Working with Farmers to Install Two Native Seed Increase Fields on the Navajo Nation

Lessons Learned while Growing Native Plant Seeds For Restoration

Introduction

As the use of native seeds for restoration grows, it is impractical to meet demand through wild seed collecting alone due to the scarcity of target species and adverse effects on wild populations. Increasingly, projects rely on agriculturally produced seed, where native species are grown in irrigated fields. These are called “seed increase” fields because, typically, 100% of the seed collected from these fields is harvested and can be used for ecological restoration. In comparison, at most, only 20% of seeds produced by wild populations can be ethically harvested. While these commercial operations produce large quantities of native seed, they often lack genetic diversity and local adaptation, which can decrease survival when used for restoration in arid regions such as the Navajo Nation. In order to meet the need for native seed for the Navajo Nation while maintaining local adaptation in the seed produced, the Diné Native Plants Program (DNPP) decided on a model for working with Navajo farmers and land managers to establish small-scale seed increase fields on agricultural land. These fields use plants grown from small, locally-sourced seed collections to produce large amounts of native grass and forb seeds that will be well suited for the unique conditions of the Navajo Nation.

In 2020, DNPP installed a 0.5-acre seed increase field at the North Leupp Family Farms community farm in Leupp, Arizona. In 2022, DNPP completed an additional 0.5-acre field on the Thompson family plot in Ganado, Arizona. Seventeen species of native grass and forbs were planted in each field. These fields not only allow us to increase the amount of seed in our seed bank but also serve as teaching tools to demonstrate the seed increase concept to local Navajo farmers interested in starting similar fields on their agricultural plots. Every seed increase project will present a unique set of challenges. Each field taught valuable lessons DNPP would like to share with other farmers interested in contributing to native seed production on the Navajo Nation. The information provided below is based on the DNPP seed increase experiments; interested parties must consider how best to tailor our suggestions to suit their specific project needs.

Methods and Planning:

DNPP spent months planning where each seed increase area would be placed within the sites for irrigation, sunlight, ease of access, pollinator, and wind protection which included making several visits to the project site. Careful consideration of the site's attributes will increase the chance of success. The seed increase areas were tilled by a tractor before installation to decrease the number of weeds on site and make it easier to plant plugs. DNPP did not treat the sites with herbicides or pesticides before installation.

A. Species selection

Species included in the fields were selected based on their ecological value as soil/watershed stabilizers, wildlife-livestock forage, and their significance to Diné culture. ‘Workhorse varieties’ such as alkali sacaton (*Sporobolus airoides*) and blue grama (*Bouteloua gracilis*) comprised the bulk of each field and are frequently used in wild grass seed mixes marketed for reclamation/restoration in the arid Southwest. Other species, such as white prairie clover (*Dalea candida*) and side oats grama (*Bouteloua curtipendula*), were planted in small plots as experiments to inform plans for expanding the fields. In an actual production field, we would suggest either omitting the experimental species to have more space for fewer species or just having a small “experimental” section to test how well species do in an agricultural setting before attempting to scale-up production.

Table 1: Species selection chart.

Scientific Name	Common Name	Field	Notes
Bouteloua gracilis	Blue grama	Leupp, Ganado	Major component. Performed well.
Sporobolus airoides	Alkali sacaton	Leupp, Ganado	Major component. Performed well.
Aristida purpurea	Purple threeawn	Leupp	Major component. High mortality.
Bouteloua cutripendula	Sideoats grama	Leupp	Small, experimental plot. Performed well.
Dalea candida	White prairie clover	Leupp	Small, experimental plot. High mortality.
Hesperostipa comata	Needle and thread grass	Leupp	Small, experimental plot. Performed well.
Linum lewisii	Lewis flax	Leupp	Small, experimental plot. Performed well.
Muhlenbergia montana	Mountain muhly	Leupp	Small, experimental plot. High mortality, replaced after the first year.
Penstemon barbatus	Scarlet buglar	Leupp	Small, experimental plot. High mortality.
Penstemon strictus	Rocky Mountain penstemon	Leupp	Small, experimental plot. High mortality.
Thelesperma megapotamicum	Navajo tea	Leupp	Small, experimental plot. Performed well.
Achnatherum hymenoides	Ricegrass	Ganado	Small, experimental plot.
Artemisia frigida	Prairie sage	Ganado	Small, experimental plot.
Bouteloua eriopoda	Black grama	Ganado	Major component.
Oenothera pallida	Pale evening primrose	Ganado	Small, experimental plot.
Pleuraphis jamesii	Galleta grass	Ganado	Small, experimental plot.
Schizachyrium scoparium	Little bluestem	Ganado	Major component.

