub-soiler. Fertilizer was applied every 12-inches in the soil slits at dose of 4g phosphorus (⅔ TBS. ammonium phosphate) and 10g potassium (1 TBS. potassium sulfate) using a Rainflo Model #1600 Series II WWT to dibble holes where the fertilizer was placed. The soil slit was ripped again to distribute the fertilizer vertically and horizontally. The field was flood irrigated again to optimize soil moisture before planting and to partially fill the soil slits. The seedlings were transplanted on August 20 and 23, 2012 using the WWT to plant the seedlings 12-inches apart with a between row spacing of 76 inches. The final planting contained 11.75 rows on the western portion of Field 34S and comprised about 3,500 plants. Figures 16 and 17 show the planting in mid-October 2012. The plants did not have enough time to develop seed in 2012 because a hard freeze occurred (25°F) on October 27, 2012.

Figure 16. *Sphaeralcea parvifolia* – Small-leaf globemallow planting on October 15, 2012.

Figure 17. *Sphaeralcea parvifolia* – Small-leaf globemallow plants on October 15, 2012

Maintenance of the field included:

- Hand hoeing every two weeks
- Mechanical cultivation every four weeks
- Weekly irrigation from August 20 to September 10; biweekly irrigation through November 20, 2012

In 2013, this field yielded 38.75 bulk lb. (16.26 PLS lbs.). The first combine harvest occurred on 6/20/13, three vacuum harvests were conducted in August and September, and a final combine harvest was done on 10/28/13.

In 2014, 3,600 globemallow seedlings were propagated (Figure 18) to establish a new seed production field. Before planting, the rows were ripped with a straight shank ripper to a depth of 22 inches and deep side-dressed (10 inches depth) with potassium sulfate and mono-ammonium phosphate at a rate of 50 lbs. K and P per acre. The seedlings were transplanted using the WWT in June and July of 2014.

In 2014, the original 0.56 acre seed field was used to compare harvest efficiency of this indeterminate ripening species; we compared vacuum harvesting with combine harvesting. On June 16 and September 10, 2014, we combine-harvested one-quarter of the field, and the other three-quarters were vacuum-harvested three times: June 16, June 27, and July 8, 2014 (Figure 19). The seed from the vacuumed rows as well as the new planting were combine-harvested in early October. The total yield was 11.8 bulk lbs. (8.10 PLS lbs.). The large decrease in yield probably resulted from several severe wind events related to thunderstorms. Because these wind events scattered seed on several occasions just prior to the planned harvests, the vacuum-harvested yield was considerably less than the combine-harvested yield on a per-row basis.

Figure 18. Sphaeralcea parvifolia – Small-leaf globemallow seedlings (6/30/14) prior to final planting.

Figure 19. Combine harvest (left three rows) and vacuum harvest (right rows)

The SPPA harvest in 2015 was 13 bulk pounds. The harvest results in 2015 are similar to 2014 in that the combine harvest greatly exceeded the vacuum harvest on a bulk seed basis per unit area harvested. Based on current knowledge, there does not appear to be any advantage of repeated vacuum harvesting versus combining. The vacuum harvesting should have an advantage in that it might collect a higher proportion of mature seed and less immature seed than combine harvest. Several explanations can be proposed for why vacuum harvesting is less effective:

- There may be frequent enough wind events that disperse considerable ripe seed between vacuum harvests. If this is occurring then more frequent harvests would be necessary.
- The vacuum system does not efficiently detach the seed and/or the seed that is detached is not efficiently drawn in by the vacuum.
- The cyclone allows some of the seed to escape to end up in the air stream used to blow seed off the plants and is lost before being vacuumed in.

Harvesting SPPA with a combine in early summer and again in late summer seems the most efficient harvesting method although considerable immature seed will be harvested.

Vacuum Harvester with Blower Facilitated Seed Detachment

One of greatest limitations in obtaining high seed yields from native forb production fields is the indeterminate seed maturation of many species. Seed harvesters such as the Woodward Flail-Vac Seed Stripper can be used to attempt to repeatedly harvest a seed production field as the seed matures. The brushes on seed strippers can damage ripening seedheads as well as developing flowers, especially on some forb species. We have attempted to use a PTO driven vacuum to harvest forb seed using a handheld collection vacuum hose as well as a toolbar mounted vacuum intake hood.

Two principal problems encountered with these approaches were

1. The vacuum hose or collection hood had to brush the plant to dislodge most of the seed
2. The seed and chaff had to go through the vacuum blower impellers where unknown damage could occur to the seed.

