

2024
ANNUAL REPORT

FABIAN GARCIA RESEARCH CENTER

THE NMSU AGRICULTURAL EXPERIMENT STATION SUPPORTS RESEARCH THAT ADDRESSES REAL-WORLD PROBLEMS. RESEARCH IS AT THE CORE OF NMSU'S MISSION TO IMPROVE THE LIVES OF PEOPLE GLOBALLY.

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College of Agricultural, Consumer and Environmental Sciences
Agricultural Experiment Station

Fabian Garcia Research Center

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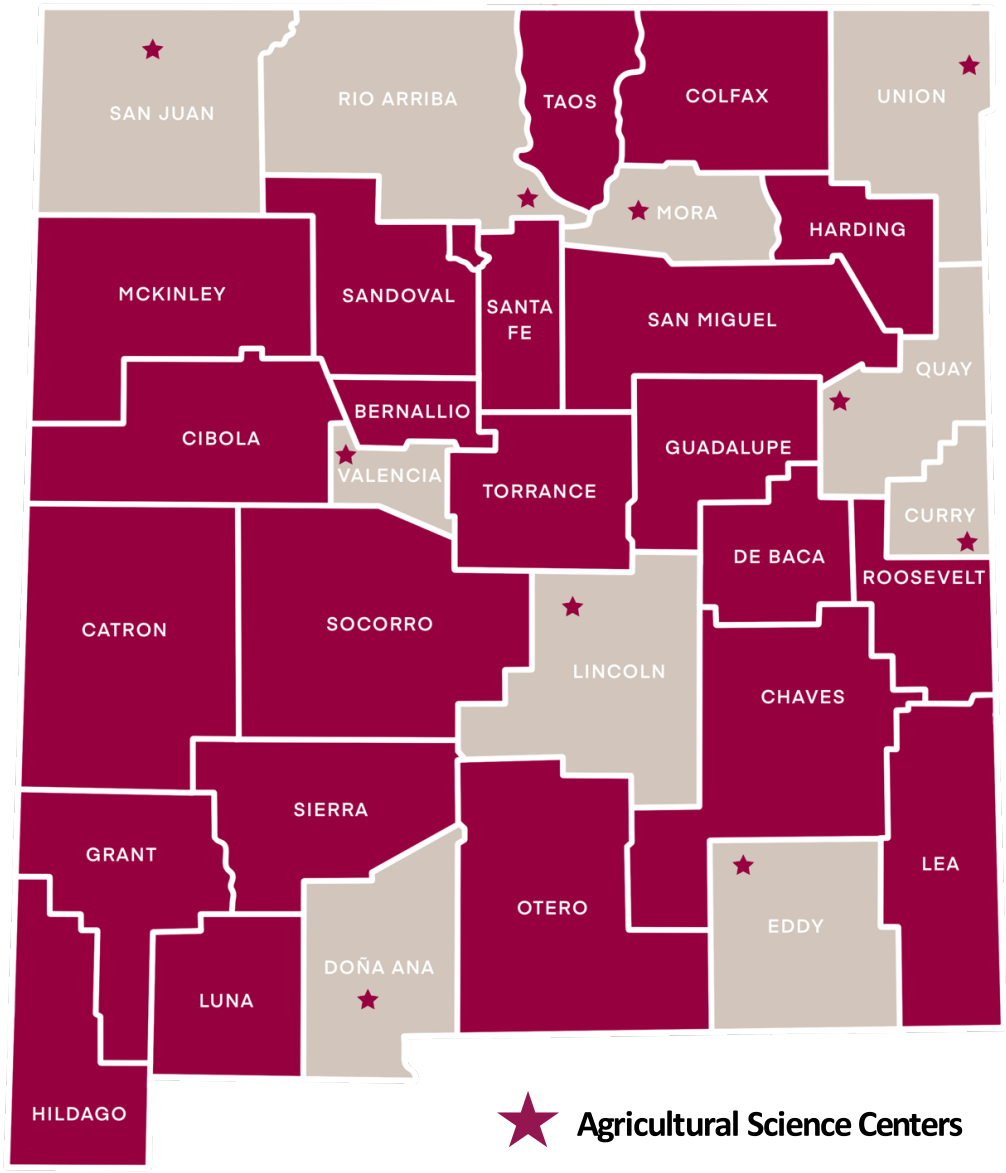
Notice to Users of this Report

These are not formal Agricultural Experiment Station Report research results. The reader is cautioned against drawing conclusions or making recommendations as a result of the summaries in this report. In many instances, data represents only one of several years' results that will ultimately constitute the final formal report.

None of the data are authorized for release or publication without the written prior approval of the New Mexico Agricultural Experiment Station.

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Agricultural Science Center Locations Map



Executive Summary

The Fabian Garcia Research Center supports a diverse variety of agricultural research on 47 acres located less than a mile from the NMSU main campus in Las Cruces. The center hosts research on plant breeding, regionally adapted and alternative crops, water-wise cropping, viticulture, algae for biofuel, sustainable agriculture, soil health and best management practices in its research plots and greenhouses. In addition, a student-run greenhouse hosts growing space for clubs, the Floral Team, the Horticulture Forum, and classes such as greenhouse retailing. The botanical garden and gazebo are community favorites for photographs, events, educational tours, and enjoying the seasonal landscape gardens. The Chile Pepper Institute gift shop and teaching garden offer the community, visitors and educational groups an opportunity to explore chile pepper research, culinary aspects and the cultural significance of chile peppers.

Current research at the Center focuses on plant breeding of drought-resilient varieties of alfalfa, alternative water and drought mitigation resources, onion cultivars resistant to diseases and pests, genetic improvements of chile peppers, including high yielding, open pollinated, disease resistance and mechanization, maximizing algae biomass for biofuel production. Researchers at Fabian Garcia are also are exploring environmentally sustainable agricultural practices, including the use of regionally adapted cover crop mixtures suited for hotter, drier climates, as well as testing alternative, water-efficient crops.