B. Field design

The design of each field is unique. However, both fields share the same general layout. DNPP fields use semi-permeable woven landscaping cloth and drip irrigation fed on two 2100-2500-gallon tanks. The tanks were elevated on a platform approximately 3 feet above the field to create enough pressure in the drip system. Approximately 40 feet of two-inch PVC pipe, with a manual shut-off valve, connect the tanks to the field's drip system. A two-inch suction hose connects the main PVC line to each tank, allowing flexibility if the tank shifts. The suction hose was challenging to install on the PVC adapter. However, the hose will become malleable when gently heated with a blowtorch. A two-inch flexible mainline hose connected to the PVC runs along the field. The half-inch drip line is attached to the mainline with an adjustable valve. The drip tubing is capped off on the end of the line with a half-inch compression cap.

Both fields were planted with plugs produced in the greenhouse from wild-collected seeds from the Navajo Nation. Plugs were planted in rows 3 feet apart and 1 to 2 feet between plants within the rows. The species' projected growth determined the spacing. Larger species were allotted more space to fill in (2 feet between plants); smaller species were placed closer together (1 foot spacing between plants). Established plants will out-compete new weed growth over time. The team dug planting holes with a dibbling tool and applied a teaspoon of a slow-release all-purpose organic fertilizer to each planting hole. The plug was placed into the hole, covered with excavated soil, then watered.

C. Leupp field irrigation and ground cover

The Leupp field was tilled to remove weeds and loosen the soil but not furrowed with a tractor, with the thought that it would be easier to install the weed barrier. The barrier or weed cloth was spread across the plot as one continuous piece, then stapled to the soil with landscape staples every eight or so feet. Rows had five inch holes burned in the cloth with a butane blow torch marking where each plant would be transplanted. Burning the holes prevented the woven plastic fibers of the weed barrier from unraveling versus cutting holes with a blade. Once plants were established and were in their second year of growth, while the weed cloth effectively prevented weed growth around the transplants, larger grasses were also constricted by the five inch holes. As a result, each hole had to be cut between holes to allow for the continued growth of the plant. When using this method to create planting holes in weed cloth, we recommend considering how large the species is likely to get when mature and creating holes that can accommodate and not restrict full-size growth.

The team installed drip tape with one foot pre-installed, integrated emitters on each row above the weed cloth. Landscaping staples were used to fasten the tape to the ground. During the first watering, the tape contracted and misaligned the drip flow with the plants, causing mortality in many new transplants. New systems can avoid this issue if the drip tape is installed and filled with water to see where planting holes should be placed before the holes have been burned and planting has been completed.

Figure 1. *Drip irrigation installation. Leupp, AZ. 2019*

D. Ganado irrigation and ground cover

The Ganado field was furrowed with the host site tractor for improved water infiltration and to allow for flood irrigation. Three foot wide weed barrier strips were placed between each furrow, leaving the planted row bare but covered with weed cloth on both sides. Plant rows were left exposed so that the weed cloth would not constrict growth, with the expectation that we would need to spend more time hand-pulling weeds from this field. The strip method also requires landscaping staples placed every four feet to secure against the wind, resulting in twice as many staples needed to complete the project.

DNPP did not initially install drip irrigation at the Ganado field site to avoid damaging the material over winter, with plans to install it in the spring of 2023. To set up irrigation at this site, DNPP purchased 7000 feet of ½" tubing and the necessary drip irrigation accessories such as emitters, caps, mainline tubing, and valves. In the interim, furrows were used to flood-irrigate the new transplants during installation and to soften the ground for dibbling.

In total, DNPP installed 50 rows of plants on the half-acre site using the same methods as the Leupp field. Each row was approximately 130 feet long, requiring 6500 feet of drip tubing. Although the drip tubing is more expensive and labor-intensive to install (emitters need to be purchased separately and manually installed in tubing), we anticipate less maintenance, a longer lifespan, and more accurate watering than the drip tape used in the Leupp field.

