Memorandum

To: Greg Peterson
From: Brenna Mefford and Erin Wilson
Date: 5/6/2024
Re: 2024 Ag Drought Resilience Project Results

Over the past ten years, drought and limited water supplies have impacted agricultural operations throughout Colorado more frequently than seen historically. In response to increased drought conditions, in 2023 the Colorado Ag Water Alliance (CAWA) and project partners launched the Ag Drought Resiliency Program to provide funding to support the design and implementation of drought resilient and innovative water conservation projects with agricultural water users and water managers. The program serves to address several gaps in funding to support incubator projects on farms and ranches that can improve agriculture's drought resiliency. The program funded 31 projects in 2023 and 25 projects in 2024. In 2024, the program also provided funding for 12 of the 2023 projects to continue their investigation again in 2024. The program has funded the following project types:

- Alternative Cropping
- Irrigation Efficiency Improvements
- Hay and Forage Management
- Livestock Management
- Soil Health Improvements

This memo provides a summary of the projects and general lessons learned and includes a one-page summary of every project completed in 2024 in Appendix A. Note that a few projects included in Appendix A were originally funded in 2023, but the project was completed in 2024.

Projects Selected and Project Status

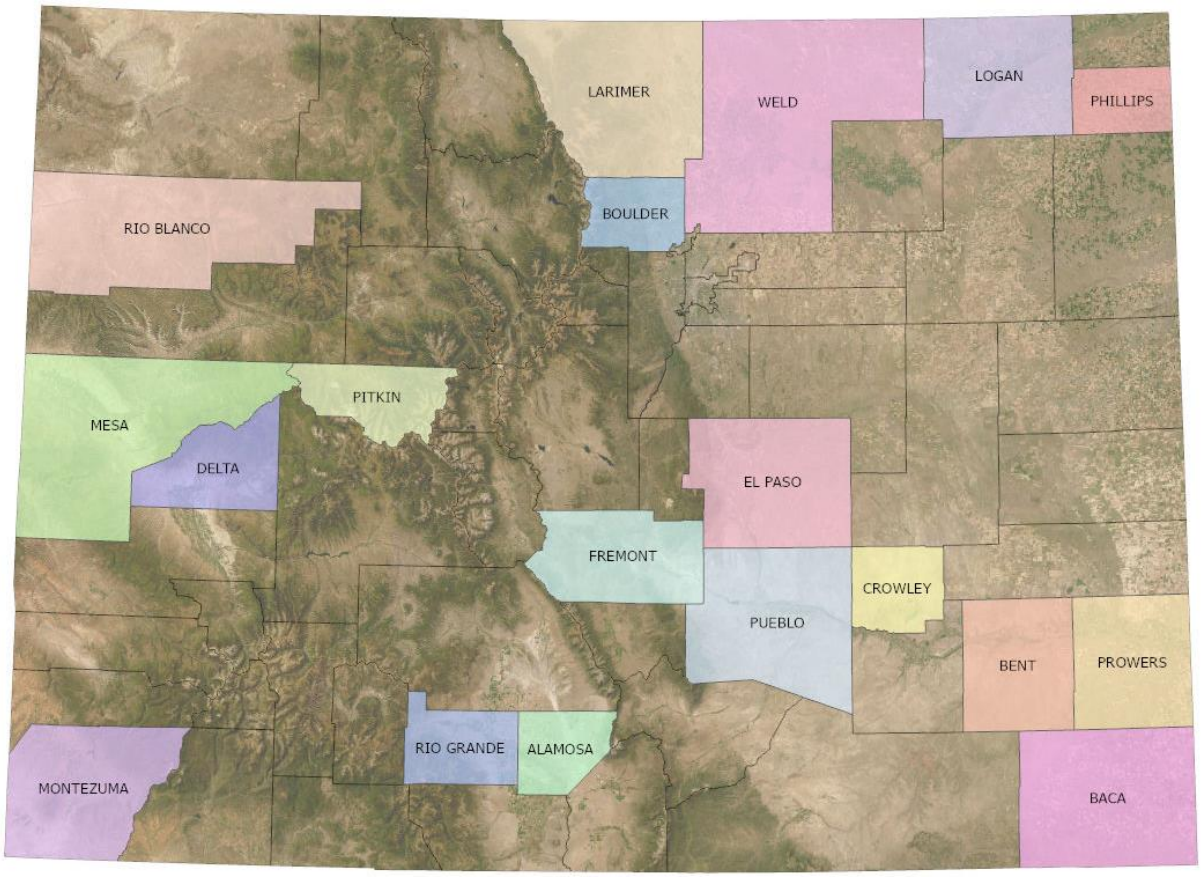
Three of the 25 funded projects for 2024 were not implemented. Most of the implemented projects were completed in 2024, but some did not begin until the fall of 2024 and will be completed in 2025. The 12 projects that were continued from 2023 were all completed in 2024. There were five projects that were not able to be completed in 2023 and were completed in 2024. The table below summarizes the projects funded, the year they were funded and their completion status. Note that the Alternative Forages Project summary was submitted and managed as one combined project with ten individual participants.

Project Name	Year Funded	Project Organization	Grant Amount	Project Type	Status
Bale Grazing Kernza Project	2024	Bent Conservation District	$ 11,125.00	Soil Health Alternative Crops Project	Bale Grazing was completed in 2024, Kernza was planted in Fall of 2024, with results in Spring of 2025
Increasing Water Holding Capacity in Dryland Project	2024	Boulder Valley Conservation District	$ 8,570.00	Soil Health Project	Started in 2024, will be completed in 2025
Virtual Fencing Project	2024	Burk	$ 29,600.00	Livestock Project	Started in 2024, will be completed in 2025
Bale Grazing Under a Center Pivot Project	2024	Camblin Livestock	$ 19,972.00	Livestock Project	Completed in 2024
Transplants versus Direct Seeding Project	2024	Christensen	$ 6,768.92	Irrigation Efficiency	Completed in 2024
Irrigation Application Project	2024	Clark	$ 5,765.00	Irrigation Efficiency	Completed in 2024
Semi-dwarf Apples & Alley Cropping	2024	Clayton	$ 3,985.00	Alternative Crops Project	Completed in 2024
Kernza vs. Alfalfa	2024	Freel Farms	$ 19,500.00	Alternative Crops Project	Completed in 2024
Black-Eyed Peas Ahead of Winter Wheat Project	2024	Haynes	$ 17,302.50	Alternative Crops Project	Completed in 2024
Surge Valves Project	2024	Heimerich Farms	$ 8,772.00	Irrigation Efficiency	Completed in 2024
Grazing vs. Haying	2024	Isabelle Farms	$ 8,900.00	Soil Health Project	Completed in 2024
Corn/Sorghum Crop Mixes Project	2024	Jacquart	$ 5,022.00	Alternative Crops Project	Completed in 2024
Irrigation Scheduling and Inter-seeding Project	2024	Johnson - Eaton Organics	$ 13,206.00	Soil Health	Completed in 2024
Bale Grazing to Improve Soil Moisture	2024	Kokes	$ 11,465.60	Livestock Project	Completed in 2024
Evaluate Soil Moisture on Dryland Plots	2024	Lempka	$ 5,000.00	Soil Health Project	Project was not implemented

Project Name	Year Funded	Project Organization	Grant Amount	Project Type	Status
Milo Seeding Rates Project	2024	Lubbers	$ 25,000.00	Irrigation Efficiency	Completed in 2024
Crop Residue impacts on ET Project	2024	Mesa Conservation District	$ 13,152.00	Soil Health	Will be completed 2025
Pivot Improvements to Increase Water use Efficiency	2024	Miller	$ 23,716.31	Irrigation Efficiency	Completed in 2024
Monitoring Soil Moisture on Different Crop Types Project	2024	Olander	$ 16,000.00	Irrigation Efficiency	Completed in 2024
Orchard Sheep Bale Grazing Project	2024	Rickard	$ 2,855.00	Livestock Project	Completed in 2024
Bale Grazing on Cropland Project	2024	San Juan Land & Livestock	$ 11,657.00	Livestock Project	Completed in 2024
Growing Wheatgrass with Limited Water Project	2024	Thode	$ 9,240.00	Alternative Crops Project	Project was not implemented
Orchard Soil Moisture Monitors Project	2024	Tuft	$ 16,780.00	Irrigation Efficiency	Completed in 2024
Alternative Forages for Uncertain Water Project	2024	Ute Mountain Ute Ranch	$ 22,500.00	Alternative Crops Project	Project was not implemented
Camelina Trials Project	2024	Waters	$ 21,950.00	Alternative Crops Project	Completed in 2024
Cowpeas for Animal Feed Project	2023 & 2024	Arkansas Valley Research Station	$ 20,000.00	Hay and Forage Project	Completed in 2024
Mapping Ditch Assets	2023 & 2024	Mapping Ditch Assets	$ 20,000.00	Irrigation Efficiency	In progress, application will be completed in 2025 and tested in 2026
Drip Tape – Gated Pipe Connector Project	2023 & 2024	Delta Conservation District	$ 19,052.00	Irrigation Efficiency	Completed in 2024
Compost and Biochar Project	2023 & 2024	GBT Farms	$ 26,920.50	Soil Health Project	Completed in 2024

Project Name	Year Funded	Project Organization	Grant Amount	Project Type	Status
Bale Grazing Project	2023 & 2024	Grama Grass & Livestock	$ 12,524.52	Soil Health Project	Completed in 2024
Biochar Injection Project	2023 & 2024	Lobato Farms	$ 1,954.00	Soil Health Project	Completed in 2024
Soil Moisture Monitoring Project	2023 & 2024	LoPresti	$ 2,250.00	Irrigation Efficiency	Completed in 2024
Autonomous Pivot & Radar	2023 & 2024	Mike Mitchell Farms	$ 6,000.00	Irrigation Efficiency Project	Completed in 2024
Drought Hardy Seeds and Legumes Project	2023 & 2024	Pueblo Seed & Food Company	$ 12,500.00	Alternative Crops Project	Completed in 2024
Stubble Height and Soil Health	2023 & 2024	Reker Farms LLC	$ 6,514.00	Soil Health Project	Completed in 2024
Alternative Forages Project	2023 & 2024	SW Alt Forage Projects	$ 194,480.00	Alternative Crops Project	Completed in 2024
Kernza and Sainfoin Trails Project	2023 & 2024	Ute Mountain Ute Farm 2023	$ 29,654.00	Alternative Crops Project	Completed in 2024
Forage Conversion	2023 - Operated in 2024	2C Ranch	$10,439	Hay and Forage Project	Completed in 2024
Perennial Forages – Otero Project	2023 - Operated in 2024	KX Ranch	$16,929	Hay and Forage Project	Completed in 2024
Perennial Forages – Mesa Project	2023 - Operated in 2024	Mountain Island Ranch	$11,830	Hay and Forage Project	Completed in 2024
Soil Treatments	2023 - Operated in 2024	Roaring Fork	$18,860	Soil Health Project	Completed in 2024
Contours and Ditches Project	2023 - Operated in 2024	Two Roots Farm	$18,860	Soil Health Project	Project is scheduled to start in spring of 2025
Precision Irrigation Project	2023 - Operated in 2024	RGCD	$21,820.00	Irrigation Efficiency Project	Completed in 2024

The following map highlights the counties where projects occurred in 2024.