Research Highlights







Onion Genetic Improvement

Investigator: Chris Cramer (cscramer@nmsu.edu)

Project Overview Fusarium basal rot (FBR) is a soil-borne fungal disease that causes a disintegration of the onion bulb killing the entire plant. Onion stakeholders have identified FBR as a severe disease threat to onion yield and economic sustainability. Breeding for host plant resistance to FBR may eliminate the detrimental effects of the disease. Onion germplasm was evaluated for susceptibility to FBR by inoculating onion bulbs with a virulent isolate of the disease-causing pathogen. Onion germplasm was identified that exhibited a lower disease severity than an FBR-susceptible and an FBR-resistant onion cultivar used in the evaluation. Selection for reduced disease severity proved successful as severity has decreased over successive generations of selection.

Meeting the Needs of New Mexico: This research demonstrated that the evaluation method was successful in reliably producing disease symptoms, which is essential for disease resistance development. Germplasm has been developed that expresses lower disease severity because of selection. Researchers have identified in the onion a group of host plant compounds that appear to be involved in conferring resistance to this disease. Selection for these compounds will aid in the development of FBR-resistant onion cultivars. Commercial seed companies can use this information and germplasm to develop FBR-resistant onion cultivars. This will result in improved onion cultivars that growers in New Mexico can use to improve their productivity.

Impact(s): With onion cultivars that are resistant to FBR, fewer onion bulbs will be lost to disease. With fewer bulb losses, fewer acres of onions will need to be grown to satisfy domestic onion demand. Fewer onion acres with higher production reduces environmental impacts while increasing economic sustainability. While the financial impact of FBR on onion bulb yield has not been determined, a conservative estimate of the damage caused by this disease would be a 10% reduction in yield. With the current annual farm gate value of U.S. onion production, this disease could be causing $90-100 million in damages annually. FBR-disease-resistant onion cultivars could eliminate entirely the economic damage caused by disease.



Regeneration of Short-Day Onion Accessions

Investigator: Chris Cramer (cscramer@nmsu.edu)

Project Overview: Numerous short-day onion plant introduction (PI) accessions maintained at the Plant Genetic Resources Unit (PGRU) of Geneva, NY, were in danger of being lost from the U.S. germplasm collection due to sub-standard viability and low seed supply of those accessions. Seed regeneration of short-day onion at Geneva, NY, has been difficult because of improper daylengths and environmental conditions. The onion curator at PGRU sent seeds of 20 onion accessions to NMSU for our program to produce new seed of those accessions. The received seed was sown in growing media in the greenhouse before being transplanted to the field. Those plants produced onion bulbs that went into dormancy. Onion bulbs from the previous year's planting flowered in crossing cages. Pollinators were introduced to those cages, and seed was produced. Once the seed was cleaned, seed of 12 PI accessions was sent to the onion curator in August.

Meeting the Needs of New Mexico: Seed was produced from plant introduction accessions so that this seed can be distributed to onion researchers and breeders throughout the world. Some of these accessions may have important traits or qualities that could have been lost. These accessions could be used by commercial seed companies that develop onion cultivars grown here is New Mexico. These new cultivars will help NM onion growers adapt to changing growing conditions and remain economically competitive and remain a viable agricultural industry.

Impact(s): Seed was produced from plant introduction accessions so that this seed can be distributed to onion researchers and breeders throughout the world. Some of these accessions may have important traits or qualities that could have been lost. Our efforts helped to maintain the viability and effectiveness of the US onion germplasm collection.



Reducing Costs and Improving Environmental Safety of Onion Herbicide Programs

Investigators: Christopher Cramer and Brian Schutte (cscramer@nmsu.edu)

Project Overview: Onion weed management programs benefit from residual herbicides applied at crop seeding. Residual herbicides currently registered for application at onion seeding include Bensulide and DCPA. Applications of both herbicides are relatively expensive and potentially have high environmental impacts. Pendimethalin is less expensive and has a lower environmental risk than Bensulide and DCPA. It is traditionally applied when dry bulb onions have 2 to 9 true leaves. Newer registrations allow for pendimethalin applications after onion germination prior to onion emergence. A post planting, delayed preemergence application of pendimethalin resulted in similar or better control of annual weeds than current weed control methods using Bensuilde and DCPA herbicides or pendimethalin applied at the 2-leaf stage for autumn-sown onions in New Mexico. This same application of pendimethalin did not impact onion stand and bulb yield while also not leaving any detectable residues on onion bulbs after harvest.

Meeting the Needs of New Mexico: A post planting, delayed preemergence application of pendimethalin could provide comparable or better control of annual weeds as currently used herbicides in autumn-sown and winter-sown onions in New Mexico while reducing herbicide costs by 92-95% ($99-$156/acre) and reducing the legacy costs on the environment by 74-88%. This simple switch could save the NM onion industry $1 million per year.

Impact(s): A post planting, delayed preemergence application of pendimethalin could provide comparable or better control of annual weeds as currently used herbicides in autumn-sown and winter-sown onions in New Mexico while reducing herbicide costs by 92-95% ($99-$156/acre) and reducing the legacy costs on the environment by 74-88%. This simple switch could save the NM onion industry $1 million per year.



Characterization of Onion Phenotypes Exhibiting Fewer Iris Yellow Spot (IYS) Symptoms and Release of Onion Germplasm for IYS Mitigation

Investigator: Chris Cramer

Project Overview: Onion stakeholders have identified onion thrips and *Iris yellow spot virus* as the greatest pest and disease threats to onion yield and economic sustainability. The onion industry in the US is valued at farm gate annually at $900-1,000 million. Onion germplasm is being developed and evaluated that is less impacted by onion thrips and Iris yellow spot. When exposed to high onion thrips pressure and conditions conducive for Iris yellow spot disease development, NMSU breeding lines exhibited fewer thrips per plant and a lower disease severity early in the growing season, and greater bulb size at harvest than a commercial cultivar grown under the same conditions.