Figure 2: *The subsurface PVC line connecting the tanks to the drip irrigation. Leupp, AZ. 2019*

Tools and equipment:

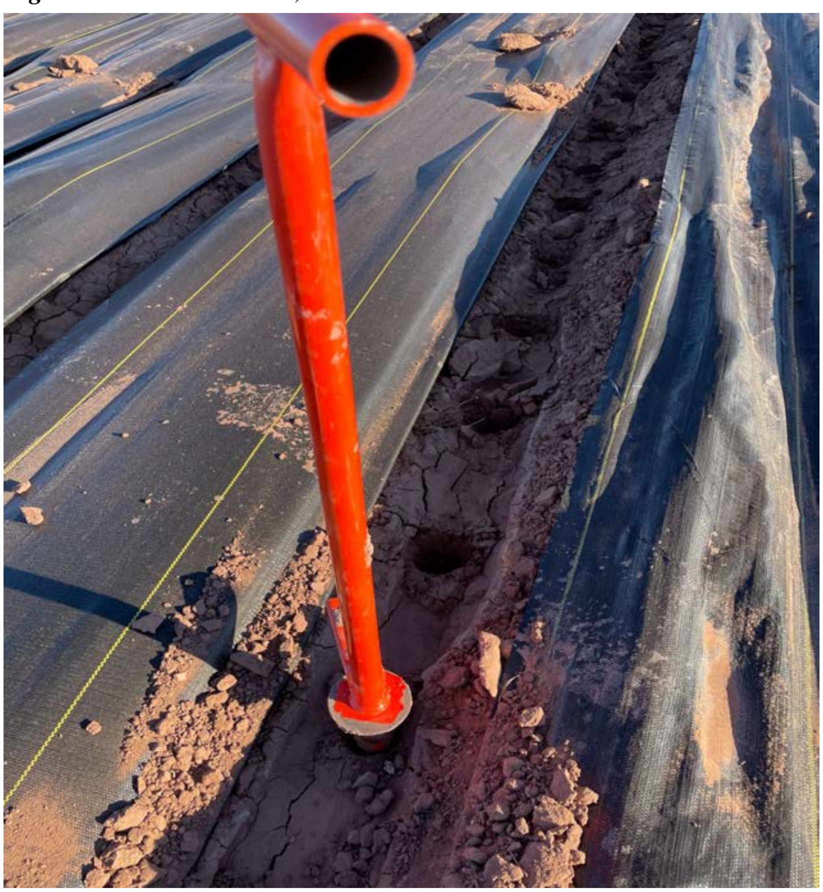
A. PVC and drip lines

PVC couplings and hose adapters were secured with a 24 inch pipe wrench and 20 inch tongue and groove pliers. These items are large and not carried by some vendors. Hose clamps fasten the suction hose to the barbed PVC adapters screwed into the bottom of the tanks. The drip line punctures were made with a specialized hole punch purchased from an irrigation supplier.

B. Dibble bars

The dibble bar is a specialized hand tool for seeding or installing plugs of greenhouse-grown plants, significantly decreasing planting time and effort. The dibble bar consists of a spike attached to the end of a medium-sized rod with a peg to increase the force applied while dibbling. DNPP hand-made two dibbler bars from scrap metal before purchasing dibblers from an online vendor, Forestry Suppliers. The dibbler bars struggled to pierce dry clay soil and required considerable force to be effective. DNPP found that flooding the furrows before dibbling softened the ground. The team also used a heavier digging or rock bar to dibble challenging soil sections. The weight of the digging bar was better suited for the dry clay soil. DNPP also experimented with a two-horsepower gas engine auger equipped with a two-inch bit when required. The auger was more efficient than hand tools and allowed faster transplanting in hard clay or compacted soils.

Figure 3: *Dibbler. Ganado, AZ. 2022*



Maintenance and harvesting:

A. Maintenance

The Leupp field is located far from the DNPP office in Fort Defiance, AZ. A two hour trip prevented DNPP from consistently watering plants through the dry period of late spring and early summer. Mortality was high during this period and weeds began to sprout in the spaces between the struggling and dead plants. Managing the weeds and watering during the dry spring and summer is crucial to decreasing plant mortality and increasing seed yield, especially when plants are small and do not yet have established roots. Over time, the Leupp field drip tape became buried in sediment around the plants, preventing adequate watering. The middle of the field also began to sink, causing rainwater to pool in the center. The weed cloth allows water to permeate slowly, resulting in rainwater pooling and infiltration into the sinking center of the field. The weed barrier was cut between planting holes two years after initial field installation to allow for better infiltration of rainwater and more efficient irrigation within the rows. Strips of cloth on the sides of each row allow rainwater to flow into the plants. The water infiltration rate going to plants increased after DNPP made these adjustments and reduced mortality.

