New Mexico State University

2017 Annual Progress Report

Agricultural Science Center at Farmington

June 2018

'2017 third shortest growing season of 130 days since 1969.'

Snowfall 18 May 2017.
Agricultural Science Center - Farmington

Notice to Users of this Report

This report has been prepared as an aid to the Agricultural Science Center – Farmington researchers in analyzing the results of the various research projects during the past year and for recording pertinent data for future reference. This is not a formal Agricultural Experiment Station Report of research results.

Information in this report represents results from only one year's research. Readers are cautioned against drawing conclusions or making recommendations because of data in this single year report. In many instances, data in this report represents only one of several years of research results that will constitute the final formal report. It is pointed out that researchers have made every effort to check the accuracy of the data presented.

This report was not prepared as a formal release. Therefore, none of the data or information herein is authorized for release or publication without the written approval of the New Mexico Agricultural Experiment Station.

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Fifty-first Annual Progress Report for 2017

New Mexico State University
Agricultural Science Center – Farmington
P. O. Box 1018
Farmington, NM 87499 - 1018

Permanent Faculty and Staff

Kevin Lombard
Superintendent, Associate Professor

Michael K. O'Neill
Professor Emeritus

Koffi Djaman
Assistant Professor

Samuel Allen
Agricultural Research Scientist

Margaret M. West
Agricultural Research Scientist

Desiree Deschenie
Agricultural Research Assistant

Sue Stone
Associate Administrative Assistant

Joseph Ward
Research Technician

Jonah Joe
Research Technician

Franklin Jason Thomas
Laboratory Research Technician

Dallen Begay
Farm/Ranch Manager

Nathan Begay
Laborer, Sr.

Temporary Employees

2017 Student Employees

Brandon Francis
Groundskeeper Sr.

Tiffany Charley
Research Lab Technician

Eugena Armijillo
Ag. Research Assistant

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Editors – M.M. West, S.C. Allen, K.A. Lombard

Cover: The cover photograph depicts a Soaptree yucca, *Yucca elata* at ASC Farmington’s front entrance taken during the May 18, 2017 snowfall. Learn more about this xeric plant and more at http://farmingtonsc.nmsu.edu/very-low-irrigation.html

(Photo credit: M.M. West).

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Misty May	Vicky Lake
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Elbert Hamlin	San Juan River Farm Board Representative
Navajo Nation Office of the President & Vice President	

Collaborators List

New Mexico State University, College of Agricultural, Consumer and Environmental Sciences, College of Health and Social Services, and College of Engineering

April Ulery, Ph.D.	Professor, Soil Chemist
Brian Hinds	Communications Specialist, ACES IT
Catherine Brewer, Ph.D.	Assistant Professor, Chemical Engineer
Don Rheay	Director, ACES IT
Gill Giesse, Ph.D.	Extension Viticulture Specialist
Ian Ray, Ph.D.	Professor, Alfalfa Breeder
Leonard Lauriault, M.S.	College Assoc., Alfalfa Agronomist
Mark Marsalis, Ph.D.	Extension Agronomy Specialist
Natalie Goldberg, Ph.D.	Interim Assoc. Dean and Director, AES
Mary O'Connell, Ph.D.	Professor, Geneticist
Robert Flynn	Professor, Soil Scientist
Rolston St. Hilaire, Ph.D.	Professor, Horticulture
Sangu Angadi, Ph.D.	Assistant Professor, Agronomist

New Mexico State University, San Juan County Cooperative Extension Service

Shelly Hathorn	County Director, 4-H Home Economist
Bonnie Hopkins	Agriculture Extension Agent

University of Arizona

Karletta Chief	Assistant Professor – Extension Specialist
Alexandra Carlisle	Cooperative Extension - Shiprock

Colorado State University, Agricultural Experiment Station

Scott Haley	Professor, Wheat Breeding Program

Diné College

Mark Baur	Head, Environmental Programs
Felix Nez	Program Manager, Inst. Integrated Rural Dev.

San Juan College

Dr. Toni Pendergrass	President
Dr. Michael Ottinger	Dean, School of Science, Math, and Engineering
Dr. Callie Vanderbilt	Instructor, Biology
Dr. Don Hyder	Instructor, Entomology
Liesl Dees	Director, Community Learning Center
Dr. Blake Barnett	Assistant Professor, Carpentry

AgVenture

Animas Environmental Services, LLC

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Bureau of Indian Affairs, Navajo Indian Irrigation Project

Independent Energy Center

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Manning's Greenhouse

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Nelson Irrigation

NM Environment Department

Bureau of Land Management, Farmington Field Office	***NM Office of the State Engineer***
DeKalb Seed	***Public Service Company of New Mexico***
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GreenWood Resources, Inc.	***Western Excelsior***
Higgins Farms, Inc.	***Wilbur-Ellis***

Executive Summary

Acknowledgments

I would like to thank the faculty and staff, graduate students, and undergraduate students for maintaining the ASC-Farmington projects. The Navajo Agricultural Products Industry (NAPI) has been very helpful in many ways, including making possible the replacement of two center pivots in 2017. We are thankful to have partnered with collaborators including; Wilbur-Ellis, Navajo Mesa Farms, Potato USA, Proximity Malt, Lima Grain Seed, Fred Hutchinson Cancer Research Center, Colorado State University, University of Washington, Diné College Navajo Technical University, Fort Lewis College, San Juan College, many seed companies, Dream Diné Charter School, Navajo chapter houses, NAPI, and the many La Plata, Animas, San Juan River agriculturalists in rural and urban areas, and NMSU's ACES and AES Departmental research collaborators.

Projects reported here have been funded through competitive requests for proposals issued from the National Institutes of Health/National Cancer Institute, United States Department of Agriculture, the New Mexico Department of Agriculture, and private/public partnerships. The Hatch Act of 1887, which established funding to "conduct agricultural research programs at State Agricultural Experiment Stations in the 50 states, the District of Columbia, and the U.S. insular areas" and the Morrill Act of 1862, "an Act donating Public Lands to the several States and Territories which may provide Colleges for the Benefit of Agriculture and the Mechanic Arts" (a.k.a. the land-grant system), provide operational and salary support.

We are indebted to the taxpayer who supports the U.S. agricultural science system, one of the best in the world. If you need help in interpreting the contents of this report or have a question/idea that we can help try to solve, please call us at 505-960-7757 or visit NMSU's Agricultural Science Center – Farmington at 300 County Road 4063, Farmington, NM during office hours between 8:00 a.m. and 4:30 p.m. Monday through Friday, except holiday closures. We will also be hosting our field day Friday July 13, 2018 from 8:00 am until lunch. Please join us for this event.

Sincerely,

Kevin A. Lombard, Associate Professor – Horticulture
Superintendent, NMSU's Agricultural Science Center at Farmington

Announcement

Dr. Koffi Djaman, Assistant Professor, joined NMSU's College of Agricultural, Consumer, and Environmental Sciences (ACES) in September 2017. His work focuses on cropping systems, irrigation technology, and water conservation. He is a faculty member with ACES' Plant and Environmental Sciences Department (PES) and the Agricultural Experiment Station (AES) with assigned location at the Agricultural Science Center – Farmington (ASCF).

Koffi's professional field of expertise includes: soil and water resources, irrigation engineering, and crop response to irrigation under subsurface drip, center pivot, surface irrigation, and rain fed systems. Additionally, he is experienced in crop and reference evapotranspiration measurement and modeling.

Prior to accepting the Agricultural Experiment Station faculty position at ASCF, Koffi was an Associate Principal Scientist, Agronomist at Africa Rice Center (ARC), Regional station of Senegal from 2014-2016. He also served at the Agronomist Field Fellow of ARC, Senegal. Koffi completed his postdoctoral research in the Biological Systems Engineering Department, University of Nebraska – Lincoln (2012-2014).

In 2008, Koffi was awarded a Fulbright Scholarship (2008-2010). During this time, he worked as a Graduate Research Assistant in the Biological Systems Engineering Department and graduated in 2011 with a Ph.D. in Soil & Water Resources and Irrigation Engineering from the University of Nebraska – Lincoln.

We graciously welcome Dr. Koffi Djaman to New Mexico and NMSU's ASCF. His professional experience in research and development plus Extension Education training will be a stellar asset to those we serve in the Four Corners Region of New Mexico, the Navajo Nation, and beyond.

If you would like to learn more about Dr. Djaman's professional career, you may contact him via email at kdjaman@nmsu.edu for a curriculum vitae.

Dedication

Dr. Michael K. O'Neill, Professor Emeritus – NMSU's Plant and Environmental Sciences Department, Extension Plant Sciences, and the Agricultural Experiment Station at the Agricultural Science Center at Farmington (ASCF), began his NMSU research and leadership career in 1999. During his 18 years of professional service to the State of New Mexico, he was the research principle investigator in agronomy and agroforestry programs at ASCF. While superintendent at ASCF, Mick's effective leadership and collaboration with the New Mexico State Legislature secured recurrent funding to expand the research program at ASCF with capital equipment and four additional research positions, including a faculty horticultural position, two research specialist positions, and one research technician. He developed an internationally recognized drip-irrigated hybrid poplar research program for arid and semiarid environments. Under his leadership, biofuels research with poplar, sunflower, and canola demonstrated their viability in the Four Corners Region.

In 2000, Mick initiated and continued discussions between NMSU and San Juan College that culminated in the 2007 signing of a unique collaborative Memorandum of Understanding for an NMSU horticulturalist to hold a split appointment with 75% research at ASCF and 25% teaching at SJC. His dedication to higher education is exemplified by his service on graduate student committees. He worked tirelessly for development of the Bridges Internship program and collaborated with BHP Billiton, Navajo Nation, Navajo Agricultural Products Industry, National Indian Youth Council, and NMSU's College of Agriculture, Consumer and Environmental Sciences to create internships for students in the Four Corners region. During his tenure as the José Fernández Memorial Chair in Crop Production (2010-2013), Mick utilized award funds for diverse student internships and international programs, such as the Service Learning for Women (SLW) and African Women in Agriculture Research and Development (AWARD) programs.

His work in international development began after earning his bachelor's degree in biology/chemistry from Concordia University in Montreal, Canada. Mick started his career as a Peace Corps Volunteer, serving first as a secondary school science teacher in Bawku, Ghana (1971–1972) and later as a leader for wide-bore water well construction in Tougouri, Burkina Faso (1972–1974). This was a transformative period instilling in him a desire to make a career in international development.

Upon receipt of his Ph.D. in 1982 from the University of Arizona, Mick began a post-doc internship with the International Crops Research Institute for the Semi-Arid

Tropics (ICRISAT), one of 15 international research centers in the CGIAR consortium. While an intern, he worked in Mali assisting in the development of an agricultural research center for crop and livestock systems in the Sahelian zone. He also worked at the ICRISAT headquarters in Hyderabad, India developing soil water models based on soil texture and evapotranspiration parameters. Upon completion of his internship, he worked for Development Alternatives, Inc. (DAI) on a USAID-funded rural development project in western Niger. In 1988, Mick transferred to Embu, Kenya, first with the University of Missouri and then with the World Agroforestry Center (ICRAF), another CGIAR center based Nairobi. He worked for 10 years at the Kenya Agricultural Research Institute's center in Embu, Kenya with responsibilities for research and training of Kenyan scientists in on-station and on-farm procedures. Since starting at ASCF in 1999, he has returned to Kenya several times for short-term assignments with ICRAF to work in Kenya and Rwanda.

In 2014 and 2015, his international development career continued via NMSU's collaboration with the University of La Salle's "Utopia Project' in Bogotá and Yopal, Colombia and Las Cruces where he led a faculty/student exchange program for the Partners of the Americas project. He returned to Bogotá in 2016 for the La Salle Summer Academy where he taught a 3-credit course in World Food Security and the application and use of the aWhere Weather Module for meteorological data acquisition and analysis. Post retirement, 2018 marks another year of leadership and international development with Mick providing instruction as NMSU's Professor of Agronomy – Emeritus with the NMSU Farmer to Farmer Can Do Volunteer project in Bogotá, Medellin, Monteria, and Yopal, Colombia.

No career journey would be so successful without the support from Mick's family. His wife, Amy O'Neill, who he met and married in Niger while she was a gardening project manager for Lutheran World Relief, has volunteered with women's groups in Kenya and is the Director for the Court Appointed Special Advocates (CASA) program for San Juan County. She has also volunteered for the ASCF Field Day and Open House events. Along with Mick she has hosted many Peace Corp Volunteer gatherings. Their sons, Casey and Kyle O'Neill, have completed summer internships at ASCF and are NMSU Alumni having completed their undergraduate degrees in Geography.

Mick's leadership and kindness will be remembered by those people he inspired throughout his professional career. To read more on his professional journey, you can access his background on the ASCF Agronomy & Agroforestry webpage. You may request a curriculum vitae of Mick via the Plant and Environmental Sciences website at http://aces.nmsu.edu/academics/pes/michael-oneill.html.

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Introduction

Serving the agricultural needs for the San Juan River basin of northwest New Mexico and the Four Corners region, the Agricultural Science Center at Farmington consists of 254 acres leased from the Navajo Nation in 1966. While the major irrigated cropland for northwestern New Mexico is in San Juan County, small parcels of irrigated lands are found in the two adjoining counties, McKinley and Rio Arriba.

San Juan County 2016 cash receipts for All Farm Commodities by (1,000 dollars) dropped by nearly 31% from $56,888 (2015) to $39,044 (2016) Cash receipts from 2016 livestock and crop production in San Juan County were 36% from all livestock sales and 64% is from all crops. In 2016, San Juan County ranked 14th in cash receipts for all farm commodities[2]

The Agricultural Science Center is located about seven miles southwest of Farmington on the high plateau of northwestern New Mexico. The Center is at an altitude of 5,640 ft above sea level (36º 4' N by 108º W) in a semi-arid environment with a mean annual precipitation of 8.05 in. The mean monthly maximum and minimum temperatures range from 41 and 19 ºF in January to 91 and 61 ºF in July (1969-2017) (Table 2). The average frost-free period is 162 days from May 4 to October 13 (1969-2017) (Table 3). Evaporation during the 2017 growing season ranged by monthly total from 7.2 inches in May to 7.1 inches in October for a total evaporation of 68.29 inches from May through October (Table 1). There are four soil orders within the Center ranging from sandy loam to loamy sand (59 – 83 % Sand) and having a pH of 7.8 (Anderson, 1970)[1].

The Center is the only agricultural research facility in the state of New Mexico that is on the western side of the Continental Divide. It is also perhaps the only 1862 Land-grant university science center located directly on sovereign First Nations land. River drainage is west into the Colorado River and then continues west and south to the Pacific Ocean by way of the Gulf of California. Over two-thirds of the total surface water that exists in the state of New Mexico runs through the northwest corner of New Mexico (San Juan County). The Center receives water through the Navajo Indian Irrigation Project (NIIP). Total irrigated land serviced by NIIP comprises about 50% of the 150,000 acres of irrigated land in San Juan County and future development will expand NIIP to over 100,000 acres. Irrigated acreage in San Juan County is increasing and when all projects being planned are completed, acreage will climb from 150,000 to about 240,000 acres.

Of the 254 acres comprising the Agricultural Science Center, 170 acres are under cultivation. Over 100 crops have been grown on the Center since its inception in 1966. Many crops, which produce well in northwestern New Mexico, are not grown in the area because of market prices at the time of harvest, high transportation costs to a suitable market, personnel unfamiliar with production practices, etc. The Center currently receives water from NIIP to irrigate crops by sprinkler systems (center pivots, solid set, and drip irrigation). Earlier irrigation methods also included side roll and flood systems but the latter was impractical on the Center's sandy soils. Agricultural production within NIIP is carried out by the Navajo Agricultural Products Industry (NAPI) and is managed as a single farm. Close collaborative links are maintained with NAPI through varietal testing of potatoes, corn, small grains, beans, onions, chile, alfalfa, and other economically important crops.