Meeting the Needs of New Mexico: Past research from our program has demonstrated that our evaluation method was successful in reliably producing disease symptoms that are essential for disease resistance development. Germplasm has been developed that expresses lower disease severity as a result of selection. Our target audience can use this information and germplasm to develop disease-resistant onion cultivars. Based upon a conducted economic analysis, onion germplasm resistant to onion thrips and/or IYS could increase profits by $1,000 per ha per year when compared with current marketable yields and management practices. Based on the annual hectarage of onions grown in New Mexico, the promising resistant breeding lines from our program could increase grower profits for the NM onion industry by $2.7 million.

Impact(s): With onion cultivars that are resistant to onion thrips and Iris yellow spot, fewer onion bulbs will be lost to diseases and pests. With fewer bulb losses, fewer acres of onions will need to be grown to satisfy domestic onion demand. Fewer onion acres with higher productivity reduces environmental impacts while increasing economic sustainability.



Onion Seed Production

Investigator: Chris Cramer

Project Overview: The Texas A&M University onion breeding program was having difficulty producing onion seed for many of their germplasm lines. Bulbs of these lines were sent to NMSU for seed production. Once those bulbs broke dormancy, they were planted in the field for seed production for the following year. Once bulbs flowered in crossing cages, pollinators were introduced to those cages and seed was produced. Once the seed was cleaned, seed of 39 different breeding lines was sent to the director of the Texas A&M University onion breeding program.

Meeting the Needs of New Mexico: In addition to NM, Texas also grows short-day onions. Some of the same cultivars are grown in both states. It is possible that cultivars developed by the Texas A&M Univ. onion breeding program could be grown in New Mexico and benefit NM onion growers in being competitive in the US onion market.

Impact(s): The seed production here in NM provided the director of the Texas A&M University (TAMU) onion breeding program sufficient quantities of viable seed of TAMU onion breeding lines so that their program could continue to advance their breeding objectives. Without this seed production, their breeding objectives may have been delayed due to their inability to produce sufficient quantities of onion seed on their own.

Optimizing Mechanical Harvesting of Fresh-Market Bulb Onions in New Mexico

Investigator: Chris Cramer

Project Overview: For New Mexico, onions are an important high value agricultural commodity that brings revenue to the state. In order for the NM onion industry to remain economically viable, the current hand harvesting methods need to be replaced with mechanical harvesting due to high costs and limited availability of hand labor. Short-day overwintering onion cultivars, that are suitable for mechanical harvesting without suffering damage, will make this transition possible. This study identified several onion cultivars with varying maturities that possess higher levels of bulb firmness than other cultivars and may be suitable for mechanical harvesting by sustaining less bulb damage during the harvesting process.

Meeting the Needs of New Mexico: Currently, the NM onion industry is an important agricultural commodity to the state with an estimated economic value of $100-130 million annually. In the past, the entire onion crop in the state was harvested by hand. In order to save money on labor costs, mechanical harvesting of onions has been tried with limited success. Damage to onion bulbs and subsequent decay has limited the use of mechanical harvesting. As the availability of farm labor continues to decrease and the cost of farm labor continues to increase, a switch to the mechanical harvesting of all onions in New Mexico will be needed. For this switch to be successful, mechanical harvesting of onions in New Mexico needs to be optimized. For this optimization to be realized, more research work is needed to evaluate short-day overwintering onion cultivars that are more suited for mechanical harvesting by suffering less mechanical damage.

Impact(s): In order for the NM onion industry to remain economically viable, the current hand harvesting methods need to be replaced with mechanical harvesting due to high costs and limited availability of hand labor. In order for that transition to occur, short-day overwintering onion cultivars, that are suitable for mechanical harvesting without suffering damage, need to be grown. This study identified several onion cultivars with varying maturities that possess higher levels of bulb firmness than other cultivars and may be suitable for mechanical harvesting by sustaining less bulb damage during the harvesting process. These cultivars could make the transition to mechanical harvesting more economically feasible.

Evaluation of Intermediate-Day Onion Hybrids

Investigators: Chris Cramer

Project Overview: The Enza Zaden seed company wanted to evaluate some promising proprietary intermediate-day hybrid onion lines in an environmental with high soil-borne disease pressure for onions. Seed was planted and plants were grown to maturity. At harvest time, bulbs in the plots were rated for pink root disease severity and overall root health. Bulbs were stored for 21 days after which the basal plates of 20 bulbs were cut and rated for Fusarium basal rot disease development. Several hybrid lines showed promise as having few soil-borne disease issues.

Meeting the Needs of New Mexico: By assisting Enza Zaden in the evaluation of promising hybrid onion lines for disease resistance, the development of hybrid onion cultivars may be hastened and so that they make it to the market sooner. These promising hybrid cultivars may help NM onion growers remain competitive in the US onion market.

Impact(s): Our breeding program assisted the Enza Zaden onion breeding program in identifying proprietary intermediate-day hybrid onion lines that expressed high levels of resistance to onion soil-borne diseases. This identification may help to expedite the development of onion cultivars that can help NM onion growers remain competitive in the US onion market.