To address these issues, we fabricated a vacuum system based on the same PTO driven vacuum but incorporated a seed collection cyclone in the intake airstream upstream of the blower and used the exhaust from the vacuum blower to dislodge seed and blow the seed into the vacuum collection hood. The harvester uses a Trac Vac Model 854 leaf vacuum with 8-inch diameter intake and exhaust hoses, approximate 2,000 cfm capacity, and a cost of $3,000 (not including shipping). The collection cyclone (designed for 1,200–1,900 cfm) and cyclone stand, 8-inch and 10-inch steel ducts and fittings, and collection drum were purchased from Oneida Air Systems for $1,700 (not including shipping). The system was designed to be 3- point hitch mounted to allow ease of height adjustment (see Figure 20).

Our initial trials were performed on small-leaf globemallow (*Sphaeralcea parviflora*) (Figure 21). The system was configured to maintain a distance of 24 inches between the blower exhaust outlet and vacuum collection hood. This distance appeared to be near the maximum distance between inlet and outlet, and still attain good seed separation from the seed head. The typical harvesting speed was about 3 mph, and it took 20 minutes to harvest a one-half acre field (twelve 300 ft. rows at 6.3 ft. row spacing).

With globemallow, the vacuum-collected material appeared to be 20 to 25% seed with the remainder being seed head parts. Most of the seed harvested by the vacuum system had reached maturity. When the globemallow is harvested with a combine, 90% of the uncleaned weight is stems and much of seed is immature.