Variety and agronomic crop research has included winter and spring wheat, winter and spring barley, oats, corn, alfalfa, and crambe. Dry bean variety and type trials, including row spacing and management for white mold control, have been conducted. Fertilizer-type/placement trials and herbicide-type/application trials have been carried out with potatoes, corn, cereal grain, and dry beans in various rotations. Alternative crops evaluated in the past have included soybeans, safflower, kenaf, licorice, buckwheat, sugarbeets, canola (rape), rye, triticale, sorghum, sunflower, amaranth, pasture and other minor acreage crops such as carrots for seed production. Agronomic work has also been conducted in no-till plots and clean-tilled areas as well as intercropping dry bean and soybean in spring wheat. Important areas of study have included leaching associated with herbicides and potential for contaminating drainage water, which affects future crop productivity and ground water draining into the San Juan basin.

Past areas of entomological study have included the control of corn ear worm, apple codling moth, and Russian wheat aphid. Weed research has included pre-plant, pre-emergence, and post-emergence applications of herbicides for grass and broadleaf control in alfalfa, corn, wheat, beans, potatoes, onion, carrot, and pumpkin. Water research has determined consumptive use indexes and efficient water application strategies on a number of crops including tomato, chile, potatoes, winter and spring grains, beans, corn, alfalfa, pasture and buffalo gourd. Turf research has included blue grass variety trials, and buffalo and blue grama evaluations for low-maintenance lawns. Horticultural crops evaluated in the past have included chile pepper, lettuce, tomato, green bean, onion, apple, pear, peach, nectarine, cherry, grape, cucumber, pea, pumpkin, winter and summer squash, and Christmas trees.

Research at the present time is being conducted on alfalfa, barley, corn, winter wheat, potatoes, pasture grass, poplars, grapes and hops. Major emphasis at the present time is on variety and other adaptive or production research, and other varied areas of research. Water application research includes determining water use-production functions of the primary crops in the area. This project includes developing and evaluating formulas to predict water application and consumptive use of crops.

Since the mid-1960's, average county yields of alfalfa have increased from 3 to more than 5 tons/acre; corn has gone from 55 to 154 bu/acre and wheat from 35 to 110 bu/acre. Potatoes have become an increasingly important crop and production could be substantially increased if a proposed French fry plant is built. With new acreage being put into production each year, new research initiatives are needed primarily in the areas of high value crops, irrigation management, herbicide use, and soils.

Buildings on the Center include an office and laboratory building with six offices, a laboratory and a tissue culture laboratory, conference room, head house, and attached greenhouse partitioned into two bays, and a three-bedroom residence. There are four metal buildings. The first building is 100 x 40 ft with a shop, small office, and restroom in a 40 x 40-ft section on the south end and a 60 x 40-ft area on the north end for machinery storage. The second building is 60' x 20' and is partitioned to form three small rooms. It is used for seed, fertilizer, and small equipment storage. The third building is a 20 x 60-ft open front machinery storage shed, the fourth building is a 20 x 30-ft chemical storage facility. There are also three additional lean-to sheds for equipment and vehicles. Most of the machinery and equipment needed to carry out field, laboratory, and greenhouse research is available at the Center. Office, laboratory, greenhouse, and irrigated field plots are available to resident and visiting technical personnel.

Graduate students may participate in the program. Most research is towards adaptive or applied research programs. Recent research on the Gold King Mine spill has presented research assistant opportunities for students. A seasonal resident house equipped with appliances and washer/dryer unit is available for students and sleeps up to four.

Center personnel includes 2 faculty, 3 professional and 6 support staff. Faculty and professional staff fields of research are agronomy/agroforestry, horticulture, irrigation, cropping systems, water conservation, extension, and engine repair. The 3 professional staff include the 2 Agricultural Research Scientists, and 1 Farm Manager. The Center has a full-time Administrative Assistant, 3 full-time Research Technicians, 1 full-time Farm/Ranch Laborer, 1 part-time Research Assistant, and 2 Temporary/Student employees.

Literature Cited

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Weather Conditions During 2017 at the NMSU Agricultural Science Center

M.K. O'Neill, M.M. West, J.P. Joe

A weather station was established at the NMSU Agricultural Science Center at Farmington, New Mexico, in January 1969. It was designated an official National Weather Service climatological observation site in 1978. Weather observations are made daily at 8:00 a.m.

Initially, the maximum and minimum U.S. Weather Service thermometers were housed in a regulation instrument shelter. In March of 2005, A Nimbus PL digital "bee hive" style thermometer was installed and replaced the mercury thermometers. A standard eight-inch rain gauge was installed in 1982. Wind movement in miles per day has been recorded at two heights since 1980. A 3-cup anemometer is set 0.15 meters (6 inches) above the rim of the evaporation pan, while a second anemometer is set at 2 meters above the soil surface. The 2 meter anemometer were replaced in 2011. The 0.15 meter anemometer was replaced in 2017. The Evaporation was measured using a standard Class-A metal pan from 1972 through 2017. A maximum and minimum thermometer with a sensor probe buried 4 inches deep was installed in bare ground to record soil temperature.

A second weather station is located at the NMSU Agricultural Science Center. This weather station is one of about 200 located throughout the state of New Mexico and is managed by the New Mexico Climate Center (NMCC) at New Mexico State University main campus in Las Cruces. This weather station was established in 1985 and has an automated data collection system. The NMCC weather station solar radiation data are digitally recorded in Megajoule per square meter units and then converted into Langley units for this report (Table 1). This relevant data and other weather data can be viewed at (http://weather.nmsu.edu).

An above average 9.11 inches of precipitation was recorded in 2017 (Figure 1). The 49 year annual precipitation average is 8.05 inches (Table 4). The wettest month was July which received 2.51 inches (31% of the total annual of 9.11 inches). January, February, April, May, July, and September received above 49 year average monthly precipitation. All remaining months which were March, June, August, October, November, and December received below average monthly precipitation (Table 4).

During the 2017 growing season, the freeze-free period was from May 19 through September 25 with 130 consecutive days of above freezing temperature. This was 32 days shorter than the 49-year average freeze-free period of 162 days. The killing freeze-free period was April 10 through October 15 with 189 consecutive days above the killing freeze-free temperature (Table 3).

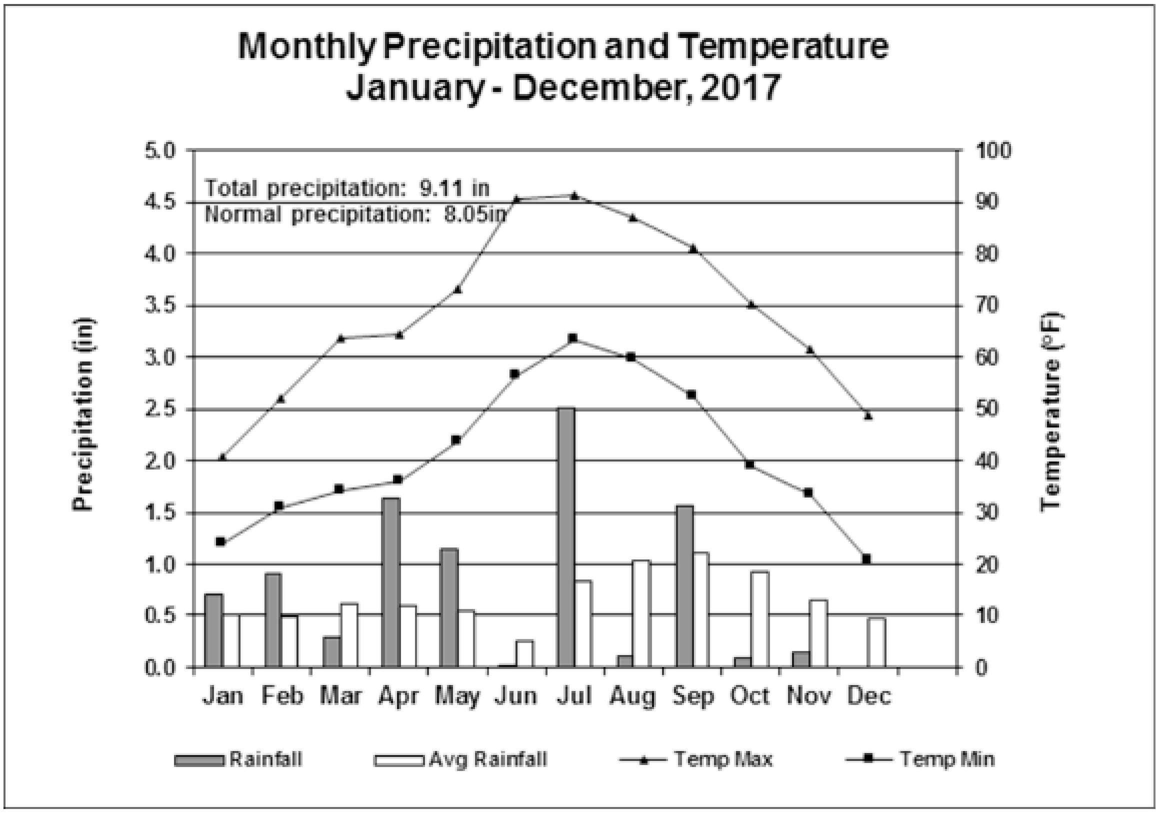


Figure 1. **Monthly and average precipitation (in), monthly mean maximum and minimum temperature (ºF). NMSU Agricultural Science Center at Farmington, NM. 2017.**

Table 1. Summary of mean daily climatological data. NMSU Agricultural Science Center at Farmington, NM. January through December 2017.

Month	Mean Temperature			Extreme Temp.		Precipi-	Wind Speed		Evapo-	Sunshine
	Max	Min	Mean	Max	Min	tation	0.15 m height	2 m height	ration	
	(ºF)	(ºF)	(ºF)	(ºF)	(ºF)	(in)	(mi)	(mi)	(in)	(Langley)
January	41	24	33	52	5	0.71	26	58		194
February	52	31	42	64	15	0.91	25	59		292
March	64	34	49	80	17	0.29		89		442
April	65	36	50	80	23	1.63	36	84	7.2	532
May	73	44	58	86	32	1.14	32	81	10.0	608
June	91	56	73	100	44	0.02	25	77	14.1	721
July	92	63	77	99	57	2.51	24	65	12.8	639
August	87	60	73	93	52	0.11	16	58	9.3	557
September	81	52	67	95	30	1.57	22	61	7.8	479
October	70	39	55	84	27	0.08	37	63	7.1	412
November	62	33	48	73	15	0.14	25	40		271
December	49	21	35	63	8	0.00	28	38		254
Total	**825.0**	**493.3**	**659.1**	**967.2**	**323.5**	**9.11**	**296.2**	**777.3**	**68.29**	**5,401**
Mean	**68.8**	**41.1**	**54.9**	**80.6**	**27.0**	**0.76**	**26.9**	**64.5**	**9.76**	**450**

Table 2. Summary of forty-nine year average monthly weather conditions. NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Month	Precip-	Mean Temperature		––––––––––––– Extreme Temperature –––––––––			
	tation	Maximum	Minimum	Maximum	Year Recorded	Minimum	Year Recorded
	(in)	(ºF)	(ºF)	(ºF)		(ºF)	
January	0.51	41	19	66	2000	-18	1971
February	0.49	48	24	70	1986	-14	1989
March	0.62	57	30	82	2004	3	2002
April	0.60	66	36	86	1992	16	1979
May	0.55	76	45	97	2000	23	1975
June	0.25	87	54	101	2016	32	1999
July	0.84	91	61	103	1989,90,2003,05	43	1969
August	1.03	88	59	99	1969,70,83,02	41	1980
September	1.10	80	51	97	1995	28	1971,1999
October	0.93	68	40	88	2010,15	15	1989
November	0.65	53	29	75	1999, 2001	1	1976
December	0.47	42	20	67	1999	-16	1990
Total	**8.05**						
Mean	**0.67**	**66.5**	**39.0**				

Table 3. Summary of freeze dates and number of consecutive freeze-free days. NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Date	––– Less than or equal to 32 ºF ––			–––––– Less than or equal to 28 ºF –––––		
	Last Spring Freeze (date)	First Fall Freeze (date)	Freeze-free Period (days)	Last Spring Killing Freeze (date)	First Fall Killing Freeze (date)	Killing Freeze-free Period (days)
1969	Apr 27	Oct 05	161	Apr 26	Oct 06	163
1970	May 02	Oct 08	159	May 01	Oct 09	161
1971	May 09	**Sep 18***	132	Apr 27	**Sep 18***	**144***
1972	May 02	Oct 30	181	Apr 27	Oct 31	187
1973	May 02	Oct 11	162	May 02	Oct 27	178
1974	May 21	Oct 30	162	May 20	Nov 04	168
1975	May 08	Oct 14	159	May 07	Oct 14	160
1976	Apr 27	Oct 07	164	Apr 27	Oct 19	175
1977	Apr 21	Oct 31	193	Apr 05	Nov 02	211
1978	May 06	Oct 26	173	May 06	Nov 13	191
1979	May 12	Oct 21	162	Apr 20	Oct 22	185
1980	May 26	Oct 16	143	May 25	Oct 17	145
1981	May 09	Oct 16	160	Apr 05	Oct 17	194
1982	May 06	Oct 06	153	Apr 21	Oct 10	172
1983	May 19	Sep 21	125	May 17	Nov 09	176
1984	May 08	Oct 15	160	May 08	Oct 16	161
1985	May 14	Sep 30	139	Apr 01	Nov 01	214
1986	Apr 27	Oct 12	168	Apr 27	Oct 13	169
1987	Apr 21	Oct 19	181	Apr 21	Nov 11	204
1988	May 07	Nov 12	189	Apr 11	Nov 16	219
1989	Apr 30	Oct 18	171	Mar 21	Oct 27	219
1990	**Apr 10***	Oct 09	181	Mar 31	Oct 21	204
1991	May 05	Oct 28	176	Apr 29	Oct 29	182
1992	Apr 21	Oct 08	170	**Mar 19***	Oct 08	203
1993	May 09	Oct 19	163	Apr 20	Oct 27	190
1994	Apr 30	Oct 17	170	Apr 08	Oct 31	206
1995	Apr 25	Oct 06	164	Apr 18	Oct 06	171
1996	Apr 30	Sep 19	142	Apr 29	Oct 18	172
1997	May 02	Oct 13	163	May 02	Oct 13	163
1998	May 15	Oct 06	144	Apr 19	Oct 06	170
1999	Jun 05	Sep 28	**115***	Apr 16	Sep 29	166
2000	May 12	Oct 14	154	Apr 03	Nov 02	212
2001	Apr 23	Oct 11	170	Apr 13	Oct 11	180
2002	Apr 22	Oct 04	165	Apr 22	Nov 04	196
2003	May 11	Oct 27	168	Apr 08	Oct 27	201
2004	May 1	Oct 23	174	Mar 29	Oct 30	214
2005	Apr 22	Oct 31	192	Apr 21	Nov 15	207
2006	Apr 20	Sep 23	155	Apr 19	Oct 22	183
2007	May 07	Oct 07	153	Apr 19	Oct 07	171
2008	May 03	Oct 12	162	May 02	Oct 12	163
2009	April 27	Sep 22	147	Apr 16	Oct 2	168
2010	May 12	Oct 26	166	May 12	Oct 26	166
2011	May 03	Oct 08	157	May 02	Oct 28	178
2012	Apr 16	Oct 25	192	Apr 16	Oct 25	192
2013	May 03	Oct 05	154	May 3	Oct 17	166
2014	May 13	Nov 03	172	May 1	Nov 04	186
2015	May 10	Oct 28	170	Apr 17	Nov 06	202
2016	Apr 26	Oct 20	176	Apr 3	Nov 18**	227**

Date	––– Less than or equal to 32 ºF ––			–––––– Less than or equal to 28 ºF –––––		
	Last Spring Freeze (date)	First Fall Freeze (date)	Freeze-free Period (days)	Last Spring Killing Freeze (date)	First Fall Killing Freeze (date)	Killing Freeze-free Period (days)
2017	May 19	Sep 25	130	Apr 10	Oct 15	189
Mean	**May 4**	**Oct 13**	**162**	**Apr 20**	**Oct 22**	**184**

* Earliest date (or shortest freeze-free period) of 49 years.
** Latest date (or longest freeze-free period) of 49 years.