Reinvigorating Chile Production in NM through Variety Development, Mechanization, and Flavor Profiling

Investigators: Stephanie Walker, Danise Coon, and Israel Joukhadar

Project Overview: This project will amplify long-term breeding efforts in developing new cultivars and germplasm, emphasizing mechanization and other traits critical for New Mexico's chile crops. Breeding priorities will continue in all the major NM chile pepper crops. Replicated mechanical harvest trials will continue for the evaluation of NM-type green chile breeding lines developed for harvest efficiency. New breeding lines developed from the best of these lines that have been introgressed with novel easy destemming traits provided by germplasm from researchers at UC Davis will be pursued, with the end goal of mechanically harvested destemmed green fruit with the pedicel remaining attached to the plant. Also, with the procurement of a new gas chromatograph equipped to measure flavor volatiles, NM-type chile flavor will be characterized, and advanced breeding lines will be analytically tested to ensure that flavor profiles are aligned with the preferred NM-type green chile flavor that brings fame to our signature crop. NM-type red chile and paprika breeding lines will be further developed, emphasizing high levels of pigmentation (ASTA), high dry yield, desired heat level, and preferred smooth-drying characteristics. In addition to more efficient dehydration, these smooth-drying breeding lines will provide useful 'red after green' niche cultivars. Finally, efforts will continue to develop open-pollinated cayenne cultivars and germplasm that provide yield, heat, and soluble solids equivalent or greater than that of the current standard hybrid cultivars. Initial efforts at breeding mechanical harvest-efficient cayenne cultivars will be continued.

Meeting the Needs of New Mexico: New Mexico's chile crops are widely renowned for flavor and quality, but acreage in the state is well below the peak seen in the mid-1990s. A key reason for decreased New Mexican chile acreage is the lack of and expense of hand labor. Development of new cultivars and germplasm that are efficient for mechanical harvest, provide increased yield, and possess improved qualities prized by growers, processors, and consumers will put New Mexico's chile crops on a more competitive path with other producing countries and ensure the long-term strength of the industry in the state. Flavor is a key quality parameter that is overwhelmingly cited as the reason for NM-type chile's popularity; however, NMSU lacks the equipment needed to measure and describe the unique volatile compounds that, taken together, account for NM-type chile flavor. Evaluation of breeding lines has relied on taste testing, an imprecise method to ensure that breeding lines with new genetics maintain the critical, favored flavor profile. Through the purchase of a gas chromatograph–mass spectrometer equipped with a 'sniff port' (GC-MS-O), breeding efforts will be enhanced and NM-type chile flavor will be categorized. Research findings will be critical to publicizing and protecting the local production of NM-type chile. Describing and publicizing the unique flavor and quality of NM-type chile will increase demand for the product, and implementing mechanization will allow NM growers to keep up with demand even with continuing labor challenges.

Impact(s): Currently, New Mexico growers are dealing with continued labor shortages, adverse growing conditions, water demand, and expensive seed. Describing and publicizing all of the improved qualities and the unique flavor of open-pollinated NM-type chile will increase demand for the product, and implementing mechanization will allow NM growers to keep up with demand even with continuing labor challenges.





Development of Improved Chile Cultivars for New Mexico Growers

Investigators: Stephanie Walker, Danise Coon, and Israel Joukhadar

Project Overview: The NMSU Extension Vegetable Program continues its breeding efforts to develop chile pepper cultivars while listening to and implementing the needs of our growers. Disease resistance, high yielding, flavor and mechanization remain the main focuses of the program. Development of new chile pepper cultivars that are adapted to local growing conditions and improved in yield and key quality attributes is critical for the support of chile pepper production in the state.

Meeting the Needs of New Mexico: New Mexico's chile crops are widely renowned for flavor and quality, but acreage in the state is well below the peak seen in the mid-1990s even as chile pepper consumption in the US continues to increase. Development of new cultivars and germplasm that are efficient for mechanical harvest, provide increased yield, and possess improved qualities prized by growers, processors and consumers will put New Mexico's chile crops on a more competitive path with other producing countries and ensure the long-term strength of the industry in the state. Flavor is a key quality parameter that is overwhelmingly cited as the reason for NM-type chile's popularity; however, NMSU lacks the equipment needed to measure and describe the unique volatile compounds that taken together account for NM-type chile flavor. Evaluation of breeding lines has relied on taste testing, an imprecise method to ensure that breeding lines with new genetics maintain the critical, favored flavor profile. Through the purchase of a gas chromatograph–mass spectrometer equipped with a 'sniff port' (GC-MS-O) breeding efforts will be enhanced and NM-type chile flavor will be categorized. Research findings will be critical to publicizing and protecting local production of NM-type chile. Describing and publicizing the unique flavor and quality of NM-type chile will increase demand for the product, and implementing mechanization will allow NM growers to keep up with demand even with continuing labor challenges.

Impact(s): With chile pepper cultivars that can produce high yields in adverse climates, are good candidates for mechanization and fill a unique and culturally significant piece of New Mexico Agriculture, growers can fulfill industry and community demand. The research and breeding outcomes of this cultivar development program benefit growers, processors, and ultimately the consumer.



Genetic Improvement of Alfalfa Germplasm for New Mexico

Investigators: Christopher Pierce and Dr. Ian Ray (retired August 2023)

Project Overview: Through a multi-year project, a field survey of New Mexico alfalfa fields was conducted to evaluate the impact of varied management with and without insecticide applications on the natural enemy community. Moreover, field cage studies were conducted in alfalfa to evaluate how changes in the natural enemy community's impact pest suppression.

Meeting the Needs of New Mexico: Broad-spectrum insecticides are traditionally used to suppress alfalfa insect pests but have unintended consequences on natural enemy populations like predatory insects that provide natural pest control. Increased natural enemy diversity has been shown to provide improved pest suppression, and different species and their life stages contribute to pest suppression. Therefore, conservation of natural enemies can provide a benefit to New Mexico alfalfa growers.

Impact(s): Broad-spectrum insecticides are traditionally used to suppress alfalfa insect pests but have unintended consequences on natural enemy populations like predatory insects that provide natural pest control. Through a field survey across alfalfa fields in New Mexico, we determined that insecticide treatments for alfalfa pests early in the season showed a decline in the abundance of natural enemies compared to untreated fields. These changes for some species altered the timing of nymphal life stages and their presence to contribute to pest suppression. A cage study in alfalfa also revealed that increasing natural enemy diversity can lead to improved pest suppression. Pairing adult and nymphal natural enemy life stages alone, however, may also contribute to improved pest control. Gaining a better understanding of the contribution of natural enemies on pest suppression and the impacts of crop management on the conservation of natural enemies provides a foundation for improved management strategies.