General Lessons Learned

Specific lessons learned by project are documented in the one-page summary included in Appendix A. The following are general lessons learned across all the projects:

- **Sensors**: Similar to 2023, many of the producers that experimented with soil moisture sensors had trouble getting the sensors to perform as expected or found that the software that accompanied the sensors was difficult to use. Sensors often did not communicate as promised by the company or the software was not user friendly and required more time than producers expected to understand how to use the data to make decisions.
- **First Time User Error**: The Ag Drought Resilience Projects were funded to allow these producers to try out a new method or new technology. The producers often had to learn on the go as they implemented their ideas. This often resulted in some type of first-time user error. The projects with the least amount of user error often had an outside consultant (agronomist, etc.) that was more experienced helping with the project.
- **Soil Health Projects**: Projects that target soil health often require multiple years to see results. A few of the projects, like biochar, were able to see changes within the project year, but others, like range land bale grazing, will require multiple years to see results.

Potential for Scalability

In general, most of the projects could be easily scaled and the methods could be used elsewhere in the state. For alternative crop projects, the producers should determine if the new crop has been tested in their specific area before trying out a crop based on results from different climates. A few of the projects noted that while the results could be scaled up, many of the neighbors or other producers in their area would not be interested as the practice was outside of the norm for the area. For most projects, the hardest part would be the initial cost to scale up; either the producer needs a new type of equipment or needs new and/or improved infrastructure to implement one of these projects. For alternative crop projects scaling up would require there be a market for that crop. Some participants found that alternative crop markets in their area were small and needed to be developed to scale up the project.

Summary

While hydrologically 2024 was an average year across the state, some areas, like the Arkansas basin, had above average streamflow, while eastern dryland irrigators did not receive average summer precipitation. A few projects were hit by hail, but most projects were able to be implemented and results were obtained and provided to CAWA. The projects that had clear results generally had well defined goals and had both trial and control areas for comparison. These projects also were identified as the easiest to replicate.

Appendix A

One Page Project Summaries for Projects Completed in 2024

DROUGHT RESILIENCY PROJECTS

Bale Grazing Project

Project Type: Soil Health
Project Location: Bent County
Grant Amount: $6,125
Producer Type: Livestock
Irrigation Method: N/A
Identified Water-related Challenge:
Rangelands have been affected by continuous drought and overgrazing, resulting in less vegetation growth and poor water infiltration.

Solution: Conservation reserve mix of native grasses were baled when the seeds were mature and fed to cows in areas of the rangeland where there is limited growth and soil erosion.

Results:

The producer placed 1,250 pound bales of native CRP hay on overgrazed rangeland. The bales were placed strategically on a hill so the organic matter and seeds would be distributed to the grass below overtime. Bales were both set and un-rolled to help see which worked better. The producer did not let the cows eat the bales completely down, instead left a matt of hay for a seed bank. The hay matt also serves as a natural catcher for precipitation. Very little precipitation occurred while the bales were grazed and no seeds have been clearly established yet. The producer is hopeful that wintertime precipitation will help the seeds establish. It will most likely be another year or more before results are seen from the bale-grazing.

Scalability: The producer plans to bale graze again next year and possibly use mineral blocks that contain seed to help spread the seed further around the rangeland.

Lessons Learned:

- Strategically placing the bales required a lot of time and effort.
- Drought conditions impacted the germination of any seeds that were spread through the cows.
- It will likely take multiple years to see results from the bale grazing.

DROUGHT RESILIENCY PROJECTS

Cattle Bale Grazing to Improve Saline Soil

Project Type: Cattle Bale Grazing Project
Project Location: Moffat County
Grant Amount: $19,972
Producer Type: Rancher
Irrigation Method: Pivot
Identified Water-related Challenge: Saline / sodic soils, high pH soils inhibiting forage production on small pivot irrigated field.

Solution: Drill a cover crop mix and then bale graze on part of the land parcel to see how bale grazing affects germination and grass growth versus the control area where no bales are placed.

Results: The trial was started on April 11th, 2024, when a mix of barley, rapeseed and sugar beet seeds were planted using a no-till drill. Cattle were then brought into the field and were given free access to feed on hay bales with the strings cut and removed. Two hard freezes occurred in the spring, but the seedlings among the bale mulch survived and grew throughout the summer. Where bales were not fed, bare spots with no growth remained. The pivot was used to irrigate the field as needed. In the areas where no bales were fed, the soil crusted over and seedlings were not able to break through the crust. Crusting is common after water (rain or sprinkler) falls on saline soils and surface drying occurs. The hard spring freezes also may have killed some of the seeds in the non-bale grazed areas.

Testing of soil samples collected in mid-May revealed the top one foot of soil has an average of 3,080 ppm sodium (Na) sodium, 760 ppm calcium (Ca) and 196 ppm magnesium (Mg). The soluble salts are 7.3 mmhos/cm. The soil has a very high pH of 10.2. The availability of several plant nutrients, including Nitrogen, Manganese, Copper and Zinc is restricted at this pH level. The organic matter (OM) level is 1.4%, which is low for an irrigated pasture. The lack of vegetative growth largely contributes to the low organic matter content.

The areas where the bales were grazed were very productive overall and the rancher is continuing the bale grazing this winter.

Scalability: Very scalable. Costs include hay and fencing, ensuring good quality livestock drinking water availability, and normal livestock care. Costs may also include seed if, like this trial, the field is seeded in advance of the bale grazing. The hay bales contain seed heads so seeding of the bale grazed areas will occur to some extent even if no seed is drilled.

Lessons Learned: The rancher used his pivot to irrigate the field whenever the soil started drying out. The pivot was then shut off until the next time irrigation water was needed. The early crusting that occurred in the non-bale grazed areas prevented germinated seeds from breaking through the crust. In retrospect, the rancher thought he may have been better off to leave the pivot running to ensure no crusting occurred until after the seedlings were above the soil surface.

DROUGHT RESILIENCY PROJECTS

Transplants versus Direct Seeding Project

Project Type: Irrigation Efficiency
Project Location: Rio Grande
Grant Amount: $6,768.92
Producer Type: Commodity - Various
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Direct seeded crops need to be over-irrigated to ensure emergence and continued growth in sandy soils.

Solution: On a portion of the producer's acreage, transplants were planted instead of direct seeding to reduce water use and increase soil water retention by relying less on cultivation and overhead irrigation. The producer also purchased a cultivator and flame weeder to help reduce weed pressure.

Results:
The producer planted 3.5 acres of small-scale vegetables under a center pivot. The plants were started inside in a greenhouse and then transplanted into the field instead of direct seeding under the center pivot. Other crops were also located under the center pivot, meaning that water could not be reduced based on only the transplanted needs. 20 to 30 percent water savings are predicted for future years, if the techniques tested in this project are applied at a larger scale and with one crop per irrigation system. For specialty greenhouse vegetable crops like beets and greens, the producer thinks they can achieve closer to 50 percent water savings by using the transplanter in place of direct seeding. A cultivator and flame weeder were tested as a method to reduce pressure from weeds and decrease labor costs. The new equipment had a substantial impact on reducing labor, with roughly 70 percent less weeding labor required due to the equipment.

From the 3.5 acres planted of small-scale vegetables, the new equipment and methodology tested allowed the producer to gross $10,000 or more per acre.

Scalability: The producer plans to scale up this methodology in future years, due to the success from this year.

Lessons Learned:
To be able to reach higher water savings and associated lower pumping costs by using transplants, the project would need to be scaled up to have one crop per irrigation system.

DROUGHT RESILIENCY PROJECTS

Irrigation Application Project

Project Type: Irrigation Efficiency
Project Location: Rio Grande
Grant Amount: $5,765
Producer Type: Commodity/Livestock
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Over irrigation due to limited information about how much water the crops require, and the soils are retaining.

Solution: Installed a soil moisture probe system that can be used to let the participant know when and how much to irrigate according to crop requirements.

Results:

The producer installed 10 soil sensors that provided both soil moisture and soil temperature readings. The sensors were installed late in the growing season, therefore useful information was not available until nearly the end of the season. However, the participant found the information very helpful and was able to tailor the remaining irrigations based on the sensor's information. Having the sensors throughout the field revealed the variability in infiltration rates and soil water holding capacity due to differing soil types. The participant was able to use less irrigation water in 2024, however decent precipitation also played a factor. The participant plans to further analyze the information throughout the winter to be ready for the 2025 irrigation season and more accurately apply irrigation water.

Scalability: The producer plans to use this system in the future and once better acquainted with it, may look at placing sensors in other fields.

Lessons Learned:

Variable amounts of irrigation water are needed on the same field due to differing soil types under the pivot as noted by the installed soil sensors.

DROUGHT RESILIENCY PROJECTS

Orchard and forage establishment – Fremont County

Project Type: Establishing an apple orchard with forage lanes on limited irrigation and saline soils.
Project Location: Fremont County
Grant Amount: $3,985.00
Producer Type: Part-time, small acreage farmer
Irrigation Method: Drip
Identified Water-related Challenge: Maximizing agricultural productivity on saline soil with limited irrigation water.

Solution: Established semi-dwarfing apple rootstock and growing forage for hay in the alleys between the tree rows. The alley cropping will not only diversify production but should also provide shade needed to cool the soil and reduce evapotranspiration from the semi-irrigated forage area. This in turn will reduce the amount of irrigation needed to establish and grow orchards that are being lost at an increasing rate due to climate change. To benefit from the vigorous growth achieved with dwarfing rootstock and to maintain resiliency of full-size trees to dryer locations, this study focused on semi-dwarfing rootstock. Forage grass and legumes were planted in the alleys.

Results: With the slow growing natures of apple trees we anticipate this project to take a few years to see results. The 2024 growing season was not without its share of setbacks. The grasshopper plague was one of the worst in years and this forced the producer to cover the trees with bug netting, which helped to keep most of the grasshoppers at bay but the producer believes it may have helped stunt the trees. It was also a dry hot summer and, with receiving irrigation water only once every 5 weeks, the producer was not sufficiently prepared to irrigate the cover crops in the alleys. Due to a family tragedy, the producer also was unable to install an irrigation system to supplementally irrigated. Approximately 95% of the trees survived the season there is hope that the setbacks didn't stunt the trees too much and the producer was thankful that the program allowed the trees to be established in 2024. The producer is hopeful that 2025 will bring more growth, and they anticipate installing a sprinkler system and having supplemental irrigation.