Table 4. Summary of mean monthly precipitation (in). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	0.85	0.31	0.21	0.30	1.13	1.00	0.69	0.47	2.07	2.88	0.38	0.29	10.58
1970	0.06	0.03	0.49	0.60	0.11	0.81	0.68	*0.02	2.48	0.48	0.46	0.20	6.42
1971	0.18	0.09	0.05	0.11	0.41	*0.00	0.31	1.72	1.06	1.15	0.77	0.16	6.01
1972	0.03	*trace	0.03	*0.00	0.02	0.18	0.04	1.34	0.57	**3.53	0.19	0.93	6.86
1973	0.28	0.17	1.82	1.54	0.65	0.95	0.27	0.61	1.49	0.35	0.30	0.37	8.80
1974	1.10	0.13	0.01	0.20	0.02	0.09	1.48	0.12	0.37	2.39	0.48	0.38	6.77
1975	0.11	0.61	1.52	0.78	0.35	0.13	0.84	0.24	0.80	0.14	0.22	0.20	5.94
1976	0.06	0.16	*0.00	0.10	0.41	0.09	0.62	0.80	1.31	*0.01	0.01	trace	*3.57
1977	0.42	*trace	*0.00	0.01	0.29	0.04	1.01	1.41	0.38	0.30	0.62	0.63	5.15
1978	0.90	0.64	1.27	0.71	0.96	*0.00	0.07	0.18	1.55	1.46	2.24	0.59	10.57
1979	0.88	0.19	0.46	0.28	0.58	0.43	1.40	0.49	*0.08	1.37	0.97	0.73	7.86
1980	1.45	0.70	0.63	0.25	0.25	0.07	0.08	0.89	1.05	0.84	0.02	*trace	6.23
1981	trace	0.30	1.76	0.21	1.05	0.16	1.34	0.35	0.69	0.89	0.36	0.03	7.14
1982	0.32	0.77	1.18	0.67	0.82	*0.00	1.27	2.78	1.50	0.16	0.92	0.76	11.15
1983	0.94	0.69	1.84	0.31	0.13	0.35	1.67	0.72	0.53	0.52	0.91	0.67	9.28
1984	trace	0.12	0.54	1.00	trace	0.67	0.62	1.64	0.45	1.13	0.23	0.87	7.27
1985	0.39	0.13	1.74	1.76	0.29	0.01	1.38	0.43	1.31	1.21	0.52	0.22	9.39
1986	0.11	0.77	0.51	0.97	0.13	0.81	**4.10	0.93	2.18	0.65	**2.73	0.76	**14.65
1987	0.10	1.75	0.66	trace	0.68	0.02	0.28	1.17	0.27	1.07	1.65	0.59	8.24
1988	0.63	0.82	0.02	0.72	1.11	0.33	0.58	2.34	0.27	0.22	0.78	0.19	8.01
1989	1.19	0.56	0.06	*0.00	trace	trace	1.24	1.62	0.14	0.51	*0.00	trace	5.32
1990	0.53	0.53	0.74	0.85	1.07	0.07	0.35	1.32	1.97	1.12	0.78	0.59	9.92
1991	0.59	0.26	0.67	0.01	0.27	0.69	0.35	0.58	1.38	0.38	2.07	**1.01	8.26
1992	0.15	0.18	0.74	0.25	**1.75	0.05	0.98	1.25	0.85	0.42	0.31	0.63	7.56
1993	**2.05	0.82	0.93	0.28	0.38	0.04	*0.03	2.06	0.84	1.25	0.47	0.15	9.30
1994	0.09	0.48	0.24	0.57	1.32	0.07	0.20	0.66	1.37	1.18	0.96	0.64	7.78
1995	0.57	0.14	1.45	1.28	0.9	0.03	0.23	1.88	2.04	0.10	0.14	0.39	9.15
1996	0.09	0.43	0.28	0.17	*0.00	0.64	0.24	1.07	0.63	2.21	0.72	0.22	6.70
1997	1.03	0.48	0.03	**2.88	0.82	0.62	1.28	1.12	2.68	0.43	0.67	0.80	12.84
1998	0.12	0.61	0.65	0.73	0.03	0.02	1.38	1.48	0.68	2.07	1.27	0.06	9.10
1999	0.14	0.05	0.13	1.21	1.26	0.44	2.51	**2.99	0.25	*0.01	0.06	0.12	9.17
2000	0.62	0.25	**2.05	0.21	0.03	0.12	0.80	1.22	0.50	2.16	0.78	0.22	8.96
2001	0.44	0.80	1.37	0.67	0.87	0.03	0.82	1.01	0.26	0.24	0.48	0.55	7.50
2002	0.04	0.04	0.17	0.37	*0.00	*0.00	0.42	0.32	3.26	1.75	0.72	0.60	7.70
2003	0.08	1.29	0.49	0.02	0.01	0.15	0.11	1.24	0.87	0.72	1.03	0.31	6.32
2004	0.34	0.90	*0.00	2.50	*0.00	0.14	0.38	0.16	2.53	0.60	0.82	0.37	8.70
2005	1.09	**1.81	0.36	0.85	0.55	0.11	0.52	1.84	0.48	0.92	0.06	0.10	8.70
2006	0.39	0.05	0.71	0.58	0.09	0.24	1.90	0.79	1.38	1.90	0.06	0.73	8.80

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2007	0.42	0.59	1.13	0.35	1.73	0.10	0.68	0.81	0.74	0.11	0.21	0.99	7.90
2008	1.21	0.74	0.14	0.03	0.25	0.13	0.63	0.53	0.28	0.76	0.61	0.96	6.30
2009	0.36	0.44	0.21	0.28	0.78	0.47	0.15	0.27	0.09	0.68	0.32	0.42	4.50
2010	1.34	0.95	0.82	0.26	0.10	0.10	0.65	2.50	0.84	1.32	0.12	0.78	9.78
2011	0.03	0.18	0.34	1.09	0.86	0.01	0.65	0.05	1.02	1.86	0.55	0.30	6.94
2012	0.10	0.40	0.20	0.01	0.08	0.01	1.07	0.15	0.67	0.08	0.24	0.69	3.70
2013	0.88	0.07	0.14	0.49	0.26	*0.00	0.54	1.34	**3.29	0.66	0.91	0.14	8.70
2014	*0.00	0.41	0.88	0.13	0.26	*0.00	0.47	1.07	1.55	0.15	0.31	0.88	6.11
2015	1.22	0.93	0.31	0.61	1.70	**1.80	0.91	1.14	0.51	1.10	0.89	0.65	11.77
2016	0.46	0.34	0.01	0.80	0.93	*0.00	0.47	1.37	1.05	0.28	1.50	0.97	8.18
2017	0.71	0.91	0.29	1.63	1.14	0.02	2.51	0.11	1.57	0.08	0.14	*0.00	9.11
Mean	**0.51**	**0.49**	**0.62**	**0.60**	**0.55**	**0.25**	**0.84**	**1.03**	**1.10**	**0.93**	**0.65**	**0.47**	**8.05**

* Lowest in column
** Highest in column

Table 5. Summary of monthly average of the mean temperature* (ºF). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969	34	35	37	52	63	67	76	76	69	50	40	34	**52.8**
1970	31	40	39	44	60	68	76	76	64	50	42	33	**51.9**
1971	30	34	43	50	58	71	77	74	64	52	40	30	**51.9**
1972	30	38	48	53	60	70	78	74	66	54	36	26	**52.8**
1973	22	35	39	45	59	68	75	75	63	55	44	30	**50.8**
1974	24	28	48	48	63	74	75	74	65	55	40	28	**51.8**
1975	26	34	40	46	56	66	74	72	64	54	38	30	**50.0**
1976	28	41	40	52	60	70	77	74	66	51	40	32	**52.6**
1977	25	37	39	54	59	74	76	75	68	56	43	36	**53.5**
1978	33	34	46	52	56	69	76	71	65	56	42	24	**52.0**
1979	24	32	40	50	58	67	74	72	69	56	35	32	**50.8**
1980	33	39	40	48	57	71	76	73	65	52	41	37	**52.7**
1981	30	37	41	55	59	71	74	72	65	51	44	34	**52.8**
1982	30	31	42	49	57	67	73	72	65	50	40	32	**50.7**
1983	31	36	42	45	56	66	74	75	68	54	41	34	**51.8**
1984	28	34	41	47	64	69	76	74	66	47	42	35	**51.9**
1985	30	32	41	53	61	71	76	74	62	54	40	31	**52.1**
1986	40	39	47	51	60	70	72	74	62	52	40	33	**53.3**
1987	29	36	39	53	59	70	73	71	65	56	39	29	**51.6**
1988	24	36	41	51	59	72	76	74	64	58	41	31	**52.3**
1989	27	35	49	57	63	70	78	72	69	55	41	31	**53.9**
1990	29	36	46	54	59	75	76	73	69	54	42	24	**53.1**
1991	25	37	41	49	59	68	75	74	66	56	38	29	**51.4**
1992	28	39	45	56	62	68	72	73	66	56	35	26	**52.2**
1993	35	38	44	51	61	69	74	71	64	52	38	32	**52.4**
1994	33	35	46	52	61	73	77	76	66	53	38	35	**53.8**
1995	33	44	44	48	57	67	74	76	67	53	44	35	**53.5**
1996	32	41	43	51	64	71	76	73	61	52	40	32	**53.0**
1997	29	36	46	47	61	70	74	73	68	52	41	31	**52.3**
1998	34	35	42	48	61	67	77	74	70	54	42	32	**53.0**
1999	35	39	48	49	58	68	74	71	63	54	45	30	**52.8**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2000	34	40	42	53	63	71	75	75	68	54	35	34	**53.7**
2001	31	37	45	54	63	71	77	74	70	57	45	31	**54.6**
2002	32	34	42	57	63	75	78	74	66	53	40	32	**53.8**
2003	38	36	44	51	63	71	81	77	66	59	41	34	**55.1**
2004	30	34	50	53	64	72	75	73	65	54	41	33	**53.5**
2005	38	40	43	52	62	69	79	73	68	56	43	32	**54.6**
2006	34	37	43	56	65	74	78	73	62	52	44	31	**54.0**
2007	28	37	47	52	61	72	78	76	68	55	44	30	**53.7**
2008	24	33	42	50	58	70	75	74	66	54	44	31	**51.8**
2009	32	38	45	49	64	68	77	73	67	50	43	27	**52.8**
2010	26	33	41	51	57	72	76	72	67	56	39	38	**52.3**
2011	24	32	45	50	56	71	77	76	65	53	40	30	**51.5**
2012	32	35	45	55	63	74	76	75	67	55	44	32	**54.4**
2013	24	32	44	50	60	73	77	73	67	50	41	28	**51.6**
2014	32	39	44	50	59	71	77	72	69	56	42	34	**53.8**
2015	33	40	47	51	57	72	74	74	68	59	41	30	**53.7**
2016	29	38	46	51	59	76	76	72	65	58	45	34	**54.0**
2017	33	42	49	50	58	73	77	73	67	55	48	35	**54.9**
Mean	**30.1**	**36.3**	**43.5**	**50.9**	**60.1**	**70.4**	**75.8**	**73.6**	**66.0**	**53.9**	**41.0**	**31.5**	**52.8**

*The mean temperatures are the average of maximum and minimum temperatures for the month.

Table 6. Summary of monthly average maximum temperature* (ºF). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969	42	46	50	69	78	81	91	90	83	62	51	45	**65.7**
1970	42	54	52	60	78	84	91	91	78	63	55	44	**66.0**
1971	43	48	59	66	74	87	93	87	80	65	51	39	**66.0**
1972	43	54	66	70	78	86	93	87	80	63	46	37	**66.9**
1973	32	42	50	59	74	84	90	90	79	70	57	42	**64.1**
1974	34	40	62	64	80	91	89	88	80	66	52	39	**65.4**
1975	37	44	52	60	71	85	89	88	79	70	53	42	**64.2**
1976	41	54	56	68	76	87	92	88	79	65	53	45	**67.0**
1977	34	51	53	69	74	90	90	89	81	71	54	47	**66.9**
1978	41	44	58	65	70	85	90	86	78	70	51	33	**64.3**
1979	31	42	52	65	72	84	90	86	84	71	46	43	**63.8**
1980	41	50	53	64	72	89	93	88	80	66	55	51	**66.8**
1981	49	51	53	70	74	88	90	88	80	65	58	46	**67.7**
1982	41	41	54	63	72	84	89	85	78	65	51	41	**63.7**
1983	40	46	53	59	72	82	90	89	83	68	52	43	**64.8**
1984	41	48	56	61	80	84	91	87	80	60	55	45	**65.7**
1985	41	44	55	67	75	88	91	89	76	67	51	43	**65.6**
1986	49	51	61	64	75	84	86	89	75	65	50	44	**66.1**
1987	40	47	52	68	74	87	90	86	80	71	51	40	**65.5**
1988	35	47	57	65	75	87	92	87	80	73	53	43	**66.2**
1989	38	45	63	73	79	86	93	87	84	69	56	45	**68.2**
1990	41	47	58	67	73	90	90	87	82	68	54	36	**66.1**
1991	35	49	53	65	75	84	90	88	80	71	49	37	**64.7**
1992	38	50	58	71	76	84	86	87	81	72	48	36	**65.6**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1993	44	48	59	67	76	86	91	85	79	66	50	43	**66.2**
1994	46	46	61	66	76	90	93	91	81	66	50	46	**67.7**
1995	42	58	58	61	71	83	91	90	81	69	59	47	**67.5**
1996	45	54	58	68	82	87	91	89	76	66	53	43	**67.7**
1997	39	48	63	61	77	86	90	87	82	67	54	42	**66.3**
1998	45	46	57	62	78	85	92	90	86	68	56	45	**67.5**
1999	50	54	64	63	73	86	89	84	80	73	63	44	**68.6**
2000	47	53	56	68	82	89	93	91	84	66	46	45	**68.3**
2001	41	48	57	68	79	89	92	88	85	72	59	43	**68.4**
2002	45	49	57	72	79	93	94	90	80	66	53	43	**68.4**
2003	51	48	56	67	79	88	97	91	82	74	52	46	**69.3**
2004	41	45	65	66	80	89	91	88	79	67	51	44	**67.2**
2005	48	49	56	67	78	86	96	88	83	69	57	45	**68.4**
2006	46	52	56	70	82	91	92	86	75	64	57	42	**67.8**
2007	38	48	61	66	74	88	93	90	82	69	59	39	**67.3**
2008	34	43	58	66	74	85	90	88	80	69	56	40	**65.2**
2009	42	51	59	64	78	81	92	88	80	63	55	37	**65.8**
2010	35	42	54	65	73	88	90	85	82	69	52	47	**65.2**
2011	35	44	59	64	71	87	92	90	79	66	51	40	**64.7**
2012	45	46	60	70	79	90	90	89	81	70	58	42	**68.3**
2013	35	43	59	65	75	90	90	87	79	64	52	38	**64.8**
2014	46	52	58	65	74	87	92	86	83	69	55	43	**67.5**
2015	42	52	61	66	70	86	87	88	83	71	53	41	**66.6**
2016	38	52	61	65	73	92	91	84	79	72	56	43	**67.3**
2017	41	52	64	65	73	91	92	87	81	70	62	49	**68.8**
Mean	**41.0**	**48.1**	**57.4**	**65.7**	**75.6**	**86.8**	**91.0**	**87.9**	**80.4**	**67.8**	**53.5**	**42.5**	**66.5**

* The average daily maximum temperature represents the sum of the maximum daily temperatures in each month divided by the number of days in that month.