Guar Research

Investigator: Kulbhushan Grover

Project Overview: The goal of the research is to evaluate the growth and performance of guar and its agronomic management. A collaboration between NMSU and the US salinity lab looks at salt tolerance in guar genotypes. These genotypes had been evaluated for their field performance at Fabian Garcia Science Center.

Meeting the Needs of New Mexico: Guar is a drought-tolerant crop that can provide an alternative option for local growers in the region. It can be grown for seed to produce guar gum; as a legume forage; or for fresh green beans.

Impact(s): Identifying alternate crops that can grow with minimum irrigation water, reduce inputs, improve soil quality, and provide economically sustainable returns to the growers of the region is important. Guar research at NMSU has shown that guar can be successfully grown in New Mexico conditions and can help reduce reliance on imports (estimated US guar imports in 2012 $1 billion) to meet the needs of the US gas and oil industry. Program efforts have created awareness and interest among clientele in domestic guar production and led to requests for farmer field demonstrations in Dona Ana County.



Genetic Improvement of Chile Peppers in New Mexico

Investigators: Dennis N. Lozada, Seyed Shahabeddin Nourkbakshsh, Ehtisham Khokhar, and Muhammad Ibrar Khan

Project Overview: The high cost of manual harvesting has become a significant challenge in chile pepper production in New Mexico. Identifying molecular markers associated with mechanical harvestability traits is a crucial step toward developing cultivars for mechanical harvesting. Segregating families of chile pepper derived from crossing 'NuMex Odyssey' and 'NuMex Heritage Big Jim' have been evaluated and selected for mechanical harvestability traits and will be genotyped using DNA markers. By leveraging phenotypic and genomic information, breeding and selection efforts can be optimized to enhance mechanical harvest potential.

Meeting the Needs of New Mexico: By using genomics-assisted breeding to identify markers linked with mechanical harvestability, improved cultivars suited for mechanization can be developed, decreasing the reliance on traditional hand harvest and reducing the costs associated with manual labor. This can result in a more stable and reliable income to New Mexican growers and producers.

Impact(s): In recent years, chile pepper production in New Mexico has been affected by the high labor costs associated with manual harvest and the increasing inaccessibility to skilled manual harvesters. Given such current production constraints, the development of chile pepper cultivars amenable to machine-driven harvest is important for the state, where chile peppers are regarded to be a major cultural and economic crop. Knowledge on the genetic determinants of traits related to mechanical harvestability will provide robust breeding and selection decisions for genetic improvement. Growers and stakeholders will benefit from the development of mechanically harvestable cultivars through marker-assisted breeding and selection.



Preparing Future Professionals in Fisheries and Aquaculture for Positions in USDA

Investigators: Wiebke Boeing**,** Kevin Fitzsimmons (UA), Charlie Shultz (SFCC), Rossana Sallenave (NMSU)

Project Overview: In 2004, we successfully completed 2 experiments.
We found that low (0.5 kg m-3) fish density is sufficient for aquaponic systems if the sole purpose is to *produce plant/crop biomass. Medium (1.5 kg m-3) fish density would optimize simultaneous fish biomass production. Fish mortality was significantly increased and both water quality and plant* production decreased at high (2.5 kg m-3) fish density.
Furthermore, a comparison of four commercial fish feeds found that 'Optimal Aquaponic Fish Food' was the preferred fish feed.
Two graduate students and a dozen undergraduate students were involved in aquaponic research in 2024.

Meeting the Needs of New Mexico: In addition to conducting valuable research on increasing sustainability of agriculture in the Southwest, I am currently training 3 graduate students and 12 undergraduate students in aquaponic systems and research in my laboratory. My students reflect the diversity of the state of New Mexico. Overall, I am supporting 15 students, which includes one veteran. Of these 15 students, six are male and nine female and five are white, eight Latino, one Asian-American, and one international.

Impact(s): Over this past year, I established an aquaponic research facility at New Mexico State University with 16 simple-to-operate flood-and-drain systems. Aquaponics is a way to simultaneously grow fish and crops with minimal land and water usage. We are currently researching how to optimize our systems and further increase sustainability. 15 students have learned how these aquaponic systems function and need to be maintained and have been trained how to properly conduct research experiments.

Expanding Organic Systems to Reduce Water Demand and Increase Agricultural Resilience in the Southwest

Investigators: Ivette Guzman, Alexander Fernald, Connie Maxwell, Kevin Lombard, Jay Lillywhite, Robert Heyduck

Project Overview: Funded by a USDA Organic Transitions grant, the project will identify pathways to agricultural resilience for arid and semi-arid small farms. High value crops with medicinal properties are being cultivated using organic farming practices. Nine plant species were grown for one year and will be monitored for establishment, yield, growth traits, and quality for the next two years. First year data indicates that calendula (*Calendula officinalis)* and marshmallow (*Althaea officinalis*) were successful at establishment after transplanting seedlings in May 2024. Calendula medicinal flowers were harvested from August to December.

Meeting the Needs of New Mexico: Water scarcity is one of the largest challenges to agricultural resilience in the increasingly arid Southwest. An important question is if expanding organic systems can support small farms to achieve the water demand reductions needed to preserve cultivation across agricultural valleys while also achieving overall agricultural resilience. Organic systems could be critical for resilience, and our project will identify crops and practices that are culturally relevant to small farmers in the southwest. In addition, this project will offer cultivation practices for medicinal plants.

Impact(s): The impact will address organic priorities set by USDA and will improve strategies and models to optimize water use and crop production in the southwest. High value crops that perform well and use less water will be characterized and this work will be disseminated regionally and nationally, and the study will be published in a peer-reviewed article.