Scalability: The producer believes the process is scalable. Fencing, tree rootstock, equipment to prepare holes and forage seedbed, and labor are all required.

Lessons Learned: Establishing trees without a dedicated water supply is a labor-intensive process. A different approach would have been to install shade cloth at the edges of the alleys to mimic tree shade and then remove the shade cloth once the trees are at full size. This way, results in reduction of evapotranspiration could potentially be seen sooner than waiting years for trees to grow while still providing full sun to the trees to encourage growth, and provide time to determine which alley crops would grow best in a shaded/low water environment.

DROUGHT RESILIENCY PROJECTS

Kernza vs. Alfalfa

Project Type: Alternative Crops
Project Location: Alamosa
Grant Amount: $17,302.50
Producer Type: Commodity/Livestock
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Decreasing water availability for irrigation in the San Luis Valley.

Solution: Compare Kernza and Alfalfa in terms of water use, productivity, feed value, input requirements and soil health. See if Kernza is a viable alternative to Alfalfa in the valley.

Results:

The producers had to plant the Kernza seed twice. The originally planting was followed by harsh winds that blew most of the seed away. The seed is very light, which makes it more difficult to plant. On the second round of planting the drilling depth was increased to accommodate the light seed and this helped keep the seed from being blown away. The majority of the Kernza came up late after the producers believed the crop was not going to germinate in the fall and after the first frost. The Kernza germinated and emerged with only four inches of irrigation being applied and four inches of precipitation. The producer plans to monitor the Kernza through the winter and see if it survives the winter and plans to use it to graze yearlings in the spring if a good stand forms. So far, they have high hopes as it has shown to be cold hardy after coming up late in the year.

Scalability: The potential to scale depends on how the Kernza does over the winter. If the crop survives and forms a good stand, the producer would be interested in planting more acreage.

Lessons Learned: The main lesson learned is to plant Kernza later in the season after the initial spring winds are done in the San Luis Valley and to drill the seed down further to prevent the seed from blowing away with the wind and floating away with the irrigation water.

DROUGHT RESILIENCY PROJECTS

Black-Eyed Peas Ahead of Winter Wheat Project

Project Type: Alternative Crops
Project Location: Phillips County
Grant Amount: $8,722
Producer Type: Commodity
Irrigation Method: Dryland
Identified Water-related Challenge:
Need for additional drought tolerant crops that can be used in dryland farming.

Solution: The producer will plant drought tolerant black-eyed peas in order to add nutrients to the soil in preparation for planting winter wheat.

Results:

Black eyed peas were planted in late May on 255 acres of no-till milo stubble that was downed prior to harvest in 2023. The peas were planted at 46 pounds/acre on 7.5 inches. The milo stubble was very short and didn't help retain as much moisture during the winter of 2023 to 2024. Black eyed peas emergence was un-even at first, but a mid-June rain helped significantly. The peas grew well in the dryland environment and stayed fairly healthy, even with the lack of moisture during the summer and some weed pressure. Late summer rains helped rejuvenate the plants. Swathing was used to terminate the plants, which dried down fairly easily. The milo heads and stalks in the windrows caused harvest delays due to the presence of moisture in the stalks. After the delay, the field was harvested and yielded approximately 490 pounds per acres. The field received roughly 9 inches of rain over the course of the summer, with the majority coming in August. Neighbors that also grew the peas had significantly better yields but had planted into wheat stubble or fallow fields. The peas were drought tolerant and financially viable, all while putting nitrogen into the soil before the wheat crop, which will save some money on fertilizer expense in 2025.

Scalability: The black-eyed peas performed well under the dryland conditions and the producer would plant them again.

Lessons Learned:

The producer would not plant them into milo stalks again due to the trouble with swathing (hard stalks/root balls).

DROUGHT RESILIENCY PROJECTS

Surge Valves Project

Project Type: Irrigation Efficiency
Project Location: Crowley
Grant Amount: $8,900
Producer Type: Commodity
Irrigation Method: Gated Pipe
Identified Water-related Challenge:
Improve flood irrigation efficiency by reducing amount of wastewater.

Solution: The producer installed a surge valve on his gated pipe irrigation system and tested the effectiveness for improved irrigation management.

Results:

The producer planted two fields of corn, one was conventionally irrigated using siphon tubes and one was irrigated using gated pipe with a surge valve. The fields were similar in size and had similar herbicide and fertilizer treatment. The conventionally irrigated field yielded 109.4 bu/ac and the surge valve field yielded 105.3 bu/ac. Both fields were damaged from hail in early July.

Both fields were irrigated with similar amounts of water, however the surge valve allowed the water to be more evenly applied to the field. The producer reported that the surge valve did an excellent job of getting water to the bottom of the field and allowed the operator to customize the soaking of the field while simultaneously reducing runoff. While in this instance the surge valve did not save water, it saved on labor as the producer could irrigate twice as many rows without changing the set. The surge valve also provides the option to customize the percentage of water is being used on each set in the event that there are significant soil changes in the field or field dimensions.

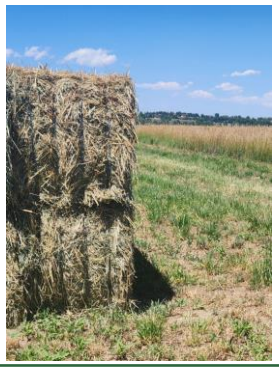
Scalability: A surge valve could be easily added to other gated pipe irrigated fields.

Lessons Learned: A surge valve could help save water, however the biggest advantage to a surge valve is the ability to reduce labor needs, allow more even irrigation, and customize the amount of water applied to certain parts of the field.

DROUGHT RESILIENCY PROJECTS

Grazing vs. Haying – A Comparison of Profitability and Soil Aspects

Project Type: Haying vs. Grazing Project
Project Location: Boulder County
Grant Amount: $17,900
Producer Type: Farmer
Irrigation Method: Gated pipe with ditch water
Identified Water-related Challenge:
Short season irrigation water rights mean annual crops are a big gamble.



Solution: Establish perennial forage and test grazing versus haying to determine how the financial and soil characteristics compare.

Results: The trial was started in mid-May with 38 cow-calf pairs, averaging ~1,400 lbs total (cow and calf). We divided the field into equal plots of 6 acres. Plots 1, 2, 3 and 5 were grazed, while plots 4 and 6 were cut and baled. The grass was flood irrigated equally and initial grass growth was good. We further divided each plot into 3 smaller paddocks and put the cows in. The cattle stayed in each plot for 4 days and were then moved into the next plot. We did not back-fence the cattle in between paddocks, but did back-fence in between plots. We provided water and salt, but no supplemental feed or mineral. The max. number of days that cattle were allowed in any one area was 12, but they spent the vast majority of their time in the newest paddock. We ran a full second irrigation in early June. We had to leap-frog around the cattle. Ditch water ran out in early July. After the cattle grazed plot 5, they were removed from the farm. On July 1st, we baled plots 4 and 6 into 3'x3'x8' bales. The average yield was 2.4 T/ac. of grass-alfalfa hay. We valued it at $205.43 / Ton based on an average local sale barn price for 1st cutting hay on 9/28/2024. Water infiltration and soil testing was conducted on both hayed and grazed acres. Soil test results will be reported when they become available. The water infiltration test results varied, but when averaged, both the grazed and hayed areas were similar. Additional years of successive grazing may start showing differences. **Financials:** We assumed hay would be much more profitable than grazing but the numbers were closer than expected. The season was cut short by drought, but both the grazing and haying were impacted similarly. We assumed capital costs and overhead were equal, and thus did not include them. We used standard regional grazing cost figures published by CSU. These costs might vary depending on the scale and efficiency of the operation. For income we used standard custom grazing rates and Hay prices from Centennial Livestock Auction. **Given these assumptions we got a profit per acre of $87.91 for grazing, compared to $100.58 per acre for hay production.** Both of these figures would likely be higher in a non-drought year. In conclusion, short term profits were higher in hay production but our assumption is that the soil health improvements in a grazing system will begin to impact this number in subsequent years.

Scalability: Very scalable. Fencing costs, water availability and labor are the main challenges.

Lessons Learned: The fence contractor was not able to install the fence until after the cattle were gone, so we had to use temporary fencing for the trial. Drought greatly reduced regrowth. We had planned to graze the cattle a second time, but decided not to due to lack of regrowth. We also only cut hay once. Typically, we would get a second grass cutting.

DROUGHT RESILIENCY PROJECTS

Corn + Sorghum Split Field Trial – Otero County

Project Type: Corn + Sorghum Split Field Trial
Project Location: Otero County
Grant Amount: $5,022
Producer Type: Farmer
Irrigation Method: Gated pipe
Identified Water-related Challenge: Variable annual ditch water supply. Growing corn and sorghum together to harvest as silage is thought to produce greater total yield per ton using the same quantity of water and fertilizer than growing each separately.

Solution: 6/3/2024: One-third of an ~35-acre field south of Rocky Ford was planted to corn, one-third was planted to sorghum, and one-third was same-row planted to a corn/sorghum mix. Fertilizer and irrigation timing and amounts were the same for the 3 plots. All three crops were harvested for silage. Soil moisture and in-field humidity was monitored. All three plots were planted on 30 inch furrow-irrigated rows. The predominant soil type is Rocky Ford Silty Clay Loam.

Results: The yields of each third were compared based on tonnage per acre. The pure sorghum had the highest yield (18.85 T/ac), the corn + sorghum mix had the second highest yield (17.84 T/ac). The pure corn plot had the lowest yield (16.33 T/ac). Thus, the sorghum stand produced about 5% more tonnage than the corn + sorghum mix, and about 13% more than the pure corn stand. The results were surprising because the pure sorghum stand had more weeds and did not appear as dense visually. Relative humidity and temperature were autonomously measured every 30 minutes at 2.5 feet above the ground within each plot. The relative humidity averaged 1% higher in the corn + sorghum plot vs. the other two plots. The average temperature was slightly lower in the corn + sorghum mixture plot as well. The theory that relative humidity is higher in a field with a corn + sorghum mixture vs. straight corn or sorghum was accurate in this case, and the soil temperature was slightly lower. Both are probably related to a more complete closure of the crop canopy, which held moisture in and kept the air temperature slightly cooler.