Table 7. Summary of monthly average of the minimum temperature* (ºF). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969	25	24	24	35	48	51	61	62	55	39	30	22	**39.7**
1970	20	27	26	29	43	53	62	62	49	36	30	22	**38.3**
1971	16	20	26	33	42	54	61	60	48	38	28	21	**37.3**
1972	18	22	31	36	43	55	62	60	53	45	27	15	**38.9**
1973	12	26	29	32	44	52	60	60	48	40	31	19	**37.8**
1974	14	17	33	33	46	57	61	59	50	44	28	17	**38.3**
1975	14	23	28	31	40	48	60	57	50	39	24	19	**36.1**
1976	16	28	25	36	45	53	62	59	54	37	26	17	**38.2**
1977	15	22	25	39	44	59	62	61	55	42	31	26	**40.1**
1978	25	25	33	38	43	53	61	57	52	43	33	15	**39.8**
1979	16	22	28	34	44	50	58	57	53	40	25	20	**37.3**
1980	26	28	27	33	41	52	59	58	50	35	27	24	**38.3**
1981	20	23	29	39	44	54	58	56	50	37	30	22	**38.5**
1982	18	21	30	34	43	51	58	60	52	35	29	22	**37.8**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1983	21	26	31	31	41	51	58	61	52	41	29	24	**38.8**
1984	16	20	27	33	48	53	61	60	52	36	30	25	**38.4**
1985	20	19	32	38	46	54	61	59	48	41	29	19	**38.8**
1986	23	26	33	39	44	55	59	60	50	40	29	22	**40.0**
1987	18	25	26	39	45	53	57	57	49	40	28	19	**38.0**
1988	13	24	25	36	44	56	61	60	48	43	29	19	**38.2**
1989	16	24	34	40	47	54	63	58	54	40	26	16	**39.3**
1990	18	25	35	41	45	59	63	60	56	40	30	11	**40.3**
1991	16	25	30	34	44	53	59	59	51	40	27	21	**38.3**
1992	18	27	32	40	48	52	57	58	50	40	22	16	**38.3**
1993	26	28	30	36	45	52	57	58	48	38	25	20	**38.6**
1994	19	24	31	38	46	56	60	61	50	39	27	24	**39.6**
1995	24	29	31	35	43	50	58	61	52	37	29	23	**39.3**
1996	19	28	29	34	47	54	60	58	47	38	28	21	**38.6**
1997	19	24	28	32	46	54	59	59	54	37	28	20	**38.3**
1998	22	25	28	33	45	48	62	59	54	40	29	19	**38.7**
1999	21	24	31	34	43	50	59	57	46	36	28	15	**37.0**
2000	22	28	29	37	44	54	58	58	52	42	25	23	**39.3**
2001	21	26	32	40	47	54	63	59	54	42	32	19	**40.8**
2002	19	18	26	41	46	57	61	58	51	39	27	22	**38.8**
2003	25	24	31	35	47	53	64	62	50	44	29	22	**40.5**
2004	19	22	35	39	47	55	59	58	51	41	30	21	**39.8**
2005	28	31	30	37	47	52	62	59	54	43	29	19	**40.9**
2006	21	21	31	39	48	57	64	60	48	40	31	20	**40.0**
2007	17	26	32	38	48	56	62	62	53	40	28	20	**40.2**
2008	13	24	27	34	42	54	61	60	51	40	32	22	**38.3**
2009	22	25	31	34	49	54	62	58	53	36	30	16	**39.2**
2010	17	24	28	37	42	55	62	59	53	43	26	28	**39.5**
2011	14	19	31	36	42	55	61	62	52	39	29	20	**38.3**
2012	19	23	30	39	47	58	62	61	53	40	30	21	**40.3**
2013	13	20	29	36	45	56	63	60	55	36	29	17	**38.3**
2014	18	26	30	35	45	54	63	59	56	43	28	25	**40.1**
2015	24	27	34	36	45	57	60	60	54	46	28	19	**40.8**
2016	19	24	30	38	44	60	61	59	51	44	34	24	**40.8**
2017	24	31	34	36	44	56	63	60	52	39	33	21	**41.1**
Mean	**19.2**	**24.3**	**29.7**	**36.0**	**44.8**	**53.9**	**60.6**	**59.3**	**51.5**	**39.9**	**28.6**	**20.3**	**39.0**

* The average daily minimum temperature represents the sum of the minimum daily temperatures in each month divided by the number of days in that month.

Table 8. Summary of highest temperatures (ºF). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969	57	61	74	82	89	96	96	**99**	95	78	63	56	**78.8**
1970	56	65	65	72	86	98	98	**99**	90	76	64	61	**77.5**
1971	60	64	77	77	84	97	101	91	90	67	70	57	**77.9**
1972	61	66	76	78	86	94	100	98	89	82	57	52	**78.3**
1973	47	61	63	76	85	98	99	97	88	81	73	65	**77.8**
1974	45	60	72	75	93	99	95	94	93	83	64	56	**77.4**
1975	61	58	65	77	85	96	95	95	89	84	73	57	**77.9**
1976	54	68	71	77	86	96	100	93	94	78	70	55	**78.5**
1977	46	65	69	81	91	98	97	98	93	82	74	63	**79.8**
1978	53	59	79	77	88	95	95	94	90	83	67	47	**77.3**
1979	46	60	62	78	82	96	97	96	94	83	60	54	**75.7**
1980	55	64	67	81	86	99	97	97	88	84	73	63	**79.5**
1981	60	67	71	82	84	100	97	96	85	78	68	56	**78.7**
1982	60	64	64	75	75	93	97	95	91	79	64	53	**75.8**
1983	53	68	68	83	89	92	96	**99**	93	74	70	50	**77.9**
1984	51	60	68	79	93	94	95	93	89	75	68	54	**76.6**
1985	50	60	70	79	85	95	100	95	93	75	68	51	**76.8**
1986	64	**70**	75	79	85	94	96	96	88	75	63	55	**78.3**
1987	56	61	69	80	82	93	98	93	89	83	66	58	**77.3**
1988	49	62	77	78	87	99	96	93	93	83	70	56	**78.6**
1989	50	67	81	85	90	98	**103**	92	91	85	67	53	**80.2**
1990	56	64	74	80	86	100	**103**	94	93	79	69	55	**79.4**
1991	44	58	67	79	85	94	97	93	91	82	67	46	**75.3**
1992	52	58	67	**86**	85	92	95	95	89	83	61	49	**76.0**
1993	54	61	72	81	86	96	96	96	88	84	61	56	**77.6**
1994	58	63	74	81	90	100	98	97	89	80	70	55	**79.6**
1995	53	68	74	77	82	92	101	97	**97**	83	68	64	**79.7**
1996	56	65	71	82	90	93	96	96	90	83	66	57	**78.8**
1997	58	60	75	76	88	93	98	92	91	84	68	54	**78.1**
1998	56	62	77	80	87	99	100	95	90	85	67	60	**79.8**
1999	62	65	75	78	85	94	99	91	89	85	**75**	**67**	**80.4**
2000	**66**	66	70	85	**97**	94	97	97	93	83	57	55	**80.0**
2001	51	62	70	81	90	96	99	94	93	86	**75**	59	**79.7**
2002	59	63	74	81	95	98	100	**99**	90	77	63	55	**79.5**
2003	57	59	74	78	95	96	**103**	98	92	87	67	62	**80.7**
2004	51	62	**82**	78	89	96	99	97	91	78	67	60	**79.2**
2005	57	57	68	80	94	98	**103**	95	89	83	74	59	**79.8**
2006	57	62	71	85	92	99	100	92	87	83	69	54	**79.3**
2007	56	64	76	81	85	95	98	96	89	80	71	53	**78.7**
2008	51	54	70	79	89	93	94	97	87	81	74	53	**76.9**
2009	53	69	73	78	88	92	96	96	88	77	72	49	**77.6**
2010	44	50	75	78	90	98	98	94	89	**88**	71	59	**77.8**
2011	50	63	72	79	87	96	97	95	89	81	68	57	**77.8**
2012	53	59	73	85	87	98	97	95	90	83	70	60	**79.2**
2013	54	58	74	80	87	99	97	93	91	77	68	55	**77.8**
2014	60	66	69	78	91	94	97	92	91	77	74	59	**79.0**
2015	58	66	76	78	81	98	97	94	88	**88**	71	57	**79.3**
2016	55	66	73	82	85	**101**	97	94	88	79	70	56	**78.8**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2017	52	64	80	80	86	100	99	93	95	84	73	63	**80.6**
Mean	**54.4**	**62.5**	**72.0**	**79.5**	**87.4**	**96.2**	**97.9**	**95.1**	**90.5**	**81.0**	**68.1**	**56.3**	**78.4**
Maximum	**66**	**70**	**82**	**86**	**97**	**101**	**103**	**99**	**97**	**88**	**75**	**67**	
Year	**2000**	**1986**	**2004**	**1992**	**2000**	**2016**	**1989 1990 2003 2005**	**1969 1970 1983 2002**	**1995**	**2010 2015**	**1999 2001**	**1999**	

Table 9. Summary of lowest temperatures (ºF). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969	9	12	13	27	37	44	**43**	52	46	26	14	7	**27.5**
1970	0	15	11	20	27	39	53	54	34	21	18	14	**25.5**
1971	**-18**	5	6	17	31	38	54	54	**28**	18	17	4	**21.2**
1972	2	2	14	24	30	47	56	54	37	22	15	2	**25.4**
1973	1	10	20	18	28	41	52	49	37	26	14	9	**25.4**
1974	-11	1	20	18	28	38	53	52	33	30	14	1	**23.1**
1975	-2	9	9	19	**23**	38	55	49	40	20	7	6	**22.8**
1976	-4	12	11	23	34	38	54	52	42	22	**1**	9	**24.5**
1977	-2	13	12	21	33	51	57	54	46	32	20	10	**28.9**
1978	12	0	20	26	31	45	51	46	32	31	18	-9	**25.3**
1979	-8	5	17	**16**	29	36	51	51	42	23	6	9	**23.1**
1980	14	18	13	18	27	36	53	**41**	37	17	12	11	**24.8**
1981	10	11	21	19	32	36	44	49	42	21	13	4	**25.2**
1982	-1	-3	19	22	30	38	47	54	38	21	17	6	**24.0**
1983	9	20	22	20	27	36	61	55	30	35	11	10	**28.0**
1984	2	11	14	18	27	40	53	54	39	23	15	13	**25.8**
1985	6	-1	13	28	29	39	53	51	31	31	8	8	**24.7**
1986	8	8	19	23	33	42	53	52	40	28	16	8	**27.5**
1987	2	8	9	24	35	43	50	47	40	32	14	1	**25.4**
1988	-2	16	9	21	30	38	54	54	33	36	12	1	**25.2**
1989	4	**-14**	14	29	36	41	55	48	36	**15**	9	3	**23.0**
1990	0	4	19	30	39	47	55	52	45	26	16	**-16**	**26.4**
1991	-3	12	17	24	30	39	53	54	39	20	11	3	**24.9**
1992	10	17	20	30	40	41	47	48	37	28	7	-2	**26.9**
1993	10	18	18	24	32	39	49	52	38	17	8	8	**26.1**
1994	7	4	12	26	35	46	50	57	39	26	8	11	**26.8**
1995	12	21	18	24	34	38	45	55	36	24	13	9	**27.4**
1996	6	12	16	20	39	41	54	52	29	16	19	3	**25.6**
1997	-1	13	13	19	26	46	51	53	43	19	17	8	**25.6**
1998	12	15	13	25	31	40	59	52	46	27	16	3	**28.3**
1999	11	7	21	20	30	**32**	50	49	**28**	19	9	3	**23.3**
2000	1	14	17	28	29	44	52	52	33	32	10	11	**26.9**
2001	10	8	21	24	34	36	57	52	36	28	13	8	**27.3**
2002	3	6	**3**	27	35	48	56	50	39	30	19	8	**27.0**
2003	17	8	22	24	29	46	53	57	41	28	12	7	**28.7**
2004	8	6	21	32	32	44	52	51	35	26	8	4	**26.6**
2005	19	18	20	20	34	37	56	53	42	30	16	-2	**28.6**
2006	10	11	17	27	35	48	56	49	31	24	4	5	**26.4**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2007	4	3	9	24	32	38	56	56	33	19	14	2	**24.2**
2008	-7	4	17	21	27	40	54	53	41	22	13	7	**24.3**
2009	15	12	21	19	43	44	56	48	31	22	12	1	**27.0**
2010	5	12	18	21	26	44	49	53	44	24	6	3	**25.4**
2011	-5	-6	19	21	26	46	51	57	44	27	19	4	**25.3**
2012	7	16	13	25	37	45	57	55	45	24	16	5	**28.8**
2013	-6	11	13	21	28	40	57	52	33	27	15	3	**24.5**
2014	8	14	18	25	27	46	58	48	41	35	12	3	**27.9**
2015	9	15	16	24	32	49	54	56	48	31	15	6	**29.6**
2016	8	8	20	25	35	50	54	49	37	31	12	11	**28.2**
2017	5	15	17	23	32	44	57	52	30	27	15	8	**27.0**
Mean	**4.2**	**9.3**	**15.8**	**22.9**	**31.5**	**41.7**	**53.1**	**51.8**	**37.7**	**25.3**	**12.8**	**5.1**	**25.9**
Minimum	**-18**	**-14**	**3**	**16**	**23**	**32**	**43**	**41**	**28**	**15**	**1**	**-16**	
Years	**1971**	**1989**	**2002**	**1979**	**1975**	**1999**	**1969**	**1980**	**1971 1999**	**1989**	**1976**	**1990**	

Table 10. Summary of number of days 32 ºF or below and 0 ºF or below in critical months. NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

	–––––––––– Number of Days 32 ºF or Below ––––––––––––											– Number of Days – 0 ºF or Below			
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	**Jan**	**Feb**	**Dec**	**Total**
1969	22	26	25	7	0	0	0	7	22	29	**138**	0	0	0	**0**
1970	29	25	26	23	2	0	0	12	23	30	**170**	1	0	0	**1**
1971	29	27	22	13	1	0	2	8	26	27	**155**	4	0	0	**4**
1972	31	27	19	10	2	0	0	2	24	31	**146**	0	0	0	**0**
1973	31	26	25	17	1	0	0	5	16	28	**149**	0	0	0	**0**
1974	30	28	14	14	2	0	0	2	24	30	**144**	2	0	0	**2**
1975	29	27	24	15	3	0	0	6	25	30	**159**	2	0	0	**2**
1976	31	22	24	8	0	0	0	10	22	31	**148**	2	0	0	**2**
1977	31	28	26	8	0	0	0	1	20	30	**144**	3	0	0	**3**
1978	28	21	12	6	2	0	0	1	14	29	**113**	0	1	5	**6**
1979	29	27	25	11	3	0	0	5	24	31	**155**	3	1	0	**4**
1980	23	21	25	15	2	0	0	12	18	28	**144**	0	0	0	**0**
1981	29	26	24	3	1	0	0	11	19	31	**144**	0	0	0	**0**
1982	29	25	18	12	1	0	0	12	22	29	**148**	1	2	0	**3**
1983	31	25	18	15	6	0	1	0	18	26	**140**	0	0	0	**0**
1984	31	29	24	15	1	0	0	12	18	29	**159**	0	0	0	**0**
1985	31	25	16	5	1	0	1	2	19	30	**130**	0	1	0	**1**
1986	28	21	20	6	0	0	0	6	18	29	**128**	0	0	0	**0**
1987	28	25	24	10	0	0	0	3	22	31	**143**	0	0	0	**0**
1988	31	25	27	9	2	0	0	0	16	29	**139**	2	0	0	**2**
1989	31	24	13	5	0	0	0	6	27	31	**137**	0	2	0	**2**
1990	30	21	14	3	0	0	0	6	19	28	**121**	2	0	7	**9**
1991	31	22	20	11	2	0	0	4	23	31	**144**	2	0	0	**2**
1992	31	23	15	3	0	0	0	2	28	29	**131**	0	0	1	**1**
1993	28	22	24	11	3	0	0	9	25	31	**153**	0	0	0	**0**
1994	30	24	14	8	0	0	0	4	22	28	**130**	0	0	0	**0**
1995	28	18	15	15	0	0	0	7	23	28	**134**	0	0	0	**0**