Using Cover Crops in Transitioning from Traditional Agriculture to Climate-Adaptive Organic Farming in the Southwestern US

Investigators: Richard C. Pratt, Koffi Djaman, Brian Schutte, Kevin Lombard, Michael Patrick

Project Overview: In 2024, we assessed four grasses and four legumes as summer cover crops at the Fabian Garcia Research Center to determine which species are best suited to restricted irrigation during the summer. The following data were collected: soil moisture, aboveground cover crops and weed biomass, and weed index (calculated from cover crop and weed biomass). The findings demonstrated that minimal irrigation was sufficient to produce a good biomass of cover crops. Compared to the other cover crops, the two types of Sorghum-Sudangrass produced greater aboveground dry biomass and showed outstanding weed suppression, followed by Sunn hemp.

Meeting the Needs of New Mexico: Identifying summer cover crops that could reduce irrigation water consumption, suppress weeds, and improve soil health will help increase ecosystem services and decrease irrigation water use on farms in New Mexico. Our findings contribute to improved sustainable farming practices for farmers, particularly those wishing to transition to climate-adaptive organic farming. Farmers in New Mexico can employ our chosen summer cover crops to lower irrigation and weed management expenses while improving ecosystem services on their farms.

Impact(s): This project will lead to:

- Reduction in irrigation water use for summer cover crops production
- Reduced costs for weed management in sustainable cropping systems
- Enhanced ecosystem services
- Improved options for transition to organic farming in the southwestern US
- Greater availability of summer forage crop options for livestock in the southwestern US



Effects of Root and Mycorrhizal Traits on Native Plant Performance Under Drought

Investigator: Magda Garbowski

Project Overview: Drought hinders the establishment of plants in dryland restoration projects. Restoration practitioners have begun to add mycorrhizal fungi to restoration planting in an attempt to improve plants' abilities to access nutrients and water. However, we do not yet know if mycorrhizae do indeed improve dryland plant performance or which species benefit most from mycorrhizal inoculation. We are working with 24 native species of grasses and forbs commonly used in restoration throughout the southwestern United States to (1) determine if mycorrhizal inoculation improves plant survival under drought and (2) identify which restoration species benefit most from mycorrhizal fungi.

Meeting the Needs of New Mexico: Ecological restoration is the process of assisting the recovery of ecosystems that have been damaged, degraded, or destroyed. Across New Mexico ecosystems are being impacted by decades or drought, wildfires, and other forms of degradation. Because of this, effective restoration is needed to reestablish ecosystem functions and services to degraded ecosystems. Our research aims to identify which native plant species benefit most from mycorrhizal inoculation with the overarching aim of improving restoration outcomes across New Mexico.

Impact(s): Our research will help land management agencies such as the Bureau of Land Management and the National Resource Conservation Service as well as ranchers, private landowners, and native seed producers determine which native plant species are most reliant on mycorrhizae in arid landscapes. With this information, restoration practitioners will be better able to plan which species to seed with inoculants and which will succeed without these amendments. More efficient restoration practices will support healthy dryland ecosystems and result in the long-term provisioning of ecosystem services including forage for livestock, soil stability to reduce erosion, and wildlife habitat to support hunting.

Assessing Which Functional Traits Improve Population Performance Under Different Soil Textures and Drought

Investigators: Magda Garbowski and Sara Fuentes-Soriano

Project Overview: The magnitude of water stress plants experience is influenced not only by precipitation but also by soil texture. With this research we aim to clarify how plant functional traits, or morphological, physiological, and phenological characteristics of plants, interact with drought and soil texture to influence plant performance. We are using 15 different populations of *Bouteloua curtipendula* (Sideoats grama) to determine: (1) how leaf and root functional traits vary among *B. curtipendula* populations, (2) how traits respond to different soil textures and drought conditions, and (3) how traits influence plant performance in these different conditions.

Meeting the Needs of New Mexico: Across New Mexico ecosystems, vegetation is being lost due to decades of persistent drought. Reestablishing key plant species which can provide forage for livestock, habitat for wildlife, and erosion control is essential to restoring degraded ecosystems across the state. Without effective and successful revegetation efforts, rangelands across the state will continue to succumb to degradative forces beyond with recovery to well-functioning states that support grazing and other industries is unlikely.

Impact(s): This research will clarify which populations of an important native grass, Sideoats grama, perform best in which soil textures and under drought conditions. This research aids land management agencies such as the Bureau of Land Management and the National Resource Conservation Service as well as ranchers, private landowners, and native seed producers in determining which populations of Sideoats grama are likely most suited for growth in specific soil textures and which populations are most resilient to drought.

Cotton Breeding

Investigator: Jinfa Zhang

Project Overview: Cotton is the world's leading fiber crop, and high-quality fibers command high cotton prices. In addition, cottonseed also produces 14-19% of farm-gate value from cotton production. Elevating cotton to a more important food crop for human consumption through improving seed oil content and quality can significantly increase the net income for cotton producers and cottonseed processers. The cotton breeding program seeks to develop cotton cultivars and elite lines with high yields, premium fiber quality, enhanced cottonseed oil and fatty acids, and resistance to biotic and abiotic stresses through conventional and introgression genetics and breeding approaches. Genetic and genomic tools are being used to identify genes responsible for desirable traits used in breeding.

Meeting the Needs of New Mexico: New Mexico cotton production brings significant economic value to the agricultural industry. Many producers and farm workers are dependent on cotton production. During the biotechnology age, when more than 97% of the US cotton acreage is grown to genetically modified (GM) cotton, there are NM farmers, including organic cotton producers, who are still growing NMSU-bred non-GM cotton varieties. Therefore, developing non-GM cotton varieties with high lint yield, premium fiber quality, stress tolerance, and added value from cottonseeds for NM cotton producers is important to NM agriculture.