Figure 4*: Harvesting seed. Leupp, 2022*

B. Harvesting

Harvesting timing depends on the species; some are cool-season while others are warm-season. Generally, the cool-season plants were the first to produce viable seeds in spring. The warm-season plants had viable seeds by the late summer into mid-autumn. The plant's inflorescences were either pruned with shears or hand pruners, with the seed head still attached, or seeds were hand stripped from the inflorescence and placed into a labeled paper bag. Extensive collections of harvested seeds were stuffed into 30-gallon paper bags and placed inside the walk-in freezer for 24 hours at the DNPP warehouse facility. The time spent in the freezer killed any seed-predating insects that may be present during harvesting. Combining the breathable paper bags and cold temperatures also prevented mold growth as the plant material dried.

Depending on the method of harvesting, the collected seed required various levels of processing before storage. Small collections were processed by hand using metal sieves to separate seeds from chaff, stems, awns, and other inert material. Collecting that occurred with shears or pruners, a faster and more efficient method in the field, required more post-processing to remove stems and extraneous material. Large-scale post-processing of seed, even on the scale of two 0.5 acre fields, needs specialized machinery to make the process more efficient. Anticipating this, DNPP recently purchased a commercial micro debearder from Hoffman Manufacturing. This machine consists of a metal drum, where harvested material is placed, with rotating metal arms that separate the seeds from the stems. We anticipate fine-tuning settings and methods for the micro debearder and other seed processing equipment as we harvest and process seed from the field. This information will be recorded and shared readily with producers in the region.

Cost and conclusion:

Table 2: The table shows the total cost of material at one half acre.

Purpose	Supplies	Quantity	Cost/item	Sub-total
Tool	Jim-Gem Container Dibble Bar, Long Dibble Point	1	$80.00	$80.00
Tool	Jim-Gem Container Dibble Bar, Short Dibble Point	1	$74.00	$74.00
Tool	2 in. Earth Auger Bit	1	$107.79	$107.79
Tool	24 in. Steel Pipe Wrench	1	$69.97	$69.97
Groundcover	Ultra Web 3000 Groundcover 3' x 600'	12	$134.10	$1,609.20
Groundcover	6 x 1", 11 Ga Staples, 1000 box	2	$44.00	$88.00
Tanks-PVC	2100 Gal Black Vertical Water Tank	2	$2,274.00	$4,548.00
Tanks-PVC	2" x 25' PVC Suction and Discharge Hose	1	$146.17	$146.17
Tanks-PVC	FPT x Insert adapter 2"	3	$5.00	$15.00
Tanks-PVC	Insert plug 2"	2	$3.15	$6.30
Tanks-PVC	Insert coupling 2"	2	$2.00	$4.00
Tanks-PVC	2 in. x 10 ft. White PVC Schedule 40 DWV Plain End Pipe	4	$19.72	$78.88
Tanks-PVC	8 oz. PVC Red Hot Blue Glue and Purple Primer Handy Pack	1	$12.93	$12.93
Tanks-PVC	2 in. PVC DWV 90-Degree Hub x Hub Elbow	6	$3.21	$19.26
Tanks-PVC	2 in. DWV PVC Sanitary Tee	1	$4.52	$4.52
Tanks-PVC	2 in. PVC Schedule 40 S x S Coupling	2	$2.11	$4.22
Tanks-PVC	2" Double Union PVC Ball Valve Slip/Weld	1	$27.42	$27.42
Drip	Flag Dripper 2.0 GPH	7000	$0.13	$910.00
Drip	Mainline tubing 2" x 150' Oval	2	$52.00	$104.00
Drip	1/2" X 1,000 Orchid Tubing	7	$88.00	$616.00
Drip	0.425” Barb x 600s Loc w/Valve	100	$1.35	$135.00
Drip	1/2" compression cap	100	$0.70	$70.00
			Total	$8,730.66

A. Cost Analysis

The total costs in Table 2 represent essential materials used for both seed increase sites. The table estimates the cost of field infrastructure and does not factor in labor or travel costs. The list also does not include items owned by DNPP and used extensively throughout the seed increase projects, such as the portable water pump, shovels, and greenhouse material. Supply costs also varied as prices fluctuated yearly based on vendors, item availability, and shipping rates. New fields would require a separate cost analysis based on the current prices of materials and the scale of the project.

Recommendations:

A. Water

Any organization planning a seed increase project should consider the water needs of the proposed project. DNPP fields are located on Navajo agricultural plots, part of the local chapter farm board, or on a community-use farm. Each site had some level of existing irrigation infrastructure fed from local reservoirs. DNPP was not required to pay for water usage, as these fields had previously negotiated water rights. The presence of irrigation infrastructure on-site eliminated the need to haul water with tanks and irrigate using a portable gas-powered water pump. Each host site required advanced notice before water could be pumped into our system. The fields required approximately 4000 gallons per field to install and an additional 4000 gallons per watering. The Leupp field required additional watering because of the arid climate conditions. The Ganado field is expected to use less water because of the colder climate conditions.