	–––––––––– Number of Days 32 ºF or Below ––––––––––––										– Number of Days – 0 ºF or Below			
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	**Jan**	**Feb**	**Dec**	**Total**
1996	31	23	21	11	0	0	2	9	24	28	**149**	0	0	0	**0**
1997	29	27	23	16	1	0	0	11	22	31	**160**	1	0	0	**1**
1998	31	23	20	17	1	0	0	4	22	30	**148**	0	0	0	**0**
1999	30	26	19	12	4	1	2	8	24	30	**156**	0	0	0	**0**
2000	25	23	24	5	1	0	0	1	24	29	**132**	0	0	0	**0**
2001	31	23	13	6	0	0	0	2	13	29	**117**	0	0	0	**0**
2002	31	28	23	2	0	0	0	4	25	31	**144**	0	0	0	**0**
2003	30	22	21	9	3	0	0	2	18	29	**134**	0	0	0	**0**
2004	31	25	11	1	1	0	0	6	20	30	**125**	0	0	0	**0**
2005	27	17	21	8	0	0	0	1	19	30	**123**	0	0	1	**1**
2006	29	27	20	3	0	0	1	10	17	30	**137**	0	0	0	**0**
2007	31	22	14	4	1	0	0	5	23	28	**128**	0	0	0	**0**
2008	29	29	23	12	2	0	0	6	20	28	**149**	3	0	0	**3**
2009	30	25	20	14	0	0	1	10	17	31	**148**	0	0	0	**0**
2010	31	28	25	9	5	0	0	5	24	20	**147**	0	0	0	**0**
2011	31	25	18	9	3	0	0	6	23	31	**146**	2	3	0	**5**
2012	31	29	20	6	0	0	0	5	17	28	**136**	0	0	0	**0**
2013	27	28	18	9	2	0	0	11	22	31	**148**	2	0	0	**2**
2014	30	26	20	12	2	0	0	0	22	26	**138**	0	0	0	**0**
2015	30	25	13	8	1	0	0	2	21	31	**131**	0	0	0	**0**
2016	30	26	21	6	0	0	0	1	10	28	**122**	0	0	0	**0**
2017	28	16	8	10	1	0	2	3	9	28	**105**	0	0	0	**0**
Mean	**29.4**	**24.6**	**19.8**	**9.5**	**1.3**	**0.0**	**0.3**	**5.4**	**20.7**	**29.2**	**140.2**	**0.7**	**0.2**	**0.3**	**1.1**
Total	**1443**	**1203**	**969**	**467**	**63**	**1**	**12**	**267**	**1013**	**1431**	**6869**	**32**	**10**	**14**	**56**

Table 11. Summary of number of days 100 ºF or above and number of days 95 ºF or above in critical months. NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

	–––––––– Number of Days 95 ºF or Above ––––––––					––– Number of Days ––– 100 ºF or Above		
Year	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**	**Jun**	**Jul**	**Total**
1969	0	1	3	5	1	**10**	0	0	**0**
1970	0	5	13	5	0	**23**	0	0	**0**
1971	0	5	11	0	0	**16**	0	2	**2**
1972	0	0	13	4	0	**17**	0	1	**1**
1973	0	5	6	6	0	**17**	0	0	**0**
1974	0	17	1	0	0	**18**	0	0	**0**
1975	0	1	1	3	0	**5**	0	0	**0**
1976	0	3	11	0	0	**14**	0	1	**1**
1977	0	3	6	3	0	**12**	0	0	**0**
1978	0	1	2	0	0	**3**	0	0	**0**
1979	0	1	9	3	0	**13**	0	0	**0**
1980	0	6	11	5	0	**22**	0	0	**0**
1981	0	5	5	1	0	**11**	0	0	**0**
1982	0	0	4	1	0	**5**	0	0	**0**
1983	0	0	3	1	0	**4**	0	0	**0**

	––––––– Number of Days 95 ºF or Above –––––––						––– Number of Days ––– 100 ºF or Above		
Year	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**	**Jun**	**Jul**	**Total**
1984	0	0	3	0	0	**3**	0	0	**0**
1985	0	3	12	1	0	**16**	0	0	**0**
1986	0	0	2	2	0	**4**	0	0	**0**
1987	0	0	2	0	0	**2**	0	0	**0**
1988	0	5	7	0	0	**12**	0	0	**0**
1989	0	2	16	0	0	**18**	0	5	**5**
1990	0	8	3	0	0	**11**	2	1	**3**
1991	0	0	3	0	0	**3**	0	0	**0**
1992	0	0	2	1	0	**3**	0	0	**0**
1993	0	4	3	2	0	**9**	0	0	**0**
1994	0	6	11	5	0	**22**	1	0	**1**
1995	0	0	12	6	1	**19**	0	3	**3**
1996	0	0	6	4	0	**10**	0	0	**0**
1997	0	0	4	0	0	**4**	0	0	**0**
1998	0	3	16	1	0	**20**	0	2	**2**
1999	0	0	2	0	0	**2**	0	0	**0**
2000	1	0	5	7	0	**13**	0	0	**0**
2001	0	3	10	0	0	**13**	0	0	**0**
2002	1	14	13	5	0	**36**	0	1	**1**
2003	1	2	26	7	0	**36**	0	9	**9**
2004	0	3	6	2	0	**11**	0	0	**0**
2005	0	2	22	1	0	**25**	0	7	**7**
2006	0	11	11	0	0	**22**	0	1	**1**
2007	0	3	12	3	0	**18**	0	0	**0**
2008	0	0	0	3	0	**3**	0	0	**0**
2009	0	0	7	1	0	**8**	0	0	**0**
2010	0	1	6	0	0	**7**	0	0	**0**
2011	0	3	4	2	0	**9**	0	0	**0**
2012	0	5	2	1	0	**8**	0	0	**0**
2013	0	5	1	0	0	**6**	0	0	**0**
2014	0	0	8	0	0	**8**	0	0	**0**
2015	0	7	2	0	0	**9**	0	0	**0**
2016	0	11	6	0	0	**17**	1	0	**1.0**
2017	0	5	6	0	0	**11**	1	0	**1.0**
Mean	**0.1**	**3.2**	**7.2**	**1.9**	**0.0**	**12.5**	**0.1**	**0.7**	**0.8**
Total	**3**	**159**	**353**	**91**	**2**	**608**	**5**	**33**	**38**

Table 12. Summary of mean daily evaporation (inches per day). NMSU Agricultural Science Center at Farmington, NM. 1972 – 2017.

Year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mean
1972	-	-	-	0.477	0.478	0.381	0.319	0.142	-	**0.359**
1973	-	-	0.347	0.370	0.372	0.344	0.319	-	-	**0.350**
1974	-	-	0.419	0.512	0.415	0.415	0.395	0.311	-	**0.411**
1975	-	0.206	0.299	0.401	0.396	0.403	0.270	0.242	-	**0.317**
1976	-	0.309	0.380	0.515	0.444	0.423	0.302	0.190	-	**0.366**
1977	0.226	0.304	0.396	0.498	0.423	0.394	0.317	0.213	-	**0.346**
1978	-	0.310	0.311	0.427	0.469	0.422	0.321	0.257	-	**0.360**
1979	-	0.278	0.278	0.362	0.354	0.342	0.317	0.229	-	**0.309**
1980	-	0.258	0.322	0.489	0.452	0.406	0.272	0.280	-	**0.354**
1981	-	0.254	0.297	0.470	0.388	0.363	0.255	0.165	-	**0.313**
1982	-	0.245	0.323	0.427	0.392	0.314	0.193	0.260	-	**0.308**
1983	-	-	0.328	0.384	0.404	0.357	0.291	0.203	-	**0.328**
1984	-	0.245	0.391	0.389	0.379	0.334	0.261	0.106	-	**0.301**
1985	-	0.212	0.282	0.409	0.409	0.374	0.233	0.141	0.155	**0.277**
1986	-	0.245	0.317	0.366	0.366	0.366	0.225	0.242	0.155	**0.285**
1987	-	-	0.277	0.383	0.393	0.335	0.274	0.101	-	**0.294**
1988	-	0.234	0.373	0.369	0.421	0.314	0.285	0.198	0.151	**0.293**
1989	-	0.330	0.393	0.418	0.446	0.356	0.312	0.219	-	**0.353**
1990	-	0.255	0.373	0.516	0.411	0.366	0.294	0.186	-	**0.343**
1991	-	0.299	0.377	0.366	0.411	0.358	0.284	0.238	-	**0.333**
1992	-	0.277	0.280	0.405	0.383	0.348	0.272	0.211	-	**0.311**
1993	-	0.322	0.339	0.465	0.477	0.328	0.304	0.180	-	**0.345**
1994	-	0.278	0.383	0.501	0.504	0.402	0.309	0.246	-	**0.375**
1995	-	0.249	0.315	0.424	0.445	0.375	0.324	0.241	-	**0.339**
1996	-	0.303	0.435	0.424	0.451	0.358	0.236	0.182	-	**0.341**
1997	-	0.246	0.301	0.395	0.399	0.309	0.259	0.187	-	**0.299**
1998	-	0.242	0.367	0.471	0.420	0.366	0.334	0.189	-	**0.341**
1999	-	0.277	0.347	0.437	0.379	0.280	0.274	0.240	-	**0.319**
2000	-	0.320	0.426	0.470	0.425	0.366	0.295	0.157	-	**0.351**
2001	-	0.281	0.378	0.465	0.405	0.352	0.361	0.235	-	**0.354**
2002	-	0.307	0.428	0.493	0.455	0.396	0.261	0.149	-	**0.356**
2003	-	0.274	0.374	0.493	0.504	0.397	0.311	0.212	-	**0.366**
2004	-	0.248	0.403	0.48	0.442	0.365	0.276	0.159	-	**0.339**
2005	-	0.272	0.362	0.420	0.490	0.338	0.277	0.162	-	**0.332**
2006	-	0.323	0.415	0.488	0.408	0.341	0.251	0.163	-	**0.341**
2007	-	0.266	0.315	0.447	0.416	0.360	0.289	0.211	-	**0.329**
2008	-	0.311	0.367	0.460	0.381	0.367	0.296	0.208	-	**0.341**
2009	-	0.277	0.285	0.336	0.430	0.362	0.261	0.169	-	**0.303**
2010	-	0.278	0.351	0.413	0.395	0.306	0.286	0.182	-	**0.316**
2011	-	0.300	0.344	0.482	0.424	0.377	0.252	0.171	-	**0.336**
2012	-	0.293	0.396	0.482	0.381	0.366	0.296	0.241	-	**0.351**
2013	-	0.300	0.349	0.462	0.387	0.318	0.265	0.177	-	**0.323**
2014	-	0.252	0.335	0.455	0.421	0.296	0.218	0.185	-	**0.309**
2015	-	0.247	0.210	0.295	0.302	0.343	0.255	0.141	-	**0.256**
2016		0.234	0.291	0.499	0.408	0.234	0.223	0.184		**0.296**
2017		0.187	0.286	0.469	0.333	0.297	0.207	0.225		**0.286**
Mean	**0.226**	**0.272**	**0.346**	**0.439**	**0.415**	**0.355**	**0.281**	**0.198**	**0.154**	**0.330**
Years	**1**	**41**	**45**	**46**	**46.0**	**46.0**	**46**	**45**	**3**	**46**

Table 13. Summary of mean monthly evaporation (inches per month). NMSU Agricultural Science Center at Farmington, NM. 1972 – 2017.

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1972	-	-	14.31	14.82	11.81	9.57	4.40	**54.91**
1973	-	10.76	11.10	11.53	10.66	9.57	-	**53.62**
1974	-	12.99	15.36	12.87	12.25	9.33	4.59	**67.39**
1975	6.18	9.27	12.03	12.28	12.49	8.10	7.50	**67.85**
1976	9.27	11.78	15.45	13.76	13.11	9.06	5.89	**78.32**
1977	9.12	12.28	14.94	13.11	12.21	9.51	6.60	**77.77**
1978	9.30	9.64	12.81	14.54	13.08	9.63	7.97	**76.97**
1979	8.34	8.62	10.86	10.97	10.60	9.51	7.10	**66.00**
1980	7.74	9.98	14.67	14.01	12.59	8.16	8.68	**75.83**
1981	7.62	9.21	14.10	12.03	11.25	7.65	5.12	**66.98**
1982	7.35	10.01	12.81	12.14	9.73	7.28	8.06	**67.38**
1983	-	8.85	11.51	12.51	11.06	8.72	6.35	**59.00**
1984	6.37	12.15	11.66	11.74	10.43	7.84	3.29	**63.48**
1985	6.35	8.74	12.27	12.68	11.61	6.99	4.44	**63.08**
1986	7.36	9.82	10.97	11.34	11.34	6.75	-	**57.58**
1987	-	6.64	11.47	12.19	10.39	8.23	3.12	**52.04**
1988	-	11.55	11.06	13.05	9.74	8.55	6.16	**60.11**
1989	-	12.18	12.54	13.83	11.04	9.37	-	**58.96**
1990	7.65	11.56	15.48	12.74	11.35	8.82	5.77	**73.37**
1991	8.68	11.68	10.99	12.77	11.11	8.53	-	**63.76**
1992	7.76	8.67	12.15	11.89	10.80	8.19	6.53	**65.99**
1993	9.66	10.52	13.94	14.78	10.17	9.11	5.57	**73.75**
1994	8.35	11.90	15.04	15.63	12.46	9.28	7.38	**80.04**
1995	7.48	9.78	12.72	13.81	11.63	9.74	7.48	**72.64**
1996	9.10	13.50	12.72	13.99	11.10	7.08	5.66	**73.15**
1997	7.37	9.33	11.84	12.36	9.59	7.78	5.80	**64.07**
1998	7.27	11.37	14.12	13.03	11.36	10.03	5.85	**73.03**
1999	8.31	10.75	13.12	11.75	8.68	8.21	7.45	**68.27**
2000	9.62	13.20	14.11	13.16	11.36	8.86	4.87	**75.18**
2001	8.45	11.35	13.92	11.75	10.93	10.59	7.29	**74.28**
2002	9.21	13.29	14.79	14.09	12.28	7.82	4.63	**76.11**
2003	8.22	11.58	14.80	15.63	12.32	9.33	6.58	**78.46**
2004	7.43	12.49	14.27	13.69	11.32	8.28	4.93	**72.41**
2005	8.17	11.21	12.59	15.20	10.47	8.30	5.03	**70.97**
2006	8.72	12.85	14.65	12.65	10.58	7.52	5.05	**72.02**
2007	7.97	9.78	13.41	12.90	11.15	8.68	6.54	**70.40**
2008	9.33	11.38	13.80	11.84	11.39	8.89	6.45	**73.08**
2009	8.33	8.86	10.08	13.34	11.24	7.83	5.26	**64.94**
2010	8.35	10.88	12.40	12.25	9.49	8.58	5.64	**67.59**
2011	9.02	10.68	14.46	13.15	11.71	7.57	5.32	**71.90**
2012	8.78	12.29	14.45	11.80	11.35	8.88	7.48	**75.03**
2013	8.02	10.82	13.86	12.00	9.86	7.96	5.50	**69.02**
2014	7.68	10.64	13.64	13.52	10.24	8.09	5.69	**69.50**

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2015	8.02	7.87	10.64	10.08	11.49	8.17	5.38	**61.65**
2016	7.83	9.94	14.98	13.12	8.40	7.74	5.80	**67.81**
2017	7.24	10.00	14.10	12.83	9.30	7.78	7.05	**68.29**
Mean	**8.15**	**10.73**	**13.20**	**12.94**	**11.05**	**8.51**	**5.98**	**68.87**
Years	**39**	**45**	**46**	**46**	**46**	**46**	**42**	**46**