Impact(s): New Mexico planted 66,000 acres of Upland cotton and produced 993 pounds of cotton lint per acre in 2022. The current cotton price stands at $0.87 per pound. When a new high-yielding cotton cultivar increases yield by 10%, NM cotton growers can increase their productivity by 100 pounds per acre with no additional production cost. When 20% of the cotton acreage is grown to the new cultivar, New Mexico cotton growers will increase net income by $11.5 million. Cottonseed with high cottonseed oil quantity and quality will further increase their production revenues. Cotton with resistance to abiotic and biotic stresses will reduce production cost and loss from insects, diseases, and drought stress.



Enhancing Microbial Recruitment and Persistence in Cover Crop Mixtures for Control of Soilborne Pathogens in Chile Pepper

Investigators: S. Sanogo, Q. Dobey, J. Fechner, P. Lujan, J. Barraza, and J. Consford

Project Overview: Experiments were initiated to compare microbial biomass in the following cover crops: 1) one-species, Triticale (variety Luoma), and 2) a 7-species winter mix (forage pea, hybrid kale, clover, brown flax, common vetch, balansa clover, hairy vetch, winter triticale, and rapeseed). Microbial biomass was lower in soil collected before planting and increased after planting of the cover crops. The increase in microbial biomass was comparable across the Triticale cover crop and the 7-species cover crop mixture. However, after application of a biological mixture, there was a greater increase in microbial biomass in the Triticale than in the 7-species cover crop mixture. These results suggest that cover cropping helps recruit microbial populations and increase soil total microbial biomass.

Meeting the Needs of New Mexico: Various producers within the chile industry in New Mexico are exploring cover crops as a way of establishing microbial balance in soil to reduce the impact of soilborne pathogens. Discussions have centered on how to achieve this microbial balance by applying biologicals in cover crops several years before chile. A commonly adopted practice is the use of cover crop mixtures, with two or more plant species. The composition of the mixtures may affect the establishment and persistence of the beneficial microbes. This project is directly relevant to the needs of the NM chile industry and to NM agriculture and citizens.

Impact(s): This project focuses on the needs of the chile pepper industry and NM agriculture. Results from the project provide information that will help producers make a decision on adopting cover cropping as a tool to increase microbial biomass in soil. Microbial biomass is an important component of soil health. All efforts to enhance soil microbial biomass will help maintain and enhance soil health, and thereby improve crop productivity and increase monetary returns to producers and processors.



Effects of Soil Amendments and Environmental Stresses on Microbial Diversity, Nutrient Availability, and Chile Growth

Investigators: Xiufen Li (PI), Stephanie Walker (Co-PI), April Ulery (Co-PI), Jose Ortega-Carranza, Barbara Hunter, and Danise Coon

Project Overview: Sustainable chile pepper farming in arid regions like New Mexico faces challenges such as water scarcity, soil salinity, and low organic matter. Soil microbes are vital for supporting plant health by breaking down organic matter, cycling nutrients, and protecting plants from diseases. Changes in microbial diversity can indicate how farming practices or environmental shifts impact crops. This project explores how chile plants interact with microbes under stress from drought, salinity, and organic treatments. The findings aim to help farmers develop stress-resistant chile varieties and improve farming methods. It also provides hands-on learning for students in soil science at NMSU.

Meeting the Needs of New Mexico: This project supports New Mexico's chile pepper industry by addressing challenges like drought, salinity, and soil health. Research on plant-microbe interactions will help develop stress-resistant chile varieties and sustainable farming practices, boosting crop yields and farmer profits. It also benefits local education by providing NMSU students with hands-on training in soil science, preparing future agricultural leaders to meet the state's needs.

Impact(s): This project tackles key challenges in New Mexico's chile industry, such as water scarcity, salinity, and declining soil health. By exploring soil microbe and chile plant interactions under stress, it aims to develop strategies for resilient crops, improved soil health, and sustainable farming practices. These efforts will boost yields and support farmers' livelihoods. Additionally, the project enhances education by offering NMSU students hands-on training in soil science, preparing them to address real-world agricultural challenges and contribute to New Mexico's agricultural sustainability.



Transition to Numbers Page

By the Numbers





Research Publications

- Schutte, B. J., C. Cramer, S. Walker. 2023. Delayed preemergence applications of pendimethalin in New Mexico onion. National Allium Research Conference
- Schutte, B. J., C. Cramer, S. Walker. 2023. Delayed preemergence applications of pendimethalin in New Mexico onion. Proceedings of the 76th Annual Meeting of the Western Society of Weed Science 76:16
- Sharma, S. and C.S. Cramer. 2023. Selection progress for resistance to Fusarium basal rot in short-day onions using artificial inoculation mature bulb screening. Horticulturae 9:99. https://doi.org/10.3390/horticulturae9010099.
- 1.Echenique-Subiabre, I., J. Greene, A. Ryan, H. Martinez, M. Balleza, J. Gerber, A. Jebali, S. Getto*, C.J. O'Kelly, S. Mandal, J.C. Quinn, S.R. Starkenburg, A.A. Corcoran, J.B. Shurin. 2023. Local Conditions Override Broad Climatic Gradients in Determining Microalgae Productivity in Open Raceway Ponds. Algal Research 103235. https://doi.org/10.1016/j.algal.2023.103235.
- 2.Sanchez, M.R., E. Denning, T. Biondi, B. Hovde, S. Eacker, S. Getto*, H. Kaur, A. Jebali, I. Echenique-Subiabre, M. Green, J. Gerber, B. Auch, F.O. Holguin, I. Liachko, H. Martinez, M. Balleza, J. Nalley, C.O' Kelly, J.B. Shurin, A.A. Corcoran, S.R. Starkenburg. 2023. Development of a field-deployable qPCR assay for real-time pest monitoring in algal cultivation systems. Algal Research 103194. https://doi.org/10.1016/j.algal.2023.103194.
- 3.Sanchez, M.R., T.C. Biondi, Y.A. Kunde, W. Eng, J.O. Nalley, E. Ganuza, B.T. Hovde, A.A. Corcoran, S.R. Starkenburg. 2022. The genome sequence of algal strain Nannochloropsis QH25. Microbiology Resource Announcements 1(12):e0092122. https://doi.org/10.1128/mra.00921-22.
- 4.Jebali, A., M.R. Sanchez, E.R. Hanschen, S.R. Starkenburg, and A.A Corcoran. 2022. Trait drift in microalgae and applications for strain improvement. Biotechnology Advances 60: 108034. https://doi.org/10.1016/j.biotechadv.2022.108034
- Sharma, S. and C.S. Cramer. 2023. Reduced Iris yellow spot symptom expression in the selected germplasm. Vegetable Research 3: 26. https://doi.org/10.48130/VR-2023-0026.
- Wood, J.B., C.S. Cramer, R. Steiner, R. Heerema, B.J. Schutte, and I. Guzman. 2023. Onions selected for reduced symptom expression of Iris yellow spot have higher photosynthetic rates. HortScience 58:254-258. https://doi.rog/10.21273/HORTSCI16878-22.
- Boote, K.J., G. Hoogenboom, S. Ale, C. Adams, R. Shreshta, R. F. Mvuyekure, S.K. Himanshu, K. Grover, and S. Angadi. 2023. Adapting CROPGRO model to simulate growth and yield of guar, *Cyamopsis tetragonoloba* L, an industrial legume crop. *Industrial Crops & Products*, 197, 1-17.
- Garcia, A., K. Grover, D. VanLeeuwen, B. Stringam, and B. Schutte. 2023. Growth and performance of guar (Cyamopsis tetragonoloba (L.) Taub.) genotypes under various irrigation regimes with and without biogenic silica amendment in Arid Southwest US. Plants. 12, 2486. https://doi.org/10.3390/plants12132486