In-Field Relative Humidity (RH) Averages			
Month	Sorghum	Mix	Corn
7	53%	55%	54%
8	61%	62%	62%
9	62%	61%	58%
10	41%	40%	40%
July - September	59%	60%	59%

In-Field Temperature Averages (F)			
Month	Sorghum	Mix	Corn
7	79	77.5	77.7
8	76.8	75.9	76.2
9	66.9	66.7	67.4
10	65.6	65.6	66
July - September	73.5	72.7	73.2

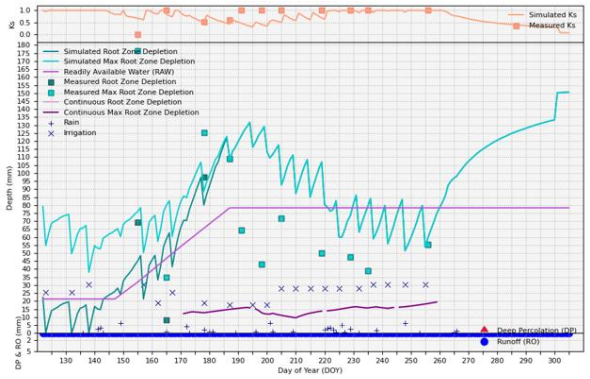
Scalability: Scalable. Useful for silage crop diversity. Requires modification of planter to accommodate a low sorghum seeding rate.

Lessons Learned: The producer had to modify his planter to reduce the sorghum planting rate used in the corn + sorghum mix plot. He is planning to conduct the trial again next year to see if he gets the same results.

DROUGHT RESILIENCY PROJECTS

Irrigation Scheduling and Inter-seeding Project

Project Type: Soil Health
Project Location: Weld
Grant Amount: $13,206
Producer Type: Commodity
Irrigation Method: Furrow
Identified Water-related Challenge:
Limited surface water during drought years can severely impact corn yields.



Solution: The producer planted a 148-acre field that has been minimally tilled with a corn and pinto beans inter-seeded with a planted winter crop. Soil moisture probes were installed and used to help schedule irrigation events and understand the impact of no-till and inter-seeding on soil moisture retention.

Results: Soil moisture probes and neutron probe tubes were installed in four different locations to help monitor soil moisture. Soil moisture was monitored weekly by the Agricultural Research Service (ARS) for comparison to the soil moisture probes. ARS is currently developing an open-source water balance model to analyze soil moisture and field specific data and help producers determine when irrigation is actually needed. Unfortunately, the ARS was not able to get the water balance model functional until late in the growing season and could not be used to schedule irrigations. The producer also had trouble interpreting the results from the soil moisture probes due to the software interface and therefore did not rely on the soil information.

Scalability: Potential scalability is currently unknown.

Lessons Learned: From this project, the ARS realized that it might take a year or more to calibrate their water balance model to a specific field before it can be used to help schedule irrigation and understand how intercropping does or does not help impact soil moisture.

DROUGHT RESILIENCY PROJECTS

Bale Grazing to Improve Soil Moisture

Project Type: Livestock
Project Location: Logan County
Grant Amount: $11,465
Producer Type: Livestock
Irrigation Method: N/A
Identified Water-related Challenge:
Dryland farming has become more difficult in recent years due to ongoing drought.

Solution: The producer used two different bale grazing styles, and two different density/style mixes, for a total of four different bale grazing strategies. The producer conducted soil health tests and water holding capacity tests prior to the effort and after to see if it could positively affect soil health and water holding capacity.

Results: The four bale grazing styles utilized were (1) 12.5 bales per 5 acres rolled out, (2) 25 bales per 5 acres rolled out, (3) 25 bales per 10 acres on end/grid pattern, (4) 25 bales per 5 acres on end/grid pattern. All four sections were grazed by 150 cattle for approximately 3 to 5 days with soil compaction test taken before and after the experiment. After bale grazing, the producer attempted plant milo but compaction and residue from setting bales was an issue during planting and the milo crop failed and was grazed. Below are pros and cons of both setting bales on end, versus rolling them out.

- Set on End Bales – Pros: provided the calves with somewhere to lay and stay dry and more residue remained. The end bales left moisture rings that could be seen later in the year. Cons: urine and manure areas were concentrated around the bales, bales were grazed according to quality.
- Rolled out Bales – Pros: manure and urine were distributed over larger areas, cattle tended to graze better, and lower quality hay was consumed. Cons: less residue was left.

Types of bales grazed also had an influence on the experiment, with alfalfa bales being cleaned up best, then millet and last oats. Cattle tended to lay in the oats residue versus cleaning it up and oat volunteer plants caused issues during milo planting.

Scalability: The producer plans to use bale grazing again to help degraded areas and cover bare areas.

Lessons Learned: Bale grazing in the spring would work best only during dry times or for short periods between precipitation events. Rolling out bales left less compaction and residue that could affect future planting, but still caused enough compaction and residue to affect any immediate cash crop plantings. Fall/Winter bale grazing is most likely the better option compared to spring.

DROUGHT RESILIENCY PROJECTS

Milo Seeding Rates Project

Project Type: Irrigation Efficiency
Project Location: Prowers
Grant Amount: $25,000
Producer Type: Commodity
Irrigation Method: Surface water
Identified Water-related Challenge:
Water from the Fort Lyon Canal can be highly variable. During drought years, the time between "runs" diverted to irrigate can be weeks or months instead of days, and water is applied to high-value crops first, before milo.

Solution: The applicant planted two fields; one with a dryland rate of 24,000 seeds per acre and one with a higher rate of 48,000 seeds per acre. The two fields were irrigated equally with a center pivot and the yield was evaluated.

Results:

52 acres were planted with grain Sorghum, with the acres equally split between the low (24,000 seeds per acre) and the high (48,000 seeds per acre) seeding rates. The producer applied approximately six inches of irrigation water throughout the growing season and about 3.5 inches of precipitation was received. The summer was very hot, and most of the rainfall came during the spring. Around the time the Sorghum matured, the canal water runs decreased and air temperature stayed around 100 degrees. The higher seeding rate yielded 120.4 bu/ac and the lower seeding rate yielded 77.7 bu/ac. With the same amount of water, the lower seeding rate still yielded more than half of the higher seeding rate. Weeds were an issue in the lower seeding rate area. Some grass weeds were able to establish and really impacted yields. The higher seeding rate acreage was not as impacted by weeds.

The Fort Lyon Canal delivered more water in 2024 than in past years, which impacted the trial and the goal of stressing the crop harder to really see the impact of the seeding rates.

Scalability: The producer plans to do another trial next year, but on a different field and with a different grain sorghum variety that has options for grass weed control.

Lessons Learned: Grass weeds are hard to control as sorghum is a grass itself, so using a field that does not have a grass problem would help with analyzing the results.

DROUGHT RESILIENCY PROJECTS

Pivot Improvements to Increase Water use Efficiency

Project Type: Irrigation Efficiency
Project Location: Baca County
Grant Amount: $23,700
Producer Type: Commodity
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Declining groundwater levels have led to reduced well production and reduction of acreage that can be irrigated. Further, aging infrastructure on the center pivots have reduced water application efficiency.

Solution: The producer installed a flow meter to collect water applied information, installed new drop connections with longer drop hoses at a consistent height off the ground, and installed new spray nozzles with bubbler pads and low-pressure regulators.

Results:

The upgraded infrastructure decreased leaks and improved water application on the center pivot. Standard drop hose heights and the installation of the bubbler pads decreased spray losses and increased water use efficiency. The regulators installed had built in screens that helped prevent nozzle plugging. The producer grew triticale on the participating field in both 2023 and 2024. The number of irrigation days in 2023 and 2024 were held consistent to allow for a comparison between triticale grown under the old and new infrastructure. The table below shows the differences in yield between 2023 and 2024. The new infrastructure allowed for a 15 percent increase in tons of hay and 16 percent increase in the number of bales, even though there was less precipitation in 2024.

Triticale Hay Yield Data	2023	2024
Number of Bales	383	445
Number of Tons	253	292
Growing Season Precipitation (inches)	12	9

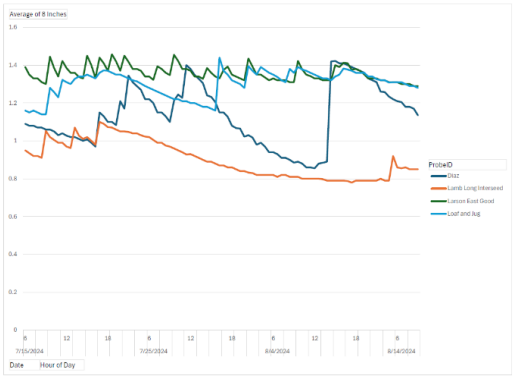
Scalability: The producer would like to upgrade infrastructure on other center pivots with the newer hoses and nozzles.

Lessons Learned: Even small improvements to water use efficiency are valuable as available water for irrigation decreases.

DROUGHT RESILIENCY PROJECTS

Monitoring Soil Moisture on Different Crop Types Project

Project Type: Irrigation Efficiency
Project Location: Larimer County
Grant Amount: $16,000
Producer Type: Commodity
Irrigation Method: Surface water
Identified Water-related Challenge:
There is a need to evaluate water efficiency related to different water irrigation practices.



Solution: The applicant implemented a soil moisture monitoring system by installing soil moisture sensors on 1,000 to 1,500 acres to measure and manage water excess. This included installing sub-surface probes on multiple fields at depths from 6 to 36 inches.

Results:
The producer investigated four corn fields utilized different farming practices:

- Diaz – Only Corn, Conventionally Tilled
- Long Lamb – Inter-seeded with Cover Crops on June 5th
- Larson East – Only Corn, Strip-Tilled
- Loaf and Jug – Only Corn, Strip-Tilled

All fields received similar amounts of irrigation supply and irrigated by a pivot. Note that Long Lamb was not irrigated for a month after hail loss caused 100 percent crop loss in late July. Soil moisture sensors were installed at multiple depths in each field. The results of the study were inconclusive. The producers attempted to decipher which fields were retaining soil moisture better after irrigation events, but there was no conclusive difference between the fields. The producer believes that results would be more apparent in an extreme water limited environments where irrigations are less frequent and there is a greater need to get the most efficient yield per inch of water applied. The soil moisture over the growing season for each field is shown in the picture above.

Scalability: The more probes you have, the more time it takes check the probes and decipher the data. Larger scale use of moisture probes would likely require remote use in tandem with pivots that are also controlled remotely, and would need a very confident user.

Lessons Learned:

- Placement of the sensors should be offset from the above ground hardware to keep from impacting the soil above the sensors and the canopy above the sensors.
- Each location will show different moisture readings from similar amounts of irrigation. As a result, if you wish to create notifications based on a certain threshold it would need to be different for each sensor otherwise you risk under/over watering because of the variation. Calibrating each probe based on soil type at each site, would reduce this risk.

DROUGHT RESILIENCY PROJECTS

Sheep bale grazing – Mesa County Project

Project Type: Sheep bale grazing on Saline Soils
Project Location: Mesa County
Grant Amount: $2,855
Producer Type: Part-time, small acreage farmer
Irrigation Method: Drip
Identified Water-related Challenge: Highly saline soils prevent germination of forage plant seeds. Orchard trees were planted into a custom soil mix. Owner would like to establish forage between the tree rows for sheep to graze on.