Table 14. Summary of wind movement in miles per day (MPD) at 0.15 meter (6 inch) height above evaporation pan. NMSU Agricultural Science Center at Farmington, NM. 1980 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
	––––––––––––––––––– 0.15 meter (6 inches) above evaporation pan –––––––––––––––––												
1980	64	66	100	97	80	57	44	41	27	30	23	14	**53.6**
1981	50	80	94	85	71	64	58	60	20	55	56	52	**62.1**
1982	69	36	63	89	78	42	59	75	77	86	77	89	**70.0**
1983	82	101	107	101	108	98	76	70	62	73	94	98	**89.2**
1984	63	101	104	114	78	94	66	61	70	71	99	67	**82.3**
1985	49	87	128	98	76	66	70	76	70	72	148	55	**82.9**
1986	53	61	72	95	78	64	52	66	60	45	50	45	**61.8**
1987	60	41	50	50	31	22	25	19	21	48	71	79	**43.1**
1988	76	73	99	88	99	81	75	71	75	64	82	82	**80.4**
1989	84	75	96	86	69	73	78	72	73	68	68	59	**75.1**
1990	78	97	90	91	91	84	82	82	76	72	71	83	**83.1**
1991	61	73	106	98	99	75	79	67	72	57	59	47	**74.4**
1992	64	66	80	76	72	74	66	70	62	58	68	66	**68.5**
1993	103	86	105	107	91	81	71	75	74	65	82	79	**84.9**
1994	81	96	83	94	71	61	72	72	63	58	84	59	**74.5**
1995	76	65	83	81	80	61	63	59	52	64	58	49	**65.9**
1996	92	79	88	93	72	73	72	60	44	51	53	71	**70.7**
1997	43	79	78	73	70	62	55	48	50	48	39	35	**56.7**
1998	59	75	83	81	66	72	70	66	62	78	66	59	**69.8**
1999	76	74	83	109	95	70	63	63	61	65	73	78	**75.8**
2000	83	88	93	93	85	80	66	64	62	63	60	57	**74.5**
2001	65	74	72	91	83	77	64	67	74	74	65	75	**73.4**
2002	74	90	104	83	59	64	69	55	62	50	56	49	**67.9**
2003	36	58	60	68	70	70	56	60	56	50	56	62	**58.5**
2004	36	56	61	65	53	54	54	46	48	44	52	29	**49.8**
2005	52	54	72	71	50	50	49	43	44	44	46	39	**51.2**
2006	52	51	61	66	57	61	53	47	43	44	37	48	**51.7**
2007	40	53	47	62	50	-	-	41	51	62	38	54	**49.8**
2008	48	69	81	92	82	65	50	35	31	60	65	69	**62.3**
2009	41	57	77	80	52	44	48	43	47	54	49	66	**54.8**
2010	33	59	79	82	-	-	-	-	-	-	-	-	
2011	-	-	-	-	-	74	60	57	58	61	72	51	
2012	65	78	84	84	73	62	50	52	46	63	60	64	**65.1**
2013	58	82	94	103	77	65	62	49	54	65	61	64	**69.5**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
	––––––––––––––––––– 0.15 meter (6 inches) above evaporation pan –––––––––––––––––												
2014	76	69	90	-	-	-	-	-	-	-	-	-	
2015	-	-	47	51	46	38	42	39	29	35	43	44	**41.3**
2016	26	47	61	44	41	36	36	29	25	22	28	21	**34.7**
2017	26	25		36	32	25	24	16	22	37	25	28	**26.9**
Mean (MPD)	**60.9**	**70.0**	**82.6**	**82.7**	**71.0**	**64.0**	**59.4**	**56.0**	**53.4**	**57.1**	**62.1**	**57.9**	**64.5**
Mean (MPH)	**2.5**	**2.9**	**3.4**	**3.4**	**3.0**	**2.7**	**2.5**	**2.3**	**2.2**	**2.4**	**2.6**	**2.4**	**2.7**

Blank cells represent 3 or more days of missing data.

Table 15. Summary of wind movement in miles per day (MPD) at two meter height above ground. NMSU Agricultural Science Center at Farmington, NM. 1980 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
	–––––––––––––––––––––– 2 meters above ground ––––––––––––––––––––––––												
1980	-	-	-	-	134	132	116	96	82	78	80	84	
1981	112	124	141	124	102	81	62	82	71	81	76	58	**92.8**
1982	88	63	97	127	100	122	103	91	99	95	86	99	**97.5**
1983	111	139	147	154	141	120	116	102	113	107	130	136	**126.3**
1984	64	115	93	136	88	96	52	46	49	44	136	110	**85.8**
1985	95	127	183	155	142	136	136	133	125	127	72	117	**129.0**
1986	113	129	145	179	154	139	128	134	128	118	116	99	**131.8**
1987	139	131	143	158	139	126	122	119	132	108	123	117	**129.8**
1988	121	122	163	148	166	138	132	126	120	91	98	98	**126.9**
1989	97	133	151	147	132	123	126	120	125	115	112	104	**123.8**
1990	125	152	146	170	165	154	141	136	127	135	127	130	**142.3**
1991	101	120	190	191	167	138	140	119	129	111	109	85	**133.3**
1992	117	119	137	142	133	137	118	118	111	110	113	106	**121.8**
1993	164	139	153	171	144	86	57	80	103	87	92	-	**116.0**
1994	130	156	144	166	135	130	136	127	120	119	154	115	**136.0**
1995	137	129	147	176	185	137	128	118	115	137	129	100	**136.5**
1996	171	145	161	182	149	140	127	119	112	134	119	147	**142.2**
1997	106	149	146	153	137	113	112	101	105	115	118	110	**122.1**
1998	100	133	145	144	112	120	111	100	105	131	111	106	**118.2**
1999	143	142	145	186	196	92	85	100	107	98	93	126	**126.1**
2000	132	141	149	158	144	135	108	104	108	110	113	109	**125.9**
2001	116	127	173	147	141	128	106	108	121	125	110	132	**127.8**
2002	117	144	163	134	126	115	114	96	108	90	110	107	**118.7**
2003	98	134	143	139	134	128	106	107	113	103	116	129	**120.8**
2004	93	121	135	134	120	114	112	99	100	102	119	87	**111.3**
2005	107	111	146	153	117	116	111	94	98	98	119	113	**115.3**
2006	131	140	139	143	126	127	106	95	103	104	122	106	**120.2**
2007	96	131	121	147	122	129	109	89	96	117	103	128	**115.7**
2008	106	125	142	165	144	128	101	95	94	108	121	133	**121.8**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
	––––––––––––––––––––––– 2 meters above ground –––––––––––––––––––––––––												
2009	100	119	144	157	108	96	96	88	94	106	87	145	**111.7**
2010	73	100	130	154	125	63	94	78	79	89	108	90	**98.6**
2011	78	113	130	159	127	107	82	78	79	85	102	74	**101.2**
2012	99	110	114	116	99	89	72	76	73	90	79	94	**92.6**
2013	83	106	122	137	98	73	81	71	76	88	84	82	**91.8**
2014	97	82	99	118	78	74	80	61	52	58	74	65	**78.2**
2015	57	67	76	90	68	56	61	57	38	49	66	56	**61.7**
2016	41	73	104	89	54	71	62	59	45	63	63	53	**64.8**
2017	58	59	89	84	81	77	65	58	61	63	40	38	**64.5**
Mean (MPD)	**105.8**	**120.8**	**137.7**	**146.9**	**127.6**	**112.8**	**103.0**	**96.9**	**97.8**	**99.7**	**103.4**	**102.4**	**113.0**
Mean (MPH)	**4.4**	**5.0**	**5.7**	**6.1**	**5.3**	**4.7**	**4.3**	**4.0**	**4.1**	**4.2**	**4.3**	**4.3**	**4.7**

Blank cells represent 3 or more days of missing data.

Table 16. Summary of mean daily solar radiation (Langleys). NMSU Agricultural Science Center at Farmington, NM. 1977 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
1977	204	305	386	552	438	530	501	464	396	360	-*	-*	4,136	**413.6**
1978	157	168	334	459	490	586	641	491	401	292	185	166	4,370	**364.2**
1979	166	261	302	423	445	527	489	477	459	267	165	155	4,136	**344.7**
1980	141	192	300	429	459	529	595	501	436	342	280	145	4,349	**362.4**
1981	190	296	292	473	499	607	550	489	422	314	248	200	4,580	**381.7**
1982	129	207	369	536	594	707	651	565	470	393	227	208	5,052	**421.3**
1983	188	294	345	518	654	734	793	725	583	332	230	176	5,575	**464.3**
1984	250	345	486	540	688	494	736	744	595	317	226	188	5,606	**467.4**
1985	242	-*	-*	499	618	816	843	801	557	410	256	184	6,274	**522.6**
1986	243	304	505	584	837	736	1,028	1,223	918	513	282	205	7,381	**614.8**
1987	229	289	506	566	551	665	638	542	483	352	246	197	5,264	**438.7**
1988	220	305	474	496	626	623	621	555	486	470	251	216	5,344	**445.3**
1989	224	280	419	550	628	633	619	570	498	361	277	219	5,278	**439.8**
1990	222	282	316	479	593	662	620	541	462	361	234	203	4,975	**414.6**
1991	212	309	356	554	651	556	613	537	450	340	249	146	4,973	**414.4**
1992	189	268	358	509	530	616	560	501	451	324	238	167	4,711	**392.6**
1993	160	230	374	514	532	599	614	464	456	331	240	187	4,702	**391.8**
1994	223	262	371	439	482	564	555	496	411	300	225	178	4,506	**375.5**
1995	189	288	358	438	481	552	520	459	373	324	212	157	4,351	**362.6**
1996	240	309	463	580	651	609	676	604	458	357	250	226	5,423	**451.9**
1997	215	314	516	513	613	657	640	567	491	390	267	220	5,403	**450.3**
1998	236	260	443	563	661	725	604	565	506	331	266	244	5,404	**450.3**
1999	263	363	458	527	624	702	584	515	505	438	320	241	5,540	**461.7**
2000	251	305	399	581	689	696	673	579	479	325	255	213	5,445	**453.8**
2001	241	322	424	508	672	766	633	580	541	396	286	248	5,617	**468.1**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
2002	251	383	492	593	710	742	663	601	479	372	294	219	5,799	**483.3**
2003	249	315	452	596	640	719	692	604	510	401	200	203	5,581	**465.1**
2004	186	264	418	451	656	703	646	531	468	346	214	201	5,084	**423.7**
2005	206	272	402	526	624	639	664	539	442	347	277	232	5,170	**430.8**
2006	258	362	375	539	644	616	533	472	426	308	249	188	4,970	**414.2**
2007	228	284	396	539	562	676	535	455	407	406	310	220	5,018	**418.2**
2008	287	341	514	617	673	729	641	587	504	405	286	223	5,807	**483.9**
2009	262	352	431	541	608	589	637	581	473	358	276	200	5,308	**442.3**
2010	232	293	451	553	677	695	624	547	501	375	286	175	5,409	**450.8**
2011	264	354	465	562	668	712	652	570	465	374	260	202	5,548	**462.3**
2012	260	333	458	544	656	706	601	551	491	415	303	244	5,562	**463.5**
2013	269	360	468	571	636	688	599	547	464	425	260	221	5,508	**459.0**
2014	265	313	-	523	614	698	-	539	474	376	-*	204	4,006	**445.1**
2015	218	326	474	572	**517	**602	575	556	481	362	289	206	5,178	**431.5**
2016	240	354	458	524	618	694	658	**551	**489	**408	258	216	5,469	**455.7**
2017	194	292	442	532	608	721	639	557	479	412	271	254	5401	**450.1**
Mean	**221.8**	**298.9**	**416.7**	**527.2**	**605.3**	**654.2**	**633.9**	**569.3**	**483.9**	**366.6**	**255.1**	**202.4**	**5,235**	**436.3**

*Blank cells represent 3 or more days of missing data.

**Months where solar radiation was missing due to a faulty sensor. Data were approximated by regressing the 2010 – 2015 NMSU data (not including missing values) on the aWhere Inc. weather database (http://awhere.com) as $y = 3.025 + 0.816x$ ($n = 2018$, $R^2 = 0.695$) where y = NMSU values and x = aWhere values.

Table 17. Summary of forty-nine year total monthly Growing Degree Days* (May through September, and first fall freeze). NMSU Agricultural Science Center at Farmington, NM. 1969 – 2017.

Year	May	Jun	Jul	Aug	Sep	May - Sep	Ist Freeze Date	Total to 1st Frost (32 ºF)
1969	434	510	729	744	570	**2,987**	**Oct 05**	**3,017**
1970	434	555	744	744	420	**2,897**	**Oct 08**	**2,949**
1971	372	600	729	713	450	**2,864**	**Sep 18**	**2,684**
1972	434	615	744	713	495	**3,001**	**Oct 30**	**3,201**
1973	372	640	713	713	435	**2,873**	**Oct 11**	**2,990**
1974	465	645	729	698	450	**2,987**	**Oct 30**	**3,227**
1975	326	525	713	667	435	**2,666**	**Oct 14**	**2,806**
1976	403	585	744	698	495	**2,925**	**Oct 07**	**2,978**
1977	372	675	744	729	540	**3,060**	**Oct 31**	**3,386**
1978	310	570	729	667	450	**2,726**	**Sep 20**	**2,576**
1979	341	510	682	667	555	**2,755**	**Oct 22**	**2,986**
1980	341	570	698	682	450	**2,741**	**Oct 16**	**2,869**
1981	372	600	682	651	450	**2,755**	**Oct 16**	**2,875**
1982	341	525	682	698	450	**2,696**	**Oct 06**	**2,741**
1983	341	495	682	729	525	**2,772**	**Sep 21**	**2,615**
1984	465	555	729	713	480	**2,942**	**Oct 15**	**3,017**
1985	397	600	710	692	416	**2,815**	**Sep 30**	**2,926**
1986	377	574	661	693	395	**2,700**	**Oct 12**	**2,790**
1987	366	592	674	646	473	**2,751**	**Oct 19**	**2,873**
1988	396	607	722	697	476	**2,898**	**Nov 12**	**2,981**
1989	468	565	731	670	540	**2,974**	**Oct 18**	**3,131**
1990	378	635	729	673	532	**2,947**	**Oct 09**	**3,029**
1991	409	557	704	701	471	**2,842**	**Oct 28**	**3,153**
1992	385	536	630	639	484	**2,674**	**Oct 08**	**2,763**
1993	416	538	652	615	454	**2,675**	**Oct 19**	**2,854**
1994	426	628	729	746	495	**3,024**	**Oct 17**	**3,169**
1995	330	516	676	729	494	**2,745**	**Oct 06**	**2,782**
1996	477	612	730	695	410	**2,924**	**Sep 19**	**2,785**
1997	441	563	685	670	568	**2,927**	**Oct 13**	**3,081**
1998	417	499	746	716	560	**2,938**	**Oct 06**	**2,984**
1999	364	554	710	655	451	**2,734**	**Sep 28**	**2,702**
2000	479	640	665	663	536	**2,983**	**Oct 14**	**3,117**
2001	465	591	751	691	578	**3,076**	**Oct 11**	**3,214**
2002	446	625	739	674	486	**2,973**	**Oct 04**	**3,004**
2003	453	586	763	730	485	**3,018**	**Oct 27**	**3,329**
2004	456	588	688	667	452	**2,851**	**Oct 23**	**3,057**
2005	428	555	745	683	542	**2,953**	**Oct 31**	**3,228**
2006	477	631	743	674	395	**2,920**	**Sep 23**	**2,826**
2007	388	581	711	720	509	**2,909**	**Oct 07**	**2,981**
2008	370	570	720	691	501	**2,852**	**Oct 12**	**2,980**
2009	450	515	738	660	515	**2,878**	**Sep 22**	**2,753**
2010	373	584	728	662	519	**2,866**	**Oct 26**	**3,139**
2011	352	584	729	722	476	**2,863**	**Oct 08**	**2,929**
2012	459	650	729	722	514	**3,074**	**Oct 25**	**3,343**
2013	396	627	758	690	528	**2,999**	**Oct 05**	**3,051**
2014	390	596	757	658	565	**2,966**	**Nov 03**	**3,268**
2015	316	597	695	699	549	**2,856**	**Oct 28**	**3,176**

Year	May	Jun	Jul	Aug	Sep	May - Sep	Ist Freeze Date	Total to 1st Frost (32 ºF)
2016	343	689	710	648	488	**2,878**	**Oct 20**	**3,092**
2017	608	721	639	557	479	**2,924**	**Sep 25**	**2,918**
Mean	**399**	**583**	**716**	**690**	**490**	**2,879**	**Oct 12**	**2,983**
Mean Accum-mulation	**399**	**983**	**1699**	**2389**	**2879**			

*Growing Degree Days = $(Temp_{(max)} + Temp_{(min)})/2 - Temp_{(base)}$ $Temp_{(max)}$ = 86 ºF at temperatures ≥ 86 ºF; $Temp_{(min)}$ = 50 ºF at temperatures ≤50 ºF; $Temp_{(base)}$ = 50 ºF.
There is very little growth at temperatures above 86 ºF and below 50 ºF.