Grants and Contracts

Christopher Cramer

- Regeneration of short-day onions, National Plant Germplasm System, ARS, USDA, $126,376 (2019-2024).
- NMDA Specialty Crop Block Grant Program, $62,843 (2021-2024)
- Characterization of onion phenotypes exhibiting fewer Iris yellow spot (IYS) symptoms and release of onion germplasm for IYS mitigation, Washington State Univ., $543,555 (2018-2023)

Stephanie Walker

- ChIP - 2 yr total**:** $476,000
- NMCA – 1 year: $15,000

Ian Ray/Chris Peirce

- Hatch project 7001870-NMRAY22H

Kulbhashan Grover

- HATCH, USDA
- Broadening Agricultural Science Education: A FL-TX-NM Consortium, NIFA, $292,000.

Dennis Lozada

- USDA Hatch Capacity Grant – 5years – $477,074
- Dr. Paul W. Bosland Endowment Fund

Wiebke Boeing

- USDA – NIFA – 3-year – $390,712

Ivette Guzman

- NIFA-ORG – 2 years - $750,000

Richard Pratt & Brian Schutte

- USDA/NIFA - $744,971

Magda Garbowski

- ACES Chile Award - $60,000

Soum Sanogo

- NMCA – 2years - $40,000

Ricardo Ramirez

- USDA/NIFA – 3years-$382,620

Sophia Xiufen

- ACES Chile Award – 2 years- $ 60,000

Outreach Activities

- Fabian Garcia Science Center Field Day
- Onion Day
- Chile Pepper Institute Teaching Garden
- State 4-H Conference
- Chile Pepper Institute Chile Camp for High School Students
- Numerous Chile Tasting Classes hosted by the Chile Pepper Institute
- Dona Ana County and Southern New Mexico State Fair meetings
- WSARE Workshop











People





Cooperators and Collaborators

NMSU

- I. Joukhader
- D. Coon
- B. Schutte
- C. Cramer
- S. Walker
- C. Pierce
- K. Grover
- I. Guzman
- R. Heyduck
- A. Mesbach
- C. Robbins
- S. Salmasi
- S. Sanogo
- S. Nourkbakshs
- E. Khokhar
- M. Khan
- E. Lehnhoff
- R. Ramirez
- R. Larsen
- S. Bernhardt
- A. Mostafa
- E. Khokhar
- M. Ibrar Khan
- W. Boeing
- K. Fitzsimmons
- C. Schultz
- R. Sallenave
- S. Fuentes-Soriano
- M. Patrick
- K. Pjaman
- A. Fernald
- L. Xiufen Li
- A. Ulery
- J. Ortega-Carranza
- B. Hunter
- Q. Dobey
- J. Fechner
- P. Lujan
- J. Barraza
- J. Consford

Other University

- Colorado State University (Fort Collins, CO)
- University of Arizona
- Texas A&M University
- Utah State University
- Michigan State University
- UC Davis
- Oregon State University
- Arkansas State University

State

- Los Alamos National Laboratory (Los Alamos, NM)
- New Mexico-WRRI
- NM Bureau of Land Management

Federal

- Rebecca Povilus, USDA Onion Curator, Geneva, NY
- USDA-ARS, Southwestern Cotton Ginning Lab
- USDA-ARS, Crop Genetics Unit
- USDA/ARS, Riverside CA
- BASF
- USBR-BGNDRF

Industry

- Multiple Alfalfa Seed Companies.
- NM Hay Association
- Cyanotech Corporation (Kailua-Kona, HI)
- Phase Genomics, Inc. (Seattle, WA)
- Qualitas Health, Inc. (Imperial, TX)
- New Mexico Chile Association
- El Paso Water
- Ward Laboratories
- Los Pablanos Historic Inn and Organic Farm
- High Desert Jujube Coop
- Gillis Farms
- Paul Neher- Retired Electrical Engineer
- Cotton Inc.

ASC Personnel

- Dave Lowry, Program Operations Director
- Anthony Aranda, Farm Ranch Manager
- Autumn Martinez, Administrative Assistant
- Dawson Moon, Assistant Farm Manager
- Danise Coon, Research Coordinator
- Liberato Valdes, Senior Laborer
- Florencio Flores, Laborer