Solution: In half of the orchard, sheep were to be rotationally bale grazed in between the trees. The other half would not be accessed by sheep and only weeded as necessary for tree health. All of the trees are on drip irrigation. The trees are spaced 12-16' apart. The intent of this project was to use intensive rotational bale grazing with sheep to cost-effectively improve soil moisture and quality, productive capacity, and establish desirable forage cover in the orchard between the trees. This effort was intended to increase the landowner's available grazing acreage and continue to improve soil and forage quality after completion of the trial. The landowner was also going to install small irrigation piping to water the area.

Results: A seed mix of orchard grass, tall fescue, and meadow brome was broadcast over the trial area. The landowner reported that the irrigation system he installed continuously clogged and he could not keep up with the maintenance. The landowner did do some bale grazing with the sheep in the area but did not have a significant number of sheep. This limited the impact of the bale grazing effort. Germination of grasses within the bale grazed area did occur and some growth was observed, despite the lack of irrigation (photo at right).

Scalability: Scalable. Fencing, water and livestock are needed. Daily checking of the drinking water supply and feed and animal health is required.

Lessons Learned: More sheep would have helped to demonstrate the effects of bale grazing. A filtration system would have helped reduce clogging of the sprinkler.

DROUGHT RESILIENCY PROJECTS

Bale Grazing on Cropland Project

Project Type: Livestock
Project Location: Alamosa County
Grant Amount: $11,657
Producer Type: Livestock, Commodity
Irrigation Method: Groundwater, center pivot
Identified Water-related Challenge:
Farming has become more difficult in recent years in the San Luis Valley due to ongoing drought and necessary reductions in groundwater pumping.

Solution: The applicant used an experimental plot and a control plot to allow 93 weaned calves to bale graze a parcel of center pivot-irrigated land. The pivot was then planted with potatoes during the 2024 growing season to understand the impact of bale grazing on soil health.

Results: ***Bale Grazing Results***: Bale grazing was found to be an efficient way to overwinter cattle when considering labor, machinery costs, and soil fertility benefits. Cows were fed oat haybales a handful of times over the course of the feeding period. This reduced reliance on utilizing heavy machinery to feed every day and resulted in calmer animal behavior. Feeding the cows every day leads cattle to anticipate feeding occurrences and the producer believes increases anxiety levels. Feeding twice a week seemed to minimize cattle anticipating and promoted more grazing and general calmer behavior. As hay is expensive, bale grazing as a winter-feeding strategy is dependent on broader ranch economics. For the producer they found that it only worked on weaned calves and only if the relationship between calf prices and hay prices were such that the value of the weight gain that could be achieved significantly exceeded the daily cost of a hay rotation.

Impacts on Potatoes Results: After the bale grazing, the field was minimally tilled and potatoes were planted. The locations where the bales had been placed were extremely easy to see as oats came up densely in each location. The oats outcompeted the potatoes in these locations resulting in a decrease in potato yields. These areas were also hard to dig up to harvest the potatoes due to the presence of the oats. The producer believes the oats being added into the soil added fertility benefits, and will use a different type of hay that does not include a bunch of seeds in the future.

Scalability: This method could be easily scaled due to the labor/machinery efficiencies and the ability to use low-cost modular fencing. Once the bales have been placed, it is just a matter of moving the temporary fence enough to match the feed requirements of the cattle.

Lessons Learned: It is necessary to feed at intervals where you can provide enough space around the hay for all livestock to feed, and bales should be fed in the opposite direction of prevailing winds to act as a windbreak. Bale grazing did result in more organic material in the soil; however, using a hay with no seeds is important to not introduce a competing plant into the field.

DROUGHT RESILIENCY PROJECTS

Orchard Soil Moisture Monitors Project

Project Type: Irrigation Efficiency
Project Location: Delta County
Grant Amount: $16,780
Producer Type: Commodity
Irrigation Method: Center pivot
Identified Water-related Challenge:
Even with considerable water rights, this farm is at risk during extreme drought. The applicant can mitigate risk through the most efficient use of sprinklers and droppers.

Solution: The applicant installed soil moisture sensors at various locations on a 75-acre orchard parcel to make decisions on how much irrigation water needed to be applied on a weekly basis.

Results:

The producer installed the Soil Scout Soil Moisture Sensor System. The system allowed the producer to see how much water was held in the soil throughout the orchard acreage and make decisions based on that level. During the growing season, the participant determined that if the water holding capacity stayed at or above 90 percent of its holding capacity that it would allow for the growth necessary to maintain substantial vigor. Certain areas of the orchard had more than three feet of growth. This was more growth than the orchard experienced in previous years, indicating that the trees were not receiving enough water previously. While growth (vigor) is not a tool you want in a mature orchard, this is still a young orchard, and the trees are not yet fully grown. The producer plans to continue using the sensors to find proper growth balance by monitoring soil water, humidity and tree growth throughout future years.

Scalability: The producer plans to continue using the sensors to monitor the orchard and after the trees meet maturity to reduce the water to blocks of trees and grow for heath vs. vigor.

Lessons Learned: The producer determined he most likely had been under-irrigating the orchard in previous years. He also had to work through some technical issues with the sensors, including having difficulties finding a place to put the sensors so that they could communicate with the tower in the orchard.

DROUGHT RESILIENCY PROJECTS

Camelina Trials Project

Project Type: Alternative Crops
Project Location: Mesa County
Grant Amount: $21,950
Producer Type: Commodity
Irrigation Method: Surface water
Identified Water-related Challenge:
With the current state of the Colorado River, the applicant is investigating conservation efforts with a plan to plant camelina, which has a lower consumptive use compared to wheat.

Solution: The producer planted two different varieties of Camelina on 235 acres with three different planting dates to determine best yields versus irrigation timing.

Results:

The producer planted roughly 236 acres of Camelina. Seventy acres were planted at the end of September 2023, 77 acres were planted in mid-November 2023, and 88 acres were planted in February of 2024. The two trials planted in fall of 2024 germinated well and performed the best. The seed planted in February of 2024 struggled to germinate due to a lack of moisture. Much of the stand did not come up. The later plant date also pushed pollination during the hotter days in the summer, which also adversely affected the yield. The two winter plantings yielded on average 1,535 pounds per acre, with the earliest plant date yielding the highest. The spring plant date on average only yielded 931 pounds per acre. The producer applied roughly 1.86 acre-feet per acre of water less than water applied to his 2023 winter wheat crop. A 2024 crop consumptive use analysis showed that Camelina consumed roughly 0.75 acre-feet per acre less water on average than the producer's wheat fields.

The Camelina was more susceptible to weather events than other crops, but required little maintenance to grow, making it a good option in place of winter wheat.

Scalability: If a market for this crop in the Grand Valley could be developed, this crop could be used in crop rotations and/or replace winter wheat.

Lessons Learned:

- Spring planting of Camelina in the Grand Valley is likely not a viable option
- Camelina requires less water than winter wheat and is low maintenance
- Camelina is more suspectable to adverse weather conditions than winter wheat

DROUGHT RESILIENCY PROJECTS

Cowpeas for Animal Feed Project

Project Type: Hay and Forage Project
Project Location: Otero County
Grant Amount: $20,000
Producer Type: Alfalfa
Irrigation Method: Unknown
Identified Water-related Challenge:
Due to dwindling irrigation water availability, the producer has not been able to fully irrigate their alfalfa fields. The resulting shortage has led to decreased alfalfa yield.

Solution: This project operated in both 2023 and 2024 and used cowpea as an alternative drought resistant forage crop. The project tested the animal feed values and soil health benefits of three selected forage cowpea varieties. Cowpea (commonly known as black-eyed pea) can be used for human food, animal fodder, and cover cropping and is tolerant of drought, high temperatures, salinity, and infertile soil. In 2024 production was scaled up and the producer looked at how different water management regimes affect the cowpeas.

Results: Two varieties of cowpeas were planted at both the Arkansas Valley Research Center (AVRC) and by two producers - Red Ripper and 8046 (black-eyed pea). At AVRC, the Red-Ripper had good germination and stand establishment, while 8046 had very poor germination and was eventually overrun with weeds. The Red-Ripper produced an average grain yield of 1250 pounds per acre and had a relative feed value of 184.74. The first producer's first planting was severely damaged by hail, the second planting was successful with good germination for both Red Ripper and 8046. Both varieties were swathed, but not able to be baled due to large amount of snow in early November. The second producer planted in mid-June and had decent stands from both varieties. However, both varieties exhibited cupping of leaves and weeds overtook both varieties and the field were not harvested.

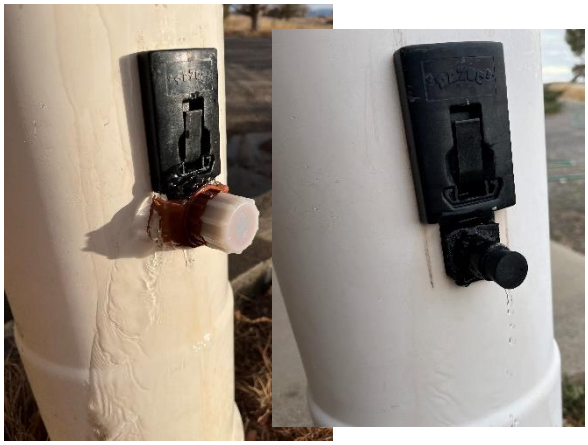
Scalability: The project manager plans to repeat the project at ARVC in 2025 to concentrate on weed control efforts by adding a grass species to help outcompete weeds and examine potential herbicide options for the cowpeas. If the weeds could be controlled, cowpeas could then be grown as an alternative crop in the Arkansas Valley.

Lessons Learned: Cowpeas are very suspectable to weed pressure. Differing water management regimes did not seem to have an effect on the cowpeas but may need to be re-evaluated after weed control measures have been further investigated.

DROUGHT RESILIENCY PROJECTS

Drip Tape – Gated Pipe Connector Project

Project Type: Irrigation Efficiency Project
Project Location: Delta and Mesa Counties
Grant Amount: $19,052
Producer Type: Commodity, Grass and Alfalfa Hay
Irrigation Method: Gated Pipe with Drip Tape
Identified Water-related Challenge:
Drip irrigation is among the most efficient methods of irrigation. However, drip irrigation typically requires clean water that is delivered under pressure. This often translates, into expensive filters and pumps and can include a bill for electricity. Along with the cost of buying and installing drip tape, the result is that drip irrigation is used on a very limited number of acres in Colorado.



Solution: The project attempted to make a drip irrigation connector that could be used to connect drip tape to gated pipe. The connector would fit a normal gated pipe allowing drip irrigation to be used on fields with gated pipe infrastructure already installed. The connector was developed in 2023 and then put into further testing in 2024.