Table 18. Summary of mean soil temperature (ºF) 4 inches below soil surface. NMSU Agricultural Science Center at Farmington, NM. September 1976 to December 2017.

Month	Mean High	Mean Low	Mean*	Extreme High	Extreme Low
January	34	30	32.4	41	25
February	42	34	37.9	52	29
March	54	41	47.5	64	34
April	66	49	57.6	77	40
May	77	59	68.5	87	49
June	88	71	79.5	96	63
July	95	76	85.5	100	69
August	92	74	83.0	98	67
September	83	66	74.4	93	56
October	66	52	59.0	78	42
November	49	39	43.9	60	32
December	36	32	33.9	45	26
Mean	**65**	**52**	**58.6**	**74**	**44**

*Mean between high and low soil temperatures.

Table 19. Summary of mean high soil temperature (ºF) four inches below surface. NMSU Agricultural Science Center at Farmington, NM. 1976 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1976	-	-	-	-	-	-	-	-	88.9	69.2	56.8	38.8	**63.4**
1977	31.8	49.8	56.2	79.1	88.3	106.6	109.7	102.9	92.6	74.1	53.3	42.6	**73.9**
1978	37.0	42.8	53.7	75.5	82.0	100.7	106.0	102.2	91.2	73.3	53.9	36.3	**71.2**
1979	35.7	40.8	53.9	68.4	81.6	92.2	99.2	98.4	93.4	75.0	49.8	38.9	**68.9**
1980	46.2	52.5	59.8	68.4	80.8	94.2	102.3	96.8	85.3	70.0	54.8	49.0	**71.7**
1981	47.6	49.9	57.6	73.9	79.3	88.5	92.8	89.7	81.2	65.6	52.0	38.1	**68.0**
1982	33.9	38.9	51.0	62.7	78.5	89.4	96.0	94.0	82.8	67.7	50.1	39.6	**65.4**
1983	34.9	44.8	51.4	59.8	73.8	81.4	90.5	92.7	82.6	66.0	47.4	37.1	**63.5**
1984	32.5	38.5	52.4	59.3	77.0	84.7	92.6	94.7	85.6	59.6	51.1	38.7	**63.9**
1985	35.5	39.9	54.1	65.2	81.4	93.3	100.4	96.2	83.3	69.5	49.6	37.0	**67.1**
1986	41.6	47.1	58.6	64.3	77.9	88.9	92.4	95.9	78.9	63.1	45.9	37.0	**66.0**
1987	32.2	41.9	47.1	62.4	77.0	88.6	93.7	91.5	82.4	70.9	50.9	40.9	**65.0**
1988	34.6	42.7	57.1	66.3	77.3	89.2	94.0	92.5	82.6	71.0	50.2	34.4	**66.0**
1989	31.1	38.7	57.2	67.8	77.3	86.6	94.6	90.6	82.3	67.8	49.7	37.0	**65.1**
1990	34.5	39.5	55.5	65.8	75.4	87.1	91.3	88.6	83.0	67.5	49.8	34.8	**64.4**
1991	33.5	42.1	51.9	66.1	76.6	86.4	95.3	95.3	85.6	70.1	46.4	37.6	**65.6**
1992	34.8	43.8	55.3	68.5	77.5	86.1	90.4	90.9	83.3	70.9	44.4	31.4	**64.8**
1993	36.8	42.4	53.7	66.0	78.9	85.9	94.8	88.4	80.2	64.2	42.5	33.7	**64.0**
1994	34.7	38.3	57.4	65.8	76.6	89.7	94.5	94.1	84.3	63.2	42.5	33.9	**64.6**
1995	34.5	48.9	55.9	60.9	69.5	83.7	91.0	92.3	-	63.9	51.7	39.9	**64.7**
1996	36.1	46.9	56.6	68.3	83.5	89.4	94.6	86.4	78.5	64.3	53.1	34.9	**61.9**
1997	33.6	41.3	54.8	58.3	73.0	-	-	91.0	83.8	65.5	47.4	32.6	**63.9**
1998	33.6	40.6	51.1	62.2	80.4	89.2	95.6	92.0	85.3	65.0	46.5	34.8	**64.7**
1999	35.6	42.5	56.1	61.9	71.2	87.0	90.7	85.0	78.7	65.1	50.5	35.2	**63.3**
2000	36.5	43.8	51.7	67.1	79.0	87.8	92.4	90.4	80.0	62.4	38.1	34.5	**63.6**
2001	29.9	37.3	51.4	64.9	78.0	88.0	92.5	89.7	83.7	66.8	52.1	34.1	**64.0**
2002	32.4	37.6	52.3	69.5	79.1	90.7	95.5	90.5	80.1	63.3	46.0	34.6	**64.3**
2003	37.5	41.3	52.0	66.0	75.9	86.8	96.1	95.1	81.4	68.8	46.2	35.9	**65.3**
2004	31.4	35.5	60.3	65.8	80.6	85.8	91.6	92.5	81.2	64.3	46.5	32.3	**64.0**
2005	38.5	43.8	54.9	68.6	81.9	88.8	101.2	92.6	81.6	63.2	47.6	35.6	**66.5**
2006	37.1	44.1	53.9	71.9	82.6	93.8	96.3	92.4	78.6	62.2	50.9	33.4	**66.4**
2007	29.8	40.4	57.2	68.2	80.4	91.6	101.1	98.9	87.8	67.1	53.5	33.4	**66.9**
2008	29.9	34.7	53.3	64.1	74.9	88.4	96.6	93.0	84.2	66.0	49.3	35.3	**64.1**
2009	32.3	39.8	54.3	63.3	78.9	84.0	97.5	93.2	84.7	62.1	45.8	29.4	**63.8**
2010	28.3	37.9	49.5	63.2	73.0	85.2	92.0	85.6	76.8	65.6	45.6	40.2	**61.9**
2011	30.4	35.8	53.0	62.0	69.3	84.0	90.2	89.8	77.4	61.1	44.7	32.5	**60.9**
2012	32.2	32.2	52.5	66.5	77.5	87.8	92.2	89.9	82.1	65.0	49.3	36.4	**63.6**
2013	27.6	34.5	47.8	63.5	76.1	87.7	93.8	87.3	80.3	60.1	46.5	30.9	**61.3**
2014	31.1	42.3	52.8	62.4	73.0	84.1	90.0	86.6	81.4	64.8	48.2	39.2	**63.0**
2015	34.4	44.7	55.9	66.1	72.3	86.2	88.7	89.3	83.3	68.5	47.2	35.2	**64.3**
2016	30.5	40.5	54.9	64.7	75.5	89.5	93.3	89.0	80.2	68.7	50.9	34.9	**64.4**
2017	36.0	44.6	56.0	63.6	73.7	73.0	88.8	88.9	83.1	65.2	55.6	39.5	**64.0**
Mean	**34.3**	**41.6**	**54.2**	**65.8**	**77.5**	**88.3**	**94.8**	**92.1**	**83.0**	**66.4**	**48.8**	**36.2**	**65.3**

Table 20. Summary of mean low soil temperature (ºF) four inches below surface. NMSU Agricultural Science Center at Farmington, NM. 1976 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1976	-	-	-	-	-	-	-	-	66.5	51.1	39.9	23.6	**45.3**
1977	21.6	30.0	35.8	52.1	59.8	78.4	80.2	78.2	70.8	53.4	39.4	32.0	**52.6**
1978	33.7	36.1	40.2	55.3	60.0	75.2	81.3	77.8	68.7	57.7	45.1	33.8	**55.4**
1979	33.7	35.9	42.5	52.0	62.0	72.1	78.6	77.7	72.7	54.4	41.2	35.6	**54.9**
1980	39.9	42.4	44.2	52.1	61.1	72.1	77.5	76.1	67.3	53.9	43.7	39.1	**55.8**
1981	37.0	37.0	42.6	54.6	59.8	70.5	75.3	75.2	67.1	53.4	42.7	33.0	**54.0**
1982	29.6	33.6	40.0	48.0	60.1	72.5	78.2	74.5	67.6	51.4	41.6	36.6	**52.8**
1983	32.7	37.9	42.4	47.1	57.6	65.6	71.2	73.6	67.6	51.5	40.3	34.0	**51.8**
1984	31.1	33.3	37.7	43.8	59.6	66.7	74.7	71.0	64.7	44.4	38.2	33.6	**49.9**
1985	32.1	31.2	40.9	48.1	56.0	68.4	72.3	70.4	58.9	47.9	37.1	31.2	**49.5**
1986	33.5	36.4	42.7	47.8	57.8	67.1	67.7	71.6	57.8	47.1	38.2	34.6	**50.2**
1987	31.2	35.1	37.0	48.4	61.7	72.9	77.2	75.0	68.3	56.8	42.7	38.5	**53.7**
1988	33.8	37.8	43.3	49.6	56.9	67.7	75.6	70.5	64.1	55.1	40.4	32.1	**52.2**
1989	27.4	34.1	43.8	53.7	61.8	68.7	74.2	71.7	66.9	52.9	38.3	28.9	**51.9**
1990	27.9	31.7	40.9	50.7	56.9	71.2	76.3	71.7	66.6	50.8	41.4	33.2	**51.6**
1991	30.6	35.2	40.7	49.4	59.4	67.7	76.4	75.6	65.9	57.1	39.5	36.4	**52.8**
1992	33.3	37.6	45.0	55.2	63.2	69.5	73.7	74.6	64.8	57.1	35.5	29.7	**53.3**
1993	33.8	36.1	40.7	47.0	59.1	68.6	74.2	68.7	57.7	46.7	32.6	28.5	**49.5**
1994	28.5	30.7	40.3	48.1	57.3	70.5	74.5	74.6	60.3	47.0	35.1	31.0	**49.8**
1995	31.8	35.4	41.4	45.2	52.2	66.6	73.5	74.9	-	48.7	39.2	31.5	**50.5**
1996	28.2	36.5	40.4	49.4	63.4	67.7	74.1	64.9	60.5	48.7	37.4	32.0	**50.3**
1997	31.3	34.8	42.4	46.6	59.8	-	-	73.4	66.1	49.7	36.7	28.9	**47.0**
1998	30.6	33.4	37.5	45.1	61.5	69.7	76.3	73.8	69.1	51.7	37.4	30.9	**51.4**
1999	31.8	33.8	44.0	46.9	55.5	71.2	76.5	70.8	66.1	55.5	43.6	30.8	**52.2**
2000	32.1	36.9	40.4	50.9	63.9	72.6	76.2	76.8	67.0	51.4	34.1	31.9	**52.9**
2001	28.7	32.5	41.0	48.7	59.6	70.3	76.3	73.1	69.2	55.1	43.2	28.5	**52.2**
2002	28.6	31.0	36.2	52.3	60.6	72.4	77.0	73.3	62.9	47.8	35.9	31.9	**50.8**
2003	31.6	34.0	39.4	48.6	59.9	69.8	78.0	75.5	63.3	53.6	37.8	30.5	**51.8**
2004	28.3	30.1	43.0	48.2	61.3	71.1	74.5	73.5	61.5	48.0	36.1	27.3	**50.2**
2005	33.7	35.3	37.8	47.2	58.0	67.6	75.2	71.0	66.6	50.2	38.6	26.0	**50.6**
2006	29.0	31.5	37.4	48.1	61.1	70.1	74.0	72.1	57.5	46.1	37.4	27.8	**49.3**
2007	26.0	32.5	40.3	47.3	57.5	69.7	77.5	76.0	65.3	49.9	40.6	29.3	**51.0**
2008	27.6	30.9	38.2	45.8	56.7	68.1	74.2	72.9	65.5	49.4	38.1	32.4	**50.0**
2009	31.2	33.8	40.5	45.7	61.3	68.9	80.8	75.3	71.2	52.0	37.8	25.6	**52.0**
2010	26.1	33.1	37.4	49.3	57.9	73.2	78.8	72.5	65.6	54.7	38.2	35.5	**51.9**
2011	28.6	29.4	42.7	51.5	58.9	73.1	81.2	81.8	68.8	52.4	38.1	30.1	**53.1**
2012	29.8	29.8	41.7	55.8	65.0	75.6	77.6	79.4	69.8	54.3	40.9	31.5	**54.3**
2013	20.9	32.5	39.5	50.0	62.3	73.9	79.7	73.9	65.5	48.6	38.5	27.5	**51.1**
2014	29.0	34.4	41.9	50.2	59.8	71.1	79.5	74.5	69.1	54.4	39.5	34.6	**53.2**
2015	30.3	36.5	44.9	50.8	56.0	68.1	72.9	73.8	67.2	55.8	37.4	31.7	**54.0**
2016	30.4	34.1	40.9	49.4	59.5	70.5	76.1	73.9	65.7	51.7	39.1	31.6	**51.9**
2017	33.5	37.0	44.1	48.4	55.9	73.0	77.5	73.9	67.1	49.2	41.6	32.1	**52.8**
Mean	**30.4**	**34.2**	**40.8**	**49.4**	**59.4**	**70.6**	**76.2**	**73.9**	**65.7**	**51.7**	**39.1**	**31.6**	**51.9**

Table 21. Summary of soil high temperature (ºF) extremes, four inches below surface. NMSU Agricultural Science Center at Farmington, NM. 1976 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1976	-	-	-	-	-	-	-	-	107	80	64	46	**74.3**
1977	44	57	68	95	106	117	117	112	103	90	67	53	**85.8**
1978	45	51	60	88	95	108	112	110	105	86	68	45	**81.1**
1979	40	53	64	80	91	101	107	107	100	89	63	44	**78.3**
1980	38	62	65	79	89	104	106	106	92	84	65	55	**78.8**
1981	52	61	69	86	88	95	98	95	88	76	58	45	**75.9**
1982	44	53	57	78	88	99	102	99	94	78	56	47	**74.6**
1983	39	53	60	71	88	91	97	97	92	74	64	43	**72.4**
1984	37	45	62	68	91	92	97	102	94	76	61	47	**72.7**
1985	45	54	63	76	90	100	108	101	103	77	66	49	**77.7**
1986	50	59	70	78	86	97	101	102	96	72	54	44	**75.8**
1987	37	54	56	77	87	93	99	97	96	80	63	49	**74.0**
1988	36	57	68	75	88	99	98	97	91	79	66	43	**74.8**
1989	35	57	69	76	85	94	100	98	90	80	59	44	**73.9**
1990	44	55	66	75	84	95	97	94	92	78	61	45	**73.8**
1991	37	50	61	76	86	94	100	99	95	85	60	42	**73.8**
1992	38	53	60	79	85	95	96	98	88	82	53	37	**72.0**
1993	42	52	67	77	89	92	99	100	88	77	53	42	**73.2**
1994	45	52	65	80	86	95	98	99	92	75	57	43	**73.9**
1995	41	60	65	72	79	90	98	99	-	70	60	50	**71.3**
1996	42	55	65	77	91	96	100	92	91	78	54	48	**74.1**
1997	45	49	64	69	84	-	-	95	91	81	57	47	**68.2**
1998	39	48	64	74	90	98	102	96	90	79	54	49	**73.6**
1999	44	50	65	72	80	95	99	92	86	73	57	48	**71.8**
2000	47	49	64	78	89	92	95	94	86	76	50	42	**71.8**
2001	32	47	63	78	86	93	100	96	90	83	62	47	**73.1**
2002	39	48	67	75	90	95	99	97	90	75	56	45	**73.0**
2003	45	49	63	74	90	91	100	99	95	79	59	45	**74.1**
2004	35	50	73	79	85	90	101	98	94	78	57	42	**73.5**
2005	45	50	64	79	93	99	106	103	89	76	59	46	**75.8**
2006	46	56	64	81	91	99	103	98	92	78	60	42	**75.8**
2007	34	52	68	82	88	102	105	102	100	79	63	45	**76.7**
2008	32	47	63	72	87	99	100	100	93	82	63	46	**73.7**
2009	44	53	65	74	86	94	101	99	94	76	58	40	**73.7**
2010	33	43	60	71	87	90	97	91	82	80	57	44	**69.6**
2011	38	45	64	71	78	87	98	97	86	75	55	42	**69.7**
2012	38	38	66	77	82	94	96	93	90	76	57	48	**71.3**
2013	40	40	62	74	82	95	97	95	94	70	55	40	**70.3**
2014	40	50	61	77	84	88	93	92	90	78	63	48	**72.0**
2015	44	52	70	75	82	96	97	95	89	82	60	42	**73.7**
2016	33	51	60	75	83	95	98	98	92	76	65	43	**72.4**
2017	44	53	67	75	84	94	98	96	93	75	79	52	**75.8**
Mean	**40.7**	**51.8**	**64.3**	**76.7**	**87.1**	**95.8**	**100.4**	**98.3**	**92.8**	**78.4**	**60.0**	**45.3**	**74.3**