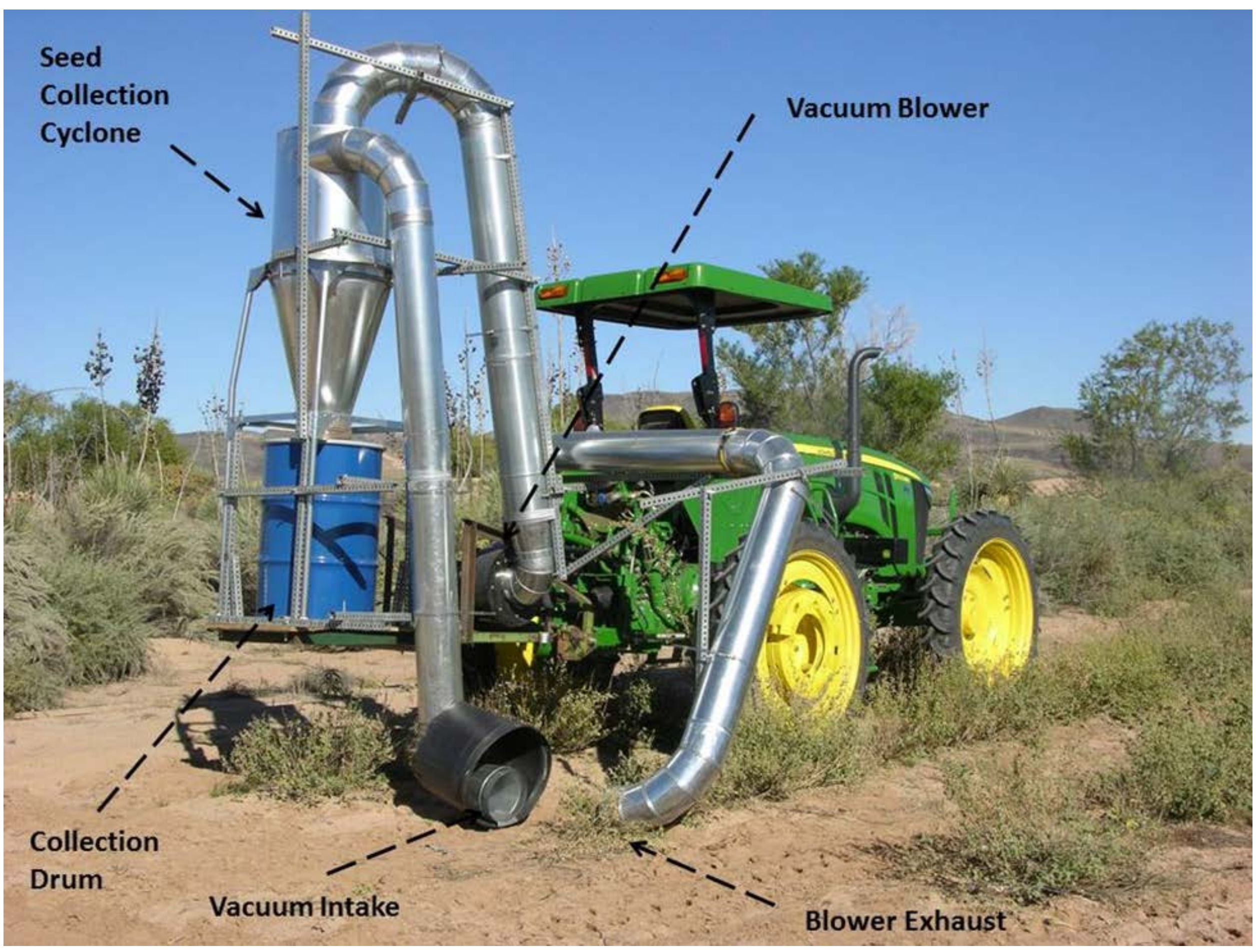

Figure 20. Components of original version of the vacuum harvesting system

In 2014, we modified the original seed harvester system (Figure 20) with a new collection apparatus that focuses the air blast from the blower while confining the vacuum inlet to maximize seed detachment and collection. We also added crop gatherers to direct stems with seedheads into the collection apparatus. These modifications have considerably increased the quantity of seed collected by the vacuum. These modifications were rather crude and the resulting collection apparatus had many places for seed to get trapped which made it difficult to clean.

In 2015, a final version was developed with smoother crop gatherers and a collection vessel with very few recesses where seed could get trapped (Figure 22).

Figure 21. *Sphaeralcea parvifolia* – small-leaf globemallow being collected with the vacuum harvester on October 1, 2013

Figure 22. Final version of the collection apparatus with smoother crop gatherers and smooth walled collection hood

Final Seed Production

Scientific Name	Common Name	Harvest Year	Bulk lbs.	PLS lbs.
Oenothera pallida	Pale evening primrose	2013 2014 2015	4.50 25.70 43.80	3.53 11.67 22.24
Totals			74.00 lbs.	37.44 lbs.
Ipomopsis aggregata	Scarlet gilia	2013 2015	0.066 0.499	
Totals			0.565 lbs.	

Scientific Name	Common Name	Harvest Year	Bulk lbs.	PLS lbs.
Sphaeralcea parvifolia	Smallflower globemallow	2013 2014 2015	38.25 11.80 13.00	16.05 8.10 8.46
Totals			63.05 lbs.	32.61 lbs.
Ratibida columnifera	Upright prairie coneflower	2010 2011 2012 2013 2014	0.123 46.00 250.00 159.16 143.00	 29.42 214.90 129.77 107.28
Totals			598.28 lbs.	481.37 lbs.

Conclusions on Seed Production Potential

Ratibida columnifera, upright prairie coneflower, has many favorable agronomic features including:

- Quick growth
- Vigorous seedlings
- Fairly upright growth
- Seed that does not shatter unless harvest is severely delayed.

In our experience, the production fields are short-lived and under conditions at the LLPMC, we could not rely on more than three years of seed production. Our experience with this Colorado Plateau ecotype shows that it behaves much as generic upright prairie coneflower which is a common and inexpensive wildflower seed in the commercial market. Because seed head stems tend to bend down, crop gatherers on a combine would be advised.

Sphaeralcea parvifolia, small-leaf globemallow, has a number of characteristics that will make it a more difficult and expensive species to commercially produce:

- Seed requires scarification and perhaps stratification (fall seeding)
- Seedling vigor is fair
- Seed ripens indeterminately with appreciable loss to wind events
- Combine harvest will result in substantial collection of immature seed

One factor favoring its production is its upright growth. Our seed production yields were fairly low at 15 to 30 lbs. PLS per acre with 76 inch row spacing. The *Forb and Shrub Seed Production Guide for Utah* reports yields from 75 to 300 lbs./acre (80% purity) for several globemallow species of the Intermountain Region at row spacings of 28 to 36 inches. Our best yield result extrapolated to 28-inch spacing would be 80 PLS lbs. per acre.

Oenothera pallida, pale evening primrose, has a number of characteristics that will make it a more difficult and expensive species to commercially produce:

- Requires light to germinate
- Seed may benefit from stratification (fall seeding)
- Seedlings have fair vigor
- Seed ripens indeterminately so harvest will be somewhat arbitrary to decide when there are a maximum number of mature but unopened capsules
- Vining and spreading plant habit makes it difficult to combine harvest, it may require:
    a. windrowing, drying, and then harvesting, or
    b. forage harvesting and then drying
- Rhizomatous so it will invade inter-row spaces

Ipomopsis aggregata, scarlet gilia, exhibits many disadvantages for commercial seed production:

- Seedlings and mature plants are prone to root-rot and will require preventative fungicide drenches
- Seed ripens indeterminately so harvest will be somewhat arbitrary to decide when there are a maximum number of mature but unopened capsules
- Crop is a biennial with just one harvest season compared with perennial forbs
- Tall stems tend to lean and easily break

These unfavorable factors result in this species being a very difficult and expensive species to commercially produce.