Results: During preliminary field trials in late 2023, the main issue identified with the connectors was water leaks. In 2024 the project focused on making the adapter watertight. The design was altered form a rigid plastic to a more flexible, rubbery plastic. This greatly helped improve the water tightness, but not quite to a level deemed acceptable by the team. The team is continuing to work on the connector through the winter. In 2025 the team plans to use the connector to irrigate a crop and perform hopefully the last field trials needed.

Scalability: Highly scalable but the design will need further refinement to meet the specified criteria and be able to reliably be used by irrigators.

Lessons Learned:
Rigid plastic was less forgiving with the pressure changes from turning on and off. A flexible rubbery plastic performed much better and had less leakage. Multiple iterations are needed to really create a working prototype.

DROUGHT RESILIENCY PROJECTS

Compost and Biochar Project

Project Type: Soil Health Project
Project Location: Weld County
Grant Amount: $26,920.50
Producer Type: Wheat and Barley
Irrigation Method: Sprinkler and Dryland
Identified Water-related Challenge:
Increased drought and reduced precipitation have negatively impacted the producer's dryland farming operation by reducing soil moisture which has resulted in reduced crop yield. Additionally, drought has reduced the water available to the producer for their irrigated acreage, resulting in reduced yield of crops.

Solution: This project began in 2023 by implement a composting system that improved soil moisture retention on both dryland fields and irrigated fields. The compost mix was composed of manure, straw chaff, brewer's yeast salvage, and biochar. In 2024 the project continued and scaled up with more acreage and refined application techniques.

Results: The producer is still tracking results from soil tests and yield on a parcel that was treated with the compost mix in late 2023. The soils Cation Exchange Capacity increased by three percent. Cation Exchange Capacity is a soil property that indicates soil fertility and ability to supply nutrients to plants. 2024 Winter Wheat yields on the parcel increased by roughly 20 percent. This parcel will be planted in Sorghum in 2025 and additional soil testing and yield tracking will be completed.

The producer applied the composting process to two additional fields, with one dryland parcel planted in Hard Red Winter Wheat in fall of 2024. The other parcel is currently being treated and will be planted in 2025, with results expected in 2026.

Scalability: The producer plans to continue tracking results from the three parcels that have received the treatment. Depending on the results from the additional fields that have different soil types and crops, the producer may expand this process to other fields in the future.

Lessons Learned: The low amount of biochar applied made the use of this mixture more economically feasible than other biochar studies. Further studies should be done to explore how biochar may influence soil properties after multiple years and how yield is affected in hydrologically drier years. Additionally, studies should be conducted to analyze the effect that biochar has on improving water quality for agricultural fields.

DROUGHT RESILIENCY PROJECTS

Bale Grazing Project

Project Type: Hay and Forage Project
Project Location: Boulder County
Grant Amount: $12,524.52
Producer Type: Livestock
Irrigation Method: Flood Irrigation
Identified Water-related Challenge:
Due to poor soil health, low water infiltration rates, lack of adequate irrigation water throughout the growing season, widespread prairie dog degradation, and an abundance of weeds/non-native grasses, the field needs rehabilitation.

Solution: For this project, the landowner will use ruminant animals to impact land that is populated by prairie dogs, invasive weeds, and brome grass. They will bale graze the animals on sections of land to disturb the heavy thatch created by brome grass, add a large amount of nutrients to the soil through manure and urine, and prepare the land for native grass planting.

Results: During the 2024 leg of this project, Grama Grass & Livestock distributed 123,468 lbs of hay on the predetermined areas of the property where this project took place. About 80% of this hay was used to feed the herd and the other 20% went to adding carbon to the soil. Grazing the cows in this manner also interrupted and deterred less desirable plants such as common teasel and Canada thistle from completing a growing cycle, ideally reducing next year's growth. Since this project took place during the growing season, Grama Grass has not witnessed all of the anticipated benefits. The team is looking forward to the springs of 2025 and 2026 to see the impacts of bale grazing. Prior to planting, Grama Grass disced and leveled burrows throughout the property to reduce compaction while making a more even seed bed. This practice was advised from an agronomist that analyzed soil samples and produced management suggestions. These samples indicated a high level of compaction. Unfortunately, the spring/summer cover crop mix planted in June of 2024 did not respond well. However, they did see a modest amount of growth in the late season, which was abnormal. Grama Grass' theory is that this reaction is due to the lack of precipitation throughout the summer months in the front range. Grama Grass anticipates seeing an increase in native species that were planted along with the cover crop in 2025. Throughout the entirety of the project, Grama Grass has witnessed an overall property increase in live plant matter. With an increased amount of live plant comes reduced amount of bare ground. This inverse relationship supports water retention and filtration. This is an indication that long-term change is happening, moving the property to a more drought-resilient and less water thirsty system. They believe the initial years of bale grazing have supported this change.

Scalability: Grama Grass believes this is a scalable project. The majority of cattle producers feed with hay in the winter months. Adopting this project or approach would involve producers being more strategic with where they place feed bales and follow the bale grazing with seeding.

Lessons Learned: Grama Grass learned that land regeneration to a more drought resistant system requires greater trial and error than the length of this project. While they believe they made positive changes and are moving towards a more drought resistant prairie, the lack of rainfall in 2024 required Grama Grass to irrigate intensively using ditch water.

DROUGHT RESILIENCY PROJECTS

Biochar Injection Project

Project Type: Soil Health Project
Project Location: Mesa County
Grant Amount: $1,954
Producer Type: Small Produce Farm/Researcher
Irrigation Method: Furrow Flood
Identified Water-related Challenge:
Due to drought and increased temperatures the producer has had a decrease in the amount of water held by the soil of his fields.

Solution: This project is a continuation of the 2023 project. This technology, which is currently used in the sports turf industry, will inject liquid and dry biochar vertically down into the soil 6-10 inches deep in a grid pattern. They injected biochar into an existing perennial hay crop.

Results: In May of 2023 biochar (Pistachio Shell biochar) was injected into a grass hay field. The biochar was injected into two different strips of the field. The research strips were Strip 1 – Biochar Injected, irrigated once per month; Strip 2 – No amendment, irrigated once per month; Strip 3 – Biochar Injected, irrigated twice per month; and Strip 4 – No amendment, irrigated twice per month. In 2024 the producer continued with the irrigation schedule set up for each strip, but no new biochar was injected. Soil tests showed that no fertilizer was needed for the strips where biochar had been injected, while the control strips required 100+ lbs/acre of NPK. The soil health of the treated strips was much better than the control strips. Hay quality tests showed negligible quality difference between the strips and hay yields were marginally better in control strips, most likely due to the fertilizer application. The treated strips maintained higher levels of moisture at all depths throughout the season than the strips that received the same amount of water:

- Strip 1 maintained 25 percent more moisture than Strip 2 on average and at all depths throughout the season
- Strip 3 maintained 19.8 percent move moisture than Strip 4 on average at all depths throughout the season.

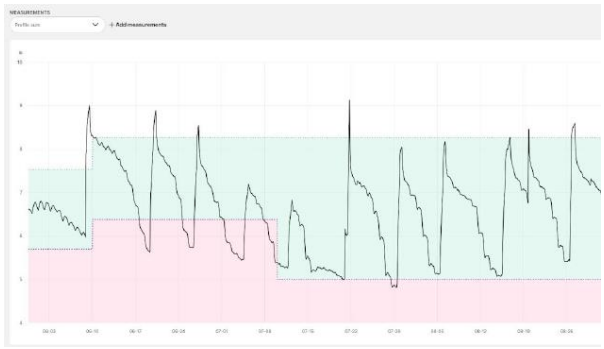
Scalability: If continued monitoring shows a long-term benefit that helps with the up-front costs, this could be implemented in more fields.

Lessons Learned: The strip treated with Biochar and had half of the water showed the largest amount of plant biomass and microbial functional groups. The treated strips also had higher soil moisture retention.

DROUGHT RESILIENCY PROJECTS

Soil Moisture Monitoring Project

Project Type: Irrigation Efficiency Project
Project Location: Pueblo County
Grant Amount: $2,250
Producer Type: Corn, Commodity
Irrigation Method: Flood
Identified Water-related Challenge:
Due to decreased water availability, crop yields have been declining. Additionally, the decrease of water supply is reducing the soil moisture on the producer's fields.



Solution: In 2023 the producer used a weather station and soil moisture monitoring system to improve irrigation water management. The fields are almost entirely flood/furrow irrigated, with numerous hurdles to switching to more efficient irrigation methods. In 2024 the producer purchased additional sensors to do a side-by-side trial comparing sensor-based irrigation scheduling to standard irrigation practices with a focus on gathering quantitative data: water applied, water consumed by the crop, and crop yield.

Results:
The producer performed the side-by-side trial on an eighteen-acre field planted in corn. Six of the acres were irrigated based on recommendations from the CropX probes. The other twelve acres were irrigated based on their standard practice of irrigating or whenever ditch water was available. Two soil moisture probes were installed, one at the head of the trial field and the other at the bottom of the water rows in the trial field. The CropX sensor interface provided the irrigator with a "refill" line, that could be adjusted based on user input. Initially user had this set at fifty percent of depletion of available moisture but changed it to 75 percent depletion of available moisture around mid-July. The switch was based on a recommendation by CropX due to the furrow irrigation practices of applying more water and applying it less frequently than a pivot. The 2024 water year in the Arkansas basin was an above average year and the producer was able to apply around 4 to 5 ac-ft to both sections of the field. There were no visible differences between the two sides, but the producer did notice more runoff on the sensor side due to more frequent irrigations. The sensor side stayed greener longer at the end of the season. The sensor yielded 297 bu/ac and the standard practice side yielded 288 bu/ac. Counting in the costs of the extra water, pumping electricity, labor and the soil moisture probes, the net profit difference between the trials was minimal.

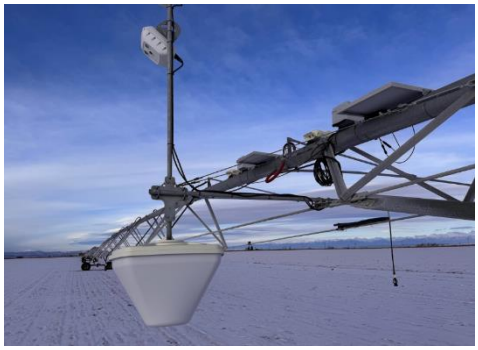
Scalability: The system could be scaled up to use on multiple fields.

Lessons Learned: Compared to the probes installed in 2023, the CropX probes were easy to install and the platform was easy to use and provided clear graphs and irrigation timing recommendations. Even with the improved sensors/platform, the producer believed that assistance from someone more familiar with the soil moisture data would have been helpful. The producer wants to figure out how to use the probes to more of an advantage during a dry year when irrigation water is less available.