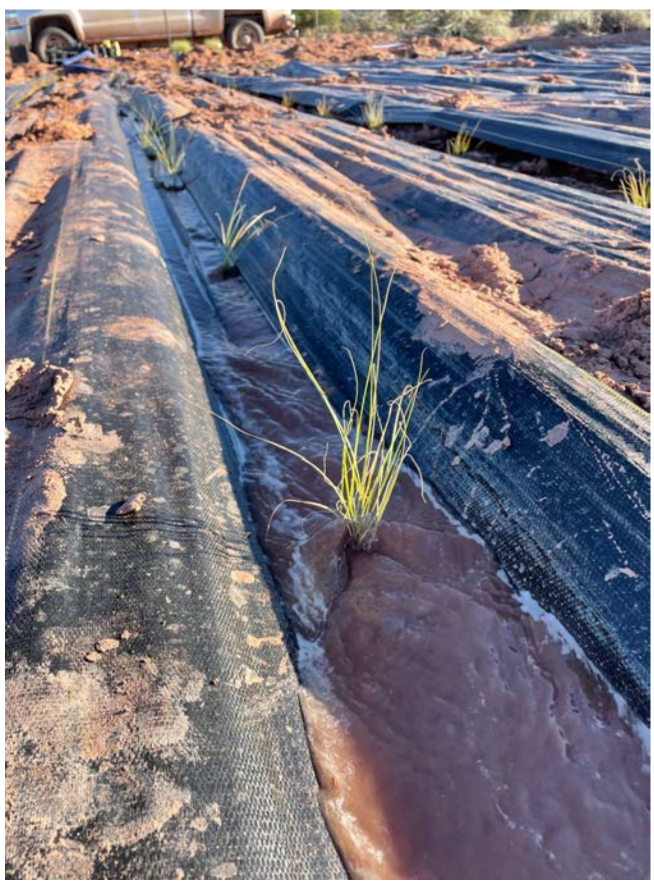


Figure 5*: Flooding planted rows. Ganado, AZ. 2022*

B. Drip and flood irrigation

Using drip irrigation is ideal in arid climates for water conservation and practical for the dry climate of the Navajo Nation. However, DNPP found that using drip irrigation presented several issues. First, drip requires carefully planned installation and regular maintenance to remain efficient. Traveling distance between the DNPP office in Fort Defiance and the field in Leupp hindered the regular maintenance drip irrigation required. Some lines became clogged over time and needed repair, resulting in zones that did not receive adequate water. Due to their plastic composition, all drip systems will deteriorate over time. The drip line will only function properly for up to five years. DNPP will be responsible for the project site for five years and decommission the field unless another interested party has assumed responsibility. Secondly, the cost was considerable and unrealistic for the average grower.

Flood irrigation was necessary to establish the Ganado field. Most growers in the Navajo Nation flood-irrigate their crops. Flooding does not provide the water efficiency of a drip system. However, it is more accessible and financially feasible, especially when considering seed increase fields larger than 0.5 acres, as there was little to no associated cost. Flood irrigation does come with downsides. If the pressure of the water is too great, transplants can be washed out or damaged. Flood irrigation is considerably more labor-intensive than drip systems because water is routed by hand throughout the field. Climate change threatens the snowmelt reservoirs used to flood, making water availability unpredictable.

Figure 6: *Ganado field strips. Ganado, AZ. 2022*

C. Ground cover

The ground cover for these projects was expensive. While it did prevent weed growth, weed management was still needed at the Leupp field. In addition, the black cloth can become very hot. This heat will benefit the field during the winter but dry the area out during the summer. DNPP recommends knee protection when working on a hot surface. High winds repeatedly displaced the barrier. Additional landscaping staples had to be applied to secure the cover. The woven structure of the weed cloth is susceptible to unraveling once cut. Burning the plastic material creates a seal that does not fray.

Figure 7: *Tanks in transit to the project site. Fort Defiance, AZ. 2022*

D. Cost and conclusion

Total cost for each field varied due to price changes over time and design. Specialty items were difficult to acquire due to fluctuations in price or shortages. DNPP upgraded some things to more efficient albeit expensive varieties. The estimate provided approximated the total with this variation in consideration. For these reasons, the Leupp field was less expensive than the Ganado field. DNPP is committed to developing sustainable methods that community members can implement in the Navajo Nation. DNPP is experimenting with different methods to determine what works best for seed increase projects in the Navajo Nation.

Diné Native Plants Program

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