DROUGHT RESILIENCY PROJECTS

Autonomous Pivot and Radar Project

Project Type: Efficiency Project
Project Location: Alamosa County
Grant Amount: $6,000
Producer Type: Potatoes
Irrigation Method: Center Pivot Irrigation
Identified Water-related Challenge:
Due to poor soil health and variable water availability, the producer has had impacts to their field's productivity and crop yield.



Solution: In 2023, this project utilized two different water sensor technologies: (1) an autonomous pivot with ground penetrating radar to detect soil moisture throughout the field and (2) soil moisture sensors buried in the field. After a successful 2023, in 2024 the autonomous pivot was tested on three different fields with varying soil types.

Results:
The autonomous pivot attaches to a center pivot irrigation system, uses ground penetrating radar to determine soil moisture content, and takes photos of the crop every 30 minutes during irrigation events. The software uses the data collected and precipitation data to recommends irrigation amounts. Three autonomous pivots were used on three separate fields. Two of the fields were planted in potatoes and one was growing Rye as a cover crop. Below are field specific results:

- Field 1 (Potatoes): The system was operational for the entire growing season. The producer did not follow the recommended irrigation schedule as he believed the recommendations were much more frequent than necessary. The producer applied 18.14 inches of water, while the system recommended a total of 32 inches for the growing season.
- Field 2 (Potatoes): This system was not functional until the end of June due to an issue with the sensors and the company not having local reps in the valley. Once fixed it worked well and was more accurate than the system in Field 1.
- Field 3 (Rye): Because rye was planted as a cover crop, irrigation recommendations were not provided. The producer stressed the crop to limit irrigation, which the sensors did accurately pick up.

Scalability: The producer scaled up compared to 2023; the producer does not plan to scale up further and may not use the system in the future.

Lessons Learned:
Compared to 2023, the producer was disappointed with the equipment and software. Because of the equipment malfunction; inaccurate data; and annual subscription fees, the producer does not plan to use the system in the future. He further noted that, when using new equipment, it is important that the company have local service and support.

DROUGHT RESILIENCY PROJECTS

Drought Hardy Seeds and Legumes Project

Project Type: Alternative Crops Project
Project Location: Montezuma County
Grant Amount: $12,500
Producer Type: Commodity
Irrigation Method: Unknown
Identified Water-related Challenge:
Increased drought has resulted in reduced water availability and a shortened water supply season. This reduced water availability has affected the producer's ability to irrigate fall grains and has led to reduced yields of their crops.

Solution: In 2023 the producer trialed nine species of grains and legumes for drought tolerance, adaptability to Southwest Colorado growing conditions, initial seed increases and potential for scaling up for local and regional seed and food markets. Based on results from 2023, there were roughly 10 species and 13 varieties that showed promise for further seed increases. In 2024 the producer saw increases of promising varieties and collected data on yield, nutritional analysis and days to maturity. The producer also worked with two growers to do produce some of the grains and legumes that were incorporated into several dry ingredient, minimally processed foods.

Results:

Two growers were contracted to do seed increases of two different crops (white sonora wheat and dryland seed corn). The white sonora wheat grew well and from first inspection produced a good yield. Taste testing, final yield results, and nutrient content still needs to be completed. One acre of dryland seed corn was planted and then minimally irrigated to try and simulate dryland conditions. The corn did well but was hit by a hail storm in august that significantly affected the yield. All the corn is being kept for seed to plant a three-to-five-acre plot in 2025. Both growers used a combine that is shared within the community and made the seed increases possible.

2024 was a good water year, which helped make successful seed increases. The small acreage seed increases completed by the producer also had good yields and samples of each were cleaned and sent to nutrient testing laboratory. The crops that were most successful are being incorporated into food production at the producer's bakery. Yield and nutrient data are still being processed and a follow up report in 2025 will contain the results.

Scalability: The more successful crops are going to continue to be used for small acreage seed increases for distribution to local growers. The producer is going to work with more local growers in 2025.

Lessons Learned: In 2025 the producer is going to try to drill seeds to see if it helps with germination. The crops did well in a good water year, but 2025 seed increases will allow the producer to understand how they perform in a drought year.

DROUGHT RESILIENCY PROJECTS

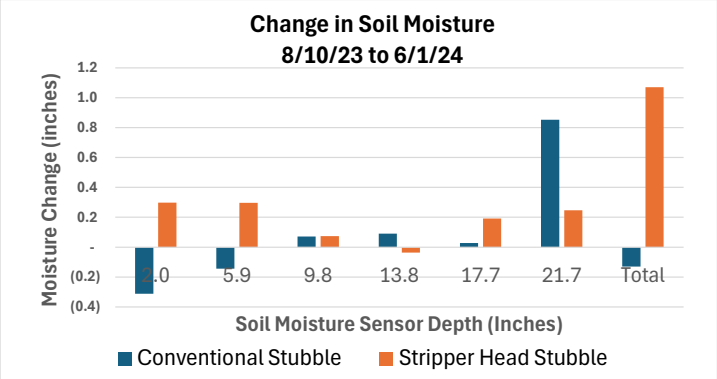
Stubble Height and Soil Health Project

Project Type: Soil Health Project
Project Location: Logan County
Grant Amount: $4,110
Producer Type: Wheat, Millet, Sorghum, cattle
Irrigation Method: None (dryland)
Identified Water-related Challenge: Intermittent droughts have reduced soil moisture levels in the producer's fields. The decline in soil moisture negatively impacts crop yields and soil health.

Solution: This study assesses the influence of stubble height on soil moisture levels, building on previous work that has found a positive correlation between increased stubble height and higher soil water content at spring planting and potentially higher yields at harvest.

Results: On 8/3/2023, half the 80 ac. wheat field was harvested with a conventional combine head and the other half was harvested with a stripper head. The stripper head ~ 10 inches more stubble height compared to the other half of the field. Soil moisture probes were installed and monitored. Seeding and fertilization rates were the same on both halves of the field.

- A comparison of soil moisture levels on 8/10/2023 (shortly after harvest) to 6/1/2024 (milo planting) showed a more positive soil moisture level in the top 6 inches and overall in the taller stubble half of the field vs. the conventional stubble height side of the field.
- The milo yield was 1.5 bu/acre higher in the field half with the higher stubble height.



Scalability: Very scalable. It only requires a stripper combine head and a conventional head.

Lessons Learned: The stripper head harvesting cost was $25 per acre, which is ~20 % higher than the cost for harvesting with a conventional combine head. Using $25/ac x 20% higher cost = $5.00 / acre higher cost to use the stripper head. The higher stubble height side of the field had 1.5 bu/ac more yield than the other half; so the value was 1.5 bu/ac x $3.80/bu = $5.70/acre. Thus, a small net premium of $0.70/ac was realized on the stripper head side of the field.

DROUGHT RESILIENCY PROJECTS

Alternative Forages Project

Project Type: Hay and Forage Project
Project Location: Montezuma County
Grant Amount: $194,480
Producer Type: Commodity
Irrigation Method: Various
Identified Water-related Challenge:
Prolonged drought conditions have led to a decrease in irrigation water storage for the producers which, combined with decreased seasonal precipitation, has resulted in reduced alfalfa yield.

Solution: This project will work with commercial producers to help shift cropping systems from alfalfa to forage mixes that use less than half the seasonal irrigation water. The economic returns are almost equal to alfalfa, allowing growers to maintain economic sustainability in exceptional drought conditions.

Results: In 2023, three commercial producers participated in the project, while in 2024, 10 commercial producers participated. Below is a summary of the crops grown, yield, water applied, and lessons learned. Note that in 2024 roughly 28 inches of water was applied to alfalfa fields.

Crop Grown	Yield	Water Applied	Results/Lessons Learned
Beardless Barely	2.37 tons per acre	11.27 inches per acre	• Yielded better in past years (normally 2.5 to 4.1 tons per acre) • Market was better for the barely than wheat
Hard Red Spring Wheat	33 bushels per acre	18.44 inches per acre	• Yield down over 50 percent from 2023 with same water applied. Chemical residue from 2023 may have played a role in decreased yields.
Prosper Spring 3-Way (beardless barley, beardless wheat, oats)	2 ton per acre	14 inches of water applied	• Planting late helped increase yield due to avoidance of spring winds and increased benefit from monsoonal moisture • 3 Way cow hay market is strong, but prices are low due to larger supply.

Crop Grown	Yield	Water Applied	Results/Lessons Learned
3-Way Forage(beardless barley, beardless wheat, oats)	3.4 ton per acre	15 inches of water applied	• Do not spray Clean Slate on forage wheat and barley. It did a great job at controlling the thistle, but it hurt the wheat and barley, but didn't seem to affect the oats.
Hard Red Winter Wheat	110 bushels per acre	18 inches of water applied	• Wheat is a good rotation choice when forage market is flooded with supply. • Adding water early and not letting ground dry up from winter moisture decreases plant stress and increases yield.
Hard Red Winter Wheat	61.5 bushels per acre	17.5 inches of water applied	• Wheat market is currently better than forage market. • Trying to produce no-till wheat is not a good option due to increased weed pressure resulting in lower yields.
Hard Red Winter Wheat	111 bushels per acre	19 inches of water applied	• Wheat market is currently better than forage market. • Adding water early and not letting ground dry up from winter moisture decreases plant stress and increases yield.
Barely in an old alfalfa stand	2.5 ton per acre 1st cutting; 0.25 ton per acre 2nd cutting	14 inches of water applied	• Lack of monsoonal moisture severely decreased 2nd cutting yield. • Planting a forage crop into older alfalfa is a great way to get some yield without plowing up the field and replanting alfalfa.
Winter Wheat	Not Harvested	8 inches of water applied	Severe weed pressure resulted in very weak crop, will not try this strategy again.
Beardless Barley	Not Harvested	N/A	Heavy rain immediately after planting crusted soil and impeded emergence. Irrigated 1 time with 2 inches of water and the minimal additional amount germinated was eaten by prairie dogs. Will need to control prairie dogs before planting another crop on the field.

DROUGHT RESILIENCY PROJECTS

Kernza and Sainfoin Trials Project

Project Type: Alternative Crops Project
Project Location: Montezuma County
Grant Amount: $29,654
Producer Type: Forage Crops
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Recent intense drought has led to a decrease in the producer's water availability. Even with investments in water efficient infrastructure, the producer has had less crop yield and had to fallow lands due reduced water supply.

Solution: This project utilized drought tolerant and less water intensive crops to understand the potential to utilize these crops instead of alfalfa or timothy. The project will conducted field trials of Kernza varieties of intermediate wheatgrass and sainfoin, perennial grains that integrate food production, and high-quality forage with soil and water conservation. They will continue to evaluate the establishment, forage production, and forage yield of the crops while determining whether there is a viable market for their grain in the future.

Results:
In 2023 the producer planted a mix of both Kernza and Sainfoin, but had issues with the irrigation system and crops were overrun with weeds. In the spring, the producer checked to see if any Kernza or Sainfoin came back, and only Sanfoin re-emerged in 2024. In 2024, the producer mowed down the weeds and applied a chemical treatment prior to planting to prevent the weeds from outcompeting the crop. In September of 2024, the producer planted Sainfoin. After pre-treating the field for weeds and only planting Sainfoin because the Kernza did not return in spring of 2024, the Sainfoin came up very well and evenly across the field. So far the producer has had no issue with weeds. The producer plans to monitor it through the winter and either graze or harvest it in spring of 2025. More results on yield and winter hardiness will be available in 2025.

Scalability: Sainfoin can be easily planted throughout the area and, depending on how it does over the winter, may be a good option for planting during drought years.

Lessons Learned:
Kernza may not be suit able for the area, while Sainfoin showed more hardiness. With the alternative crops, it is important to be aggressive about weed management as they can be outcompeted easily.

DROUGHT RESILIENCY PROJECTS

Forage Conversion – Rio Blanco County Project

Project Type: Hay and Forage Project
Project Location: Rio Blanco County
Grant Amount: $10,439
Producer Type: Rancher
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Due to sod binding in Smooth Brome-dominated meadow, forage yields have declined despite ample irrigation water and fertilizer application.


2023


2024

Solution: The producer will establish and measure the characteristics of establishing more drought tolerant, non-sod binding forage. The meadow will be ripped, tilled and planted with interim crop(s) for one or two years, then planted to a final mixture of meadow grasses and legumes.

Results: In 2024, the same 13 acre portion of a pivot irrigated field was double disked, power harrowed, and planted to a barley and sanfoin/clover mix in May. A tumbler-aerator-planter was used to plant the seed. The soil bed was better than in 2023. The barley established well. The treatment and control fields were harvested and baled in mid-September 2024. The treatment field yielded 1.7 T/acre. The control field produced 2.3 T/ac. Both fields got 6.5 inches of rain and 14" of irrigation water. Both fields were grazed together after harvest. An estimated 0.47 T/ac was removed via grazing. The combined cost of tilling, seed and planting in 2024 was $262 per acre. Soil test results are shown below. No fertilizer has been applied on the treatment field in 2023 or 2024. See the 2023 one-page summary for last year's results.

Transition Field:	NO3-N (lbs/ac)	Phos (ppm)	OM (%)
Spring, 2023	25	14	5.3
Fall, 2023	13	4	4.4
Spring, 2024	96	17	3.5
Fall, 2024	74	12	6.3

Control Field:	NO3-N (lbs/ac)	Phos (ppm)	OM (%)
Spring, 2023	34	7	5.5
Fall, 2023	7	8	6.7
Spring, 2024	37	6	4.3
Fall, 2024	31	8	7.6

Scalability: Scalable. It is a common problem throughout the mountain areas of the west slope. Tillage equipment, especially a power harrow are necessary. Rock picking from the field may be needed. Costs include tillage and planting, seed, equipment repair, and herbicides (if used).

Lessons Learned: Fewer tillage passes were needed in 2024 to prepare a seedbed vs. 2023. The peas in 2023 and clover+sanfoin in 2024 fixed significant soil N despite being visually sparse. Rocks being turned up during tillage were still a big problem in 2024. Weeds were a greater problem this year than in 2023. The producer estimated 50% of the smooth brome / other turf grasses has been eliminated. The final 8-way seed mix (4 grasses, 4 legumes) may be planted in 2025, but the producer will make the decision next spring. The producer will likely spray the remaining brome / other turf grasses in the treatment field with a herbicide before planting.

DROUGHT RESILIENCY PROJECTS

Perennial Forages

Project Type: Soil Health Project
Project Location: Otero County
Grant Amount: $16,929
Producer Type: Livestock
Irrigation Method: Gated Pipe
Identified Water-related Challenge: Can only irrigate in the winter and must rely on precipitation throughout the summer for forage for livestock.

Solution:
Convert irrigated farm ground from annual crops to perennial gasses. Native and cultivated perennial grass species that are adapted to the area are more drought tolerant and are more tolerant of alkaline/saline water than annual crops.

Results:

The producer planted 59 acres of irrigated farm fields in late fall of 2023 with perennial grasses. The fields were first disked twice to break compaction and prepare the seed bed then they were leveled with a land plane. Seed was planted using a no-till range drill and the field was furrowed. The cattle were kept off the fields using an electric fence to keep them from grazing while the perennial grass established. Winter of 2023 to 2024 was very dry and the fields were only irrigated once. Due to 2024 being dryer, low germination occurred and weeds were abundant in all the fields. Based on past experience from converting annual crop fields to perennial crops, the producer expects it to take a few years to get a good stand. They do not plan to mow or graze the fields in the next year and hope to see more germination in 2025. In November of 2024 the Ranch received a large snow storm (five feet) and irrigation water for the winter turned on. The producer is hopeful that the fall precipitation will help improve germination in the spring.

Scalability: The producer plans to convert more of their annual crop land into perennial grasses.

Lessons Learned:

Converting fields to perennial grass is a long-term project and results are not typically seen after one year when irrigation is not consistently available. However, converting to native grasses will improve drought resiliency.

DROUGHT RESILIENCY PROJECTS

Perennial Forages – Mesa Project

Project Type: Hay and Forage Project
Project Location: Mesa County
Grant Amount: $11,830
Producer Type: Alfalfa
Irrigation Method: Unknown
Identified Water-related Challenge:
Due to prolonged drought, the producer's water supply has been available for a shorter period of time in the early irrigation season. The limited water supply is challenging the producer's ability to sustain growing alfalfa for livestock.

Solution: This project will facilitate the preparation, planting and harvest of a multi-species perennial forage crop, planted directly into existing alfalfa stubble. This forage crop, planted in early spring and irrigated for the short season, requires approximately 15" of water, less than 50% of alfalfa, and sells for a comparable price/ ton.

Results:
Roughly 50 acres of a perennial forage crop (TZ Farm Wildlife Habitat Seed Mix) was planted into the alfalfa stubble using a no till drill in early November of 2023. The crop had good emergence and despite dealing with extreme drought conditions in the area the producer was able to get one good cutting and then grazed it again in the fall. Although the producer believes it will take a few years before it can be determined if the seeding was successful, the producer was able to get similar tons per acre to alfalfa produced under similar water conditions in previous years. The amount of irrigation applied is typically determined by water availability, but the producer does believe this mix did not need as much water as the previous alfalfa. OpenET (ETData.org) showed that the field had roughly 4 inches less of ET compared to alfalfa fields on the ranch. It is unclear if the ET from the perennial forage crop will increase in future years after the crop has become more established.

From the one cutting, the field produced 46 tons of hay (71 round bales). Due to the forage market being flooded with supply in 2024, there was not very much amount of profit after expenses.

Scalability:
The mix could be planted on more acres in the area to benefit both wildlife and livestock.

Lessons Learned:
Seeing results from a perennial forage crop will likely take multiple years to understand how it performs in both dry and wet conditions and its ability to come back each year.

DROUGHT RESILIENCY PROJECTS

Soil Treatments Project

Project Type: Soil Health Project
Project Location: Pitkin and Eagle Counties
Grant Amount: $18,860
Producer Type: Grass Pasture and Hay
Irrigation Method: Flood Irrigation
Identified Water-related Challenge:
Farmers are experiencing a lack of water and as the trend of drought conditions persists, they are looking for ways to continue producing with less water availability.

Solution: The project applied different soil and irrigation treatments to four separate Roaring Fork Valley study sites. Soil treatments included Aeration and Biochar application, while irrigation treatments included full irrigation and deficit irrigation. The project evaluated outcomes associated with a limited set of scalable, no till soil management practices that could potentially improve agriculture's resilience to drought.

Results:
In 2023 baseline monitoring was done on the plots and the soil treatment application occurred in late fall. In 2024 one-half of each of the one-acre soil treatment swaths received normal irrigation water throughout the growing season, while the other half of each swath received irrigation water for a limited period through June 15. Soil moisture data was collected along with crop yield and forage quality. Results from the study are:

- Based on the linear model fit to the data collected, at two of the sites deficit irrigation had a negative effect on yields (-0.77 tons/acre) and the biochar-aeration treatment had a limited effect on yield (+0.35 tons per acre)
- At the two other sites, there was no significant effect from deficit irrigation while aeration had the largest effect on yield (-0.83 tons/acre) and biochar-aeration treatment had an expected effect of -0.5 tons per acre.
- The second half of the 2024 irrigation season was wet and rainy and may have affected the deficit irrigation study plots.

Scalability: If future years of the study show more consistent and favorable results these soil treatment techniques could be used in other hay/perineal crop fields.

Lessons Learned: Using non-precision agricultural equipment can affect the variability in application of the biochar and could be influencing some of the variability in the 2024 data analysis. Crop variability most likely impacted the study results even though the fields initially picked were believed to have consistent species mixes. A longer record of baseline conditions at the test plots would help to better understand the observed differences and 2024 results.

DROUGHT RESILIENCY PROJECTS

Precision Irrigation Project

Project Type: Irrigation Efficiency Project
Project Location: Rio Grande County
Grant Amount: $21,820
Producer Type: Cover Crop, Barley and Potato
Irrigation Method: Center Pivot
Identified Water-related Challenge:
Due to the over pumping of an unconfined aquifer and drought, water availability to producers has been reduced. These producers need to find ways to continue to have economic viability for their farms while reducing water use and maintaining vegetative cover year-round to reduce soil erosion and noxious weed problems.

Solution: In 2023 the Rio Grande Conservation District installed a Low Energy Precision Application (LEPA) irrigation system on an a center pivot in the San Luis Valley. LEPA irrigation systems are installed 8-18" from the topsoil, decrease water loss to wind and evaporation, ensuring that 95-98% of pumped water is delivered to the root zone. The LEPA system was tested in both 2023 and 2024 under different crops.

Results: Due to supply chain issues, the LEPA system got installed late in 2023 and was used to irrigate a field of alfalfa. The alfalfa came up thick and used less water compared to other years; however, it is unclear if this was due to the LEPA system or to the increased precipitation that occurred in 2023 in the Valley. In 2024, potatoes were planted in the field and irrigated using the LEPA system. The producer worked with an agronomist on testing the LEPA system and made some modifications to the system because some of the nozzles plugged up. With larger nozzle sizes and different spacing than in 2023, the system showed improvement and no dry rings in the field occurred. The producer put on roughly the same amount of water as a nearby field of potatoes that was also irrigated using a center pivot. Overall, the LEPA system worked well.

Scalability: The LEPA system could be used on other center pivots in the Valley; however, the producer did not plan on implementing it on other center pivots as he did not believe that the pricey cost of the system was offset by water savings.

Lessons Learned: Depending on the water source the nozzle sizes may need to be modified due to plugging. With the high winds in the valley, systems with bigger water droplet sizes may work better as the water is less likely to blow away.