Table 22. Summary of soil low temperature (ºF) extremes, four inches below surface. NMSU Agricultural Science Center at Farmington, NM. 1976 – 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1976	-	-	-	-	-	-	-	-	53	39	36	-	**36.5**
1977	6	22	24	32	52	73	70	73	62	43	31	6	**42.3**
1978	31	34	37	49	44	68	75	70	52	44	38	31	**47.4**
1979	19	30	38	39	49	62	70	69	68	44	32	19	**45.9**
1980	36	38	40	40	54	63	72	68	61	41	37	36	**48.8**
1981	33	31	39	40	52	56	67	71	62	43	36	33	**46.5**
1982	22	29	35	43	47	63	72	68	57	40	37	22	**45.3**
1983	26	34	38	39	47	60	64	65	58	49	33	26	**45.3**
1984	23	32	32	38	42	56	69	65	53	34	30	23	**42.0**
1985	29	22	35	37	45	60	66	64	47	41	31	29	**41.8**
1986	29	29	35	37	49	62	60	62	48	37	31	29	**42.7**
1987	28	32	31	36	41	65	75	71	61	50	38	28	**47.1**
1988	32	34	38	44	45	53	68	66	56	49	31	32	**45.2**
1989	20	33	35	45	53	65	63	65	60	38	30	20	**44.3**
1990	23	26	33	43	47	59	71	63	55	42	35	23	**43.8**
1991	23	25	37	43	50	56	71	68	58	40	35	23	**45.0**
1992	28	35	40	46	54	62	66	62	59	50	27	28	**46.3**
1993	30	34	36	39	45	63	71	57	49	34	26	30	**42.2**
1994	24	20	33	38	51	64	70	65	53	37	26	24	**42.3**
1995	28	29	34	38	45	59	62	66	-	42	31	28	**41.3**
1996	22	26	32	41	54	58	58	57	44	37	35	22	**41.3**
1997	27	33	34	38	46	-	-	68	57	35	32	27	**39.2**
1998	22	31	31	37	54	64	68	65	63	41	33	22	**44.4**
1999	30	29	37	40	42	63	72	67	56	48	32	30	**45.1**
2000	25	32	35	40	57	64	71	68	58	44	30	25	**46.0**
2001	24	25	35	41	46	62	69	66	63	46	27	24	**44.0**
2002	23	25	28	41	51	69	72	66	51	39	32	30	**43.9**
2003	27	30	33	40	50	65	73	70	54	45	26	24	**44.8**
2004	22	24	32	41	49	63	69	69	48	37	26	16	**41.3**
2005	31	31	35	35	44	60	69	64	56	44	27	12	**42.3**
2006	24	28	31	39	52	63	63	67	42	35	31	21	**41.3**
2007	19	28	30	36	44	61	71	64	50	40	30	19	**41.0**
2008	16	29	33	37	48	58	65	70	58	40	31	29	**42.8**
2009	29	29	31	35	51	64	73	71	62	35	32	16	**44.0**
2010	20	31	29	38	42	66	73	61	59	38	30	26	**42.8**
2011	25	18	34	35	47	68	77	78	61	41	34	26	**45.3**
2012	24	31	32	46	58	69	68	71	60	38	32	19	**45.7**
2013	9	31	31	32	55	65	70	60	50	37	29	20	**40.8**
2014	25	25	35	44	48	61	76	64	59	48	30	29	**45.3**
2015	23	30	34	44	50	58	67	69	60	46	33	26	**46.7**
2016	22	26	38	41	44	66	62	65	51	48	29	29	**44.7**
2017	29	30	31	36	45	64	70	69	51	44	34	29	**44.3**
Mean	**24.6**	**29.0**	**33.9**	**39.6**	**48.5**	**62.5**	**69.0**	**66.5**	**55.7**	**41.5**	**31.6**	**25.6**	**44.0**

Adaptive Field Crops Research in Northwestern New Mexico

The New Mexico State University's Agricultural Science Center at Farmington and the San Juan County Cooperative Extension Service, are engaged in adaptive crop, research and dissemination of research-based information, in northwestern New Mexico and the Four Corners region. The agricultural industry in northwestern New Mexico is critical to San Juan County and the rest of the state. The search for new varieties and hybrids, of currently important crops, is critical. As newly irrigated cropland is developed for the area, the demand for information on the adaptation of new crops will increase.

Field crop acreage in northwestern New Mexico is irrigated either by surface or sprinkler systems. Nearly all agricultural lands are irrigated because the average annual precipitation is approximately eight inches. Most farmland in northwestern New Mexico is located in San Juan County along three river valleys (Animas, La Plata, and San Juan) or part of the Navajo Indian Irrigation Project (NIIP) that acquires water from Navajo Lake located on the San Juan River. NIIP conveys water to Navajo Agricultural Products Industry (NAPI) that is located on a high mesa south of Farmington, NM.

Approximately 30% of all surface irrigated lands in New Mexico lie within San Juan County. The 150,000 crop acreage in the county is irrigated with surface water. Continued expansion of NIIP increases available irrigated acreage in San Juan County and should reach approximately 240,000 acres upon completion of the 110,000-acre NAPI project.

The United States Department of Agriculture has ranked statewide San Juan County 1st in production acres of forage lands used for all hay and haylage, grass silage, greenchop, corn for grain, and dry edible beans, excluding lima beans. It was ranked 2nd in value of sales for vegetables, melons, potatoes, and sweet potatoes. Additionally, it was ranked 4th statewide in wheat for grain production acres. http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/New_Mexico/cp35045.pdf)[1].

Adaptive crop research has made and will continue to make a significant contribution to the success of agriculture in the state, region, and nation. This project is designed to evaluate varieties and hybrids of field crops for production in northwestern New Mexico. This includes the evaluation of cultural practices, such as crop variety selection, planting dates, plant population, and soil fertility.

[1] 2012 Census of Agriculture, the most recent agricultural census, is released every five years.

Alfalfa – New Mexico 2014-Planted Alfalfa Variety Trial

M.K. O'Neill, M.M. West, and D.G. Begay

Abstract

The 2014–Planted Alfalfa Variety Trial is part of a statewide testing program to help determine which entries will perform best in the area they are tested. This trial was coordinated through the Plant and Environmental Sciences Department at New Mexico State University's (NMSU) main campus in Las Cruces, NM. The trial consisted of 22 varieties (Table 23) from public varieties and private seed companies. During the 2017 growing season, there were three harvests due to the mechanical failure of the Almaco forage harvester. Therefore, the 2017 harvest data is based on three cuts versus the standard four cuts. The 2017 mean seasonal total yield for this trial was 6.41 ton/acre (Table 24). The highest total yielding entry of 7.45 ton/acre was MagnaGraze, an entry from Dairyland Seed. The lowest total yielding entry of 4.99 ton/acre was Zia, an entry from Roswell Seed. There were no significant differences in total yield tons per acre at the 95% probability level between the top yielding entry and the next 21 highest entries within this trial. The second cut yielded the highest with a mean of 2.28 ton/acre, while the first cutting was the lowest yielding cut with a mean of 2.05 ton/acre (Table 24).

Introduction

The Alfalfa Variety Trial is a statewide testing program to help determine which entries will perform best in the area they are tested. This trial was coordinated through New Mexico State University's (NMSU) Plant and Environmental Sciences Department in Las Cruces, NM. The results are compiled at NMSU and distributed to all cooperating growers and seed companies.

Objectives

- Test alfalfa varieties for forage yield and yield components.
- Relate alfalfa productivity at the Agricultural Science Center at Farmington with productivity at other sites in the state.

Materials and methods

The 2014-Planted Alfalfa Variety Trial was planted at the Agricultural Science Center at Farmington on August 12, 2014 which included nine check entries. African Common was hoed-out and replaced with entry 4S417 on August 21, 2014. The trial consisted of 22 varieties from public varieties and private seed companies. The trial at Farmington was established in a randomized block design with four replications. Individual plots were six 8-inch rows by 16 foot long rows (64 ft^2). Planting rate was 20 lb/acre. (Table 23) The planter used was a Kincaid 6-row cone seeder equipped with discs that closed the seed trench directly after the seeds were dropped in the small furrow opening at a depth of about 0.25 inches.

Table 23. Procedures for the 2014-planted Alfalfa Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operation	Procedure
Number of Entries:	Twenty-Two
Check Entries:	Dona Ana, Archer III, Wilson, NM Common, Ranger, Mountaineer 2.0, Lahontan, Zia and Malone
Planting Date:	August 12, 2014. On August 21, 2014 African Common hoed out and replaced with variety 4S417.
Planting Rate:	20 lb/acre
Plot Design:	Complete randomized block with four replications
Plot Size:	Six 8-inch rows, 16 feet long with 4-foot alley.
Cutting Date:	Three cutting dates: June 7, July 11, and August 24, 2017.
Fertilization:	Pre-plant fertilizer applied on August 7, 2014 at 300 lbs. of 11-52-0 e.g. N 11 lb/acre, P_2O_5 52 lb/acre, K_2O 0 lb/acre
Herbicide:	No preplant herbicide application.
Insecticide:	None
Soil Type:	Doak fine sandy loam
Irrigation:	Solid set pipe, watered 40.29 inches applied irrigation. Precipitation was 5.53 inches for the total water applied of 45.82 inches.
Results and Discussion:	Yield and other characteristics are presented in Table 24 .

Dry fertilizer was applied pre-plant on August 7, 2014 at the rate of N 11 lb/acre, P_2O_5 52 lb/acre, K_2O 0 lb/acre. The plot area was not chemically treated with preplant herbicide.

During the 2017 growing season, there were only three cutting dates: June 7, July 11, and August 24 due to harvester equipment failure during the fourth cut. The plots were cut with an Almaco forage harvester equipped with an electronic scale to weigh the green weight of each plot as it was cut. At harvest, cutting, samples were hand-collected from select plots then dried to determine dry matter percent.

Weed management was performed by hand pulling weeds in plots, borders, and alleyways throughout the growing season.

Results and discussion

Yield results for the 2017 growing season of the 2014-Planted Alfalfa Variety Trial are presented in Table 24. Yield for each cut along with the seasonal total yield are shown for each entry as dry ton/acre. 2017 was the third and final year to obtain harvest data from this trial planted in August of 2014. Due to the untimely mechanical failure of the Almaco forage harvester there were three cuts for data analysis versus the standard four cuts per season.

The 2017 mean seasonal total yield from three cuts for this trial was 6.41 ton/acre (Table 24). The highest total yielding entry of 7.45 ton/acre was MagnaGraze, an entry from Dairyland Seed. The lowest total yielding entry of 4.99 ton/acre was Zia, an entry from Roswell Seed. There were no significant differences in total yield at the 95% probability level between the top yielding entry and the remaining 21 entries within this trial. The second cut yielded the highest with a mean of 2.28 ton/acre, while the first cutting was the lowest yielding cut with a mean of 2.05 ton/acre (Table 24).

Table 24. Forage yield of the 2014-planted Alfalfa Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Variety	Company	------------ Yield dry ton/acre [a] ------------			
		Cut – 1	Cut – 2	Cut – 3	Total
MagnaGraze	Dairyland Seed	2.63	2.51	2.31	7.45
Grandstand	CPS	2.50	2.59	2.28	7.37
Raven	Blue River Hybrids	2.22	2.70	2.39	7.31
4S417	Mycogen Seeds	2.47	2.45	2.13	7.05
Lahonton	Public	2.23	2.54	2.22	6.98
Roadrunner	Blue River Hybrids	1.91	2.45	2.54	6.90
PGI 424	Alforx	2.44	2.38	2.07	6.90
Ranger	Public	1.98	2.60	2.09	6.66
Gunner	Croplan	2.17	2.41	2.04	6.61
Mountaineer 2.0	Croplan	2.43	2.16	1.88	6.47
NM Common	Roswell Seed	2.03	2.24	2.15	6.42
Mallard	Blue River Hybrids	2.04	2.49	1.88	6.41
AFX103009	Alforx	1.97	2.39	1.93	6.28
Arrowhead II	Dairyland Seed	1.74	2.47	2.00	6.22
Dona Ana	Roswell Seed	1.96	1.97	2.13	6.06
WL 354 HQ	W-L Research	1.79	2.06	2.20	6.05
Archer III	America's Alfalfa	1.82	2.21	1.89	5.92
Malone	Roswell Seed	2.14	1.82	1.85	5.81
Wilson	Roswell Seed	1.55	2.13	2.11	5.80
WL 363 HQ	W-L Research	1.74	2.08	1.89	5.71
54VR03	Pioneer Hi-Bred Int.	1.66	2.12	1.85	5.63
Zia	Roswell Seed	1.66	1.47	1.86	4.99
Mean		**2.05**	**2.28**	**2.08**	**6.41**
LSD (0.05)		ns	0.536	ns	ns
CV (%)		25.43	16.62	14.94	15.38
P Value		0.1543	0.0040	0.0855	0.0603

[a] Yield data may be different than that presented in other publications due to a difference in statistical analysis methods.

Corn – Early Season Corn Hybrid and Variety Trial

M.K. O'Neill, M.M. West, D.G. Begay, S.C. Allen, and K. Djaman.

Abstract

The Early Season Corn Hybrid and Variety Trial is part of a statewide entry fee program. Seed companies intending to test their hybrids pay an entry fee to help with the cost of running the test. Hybrids in this test were of the maturity range from 95 to 106 days, inclusive. Thirty-three hybrids of early season corn were planted in a randomized block design with four replications on the Agricultural Science Center at Farmington on May 15, 2017 and harvested November 13 - 15, 2017 (Table 25). Mean yield of this trial was 200.6 bu/acre. (Table 26) The highest yielding entry, at 235.8 bu/acre, was the hybrid D39DC43 RIB from Dyna-Gro Seed. There was no significant difference in yield between the top yielding entry and remainder of entries at the 95% probability level. The lowest yielding hybrid, at 169.2 bu/acre was IC4570-3110 from Rob See Co. The test weights averaged 59.2 lb/bu (Table 26).

Stand counts at the end of the growing season averaged 32,449 plants/acre (Table 26). The plant heights averaged 104 inches (8.6 feet) and ranged from 98 to 111 inches. The moisture content of the grain at harvest averaged 11.0 % and ranged from 10.5 % to 11.6 % (Table 26).

The plots were mechanically cultivated for weeds postemergence. The weed control from the DiFlexx, Aatrex, and Super Spread MSO applied on June 18th was effective on the first flush of weeds. The herbicide was not effective on the second flush of weeds, pigweed and thistle. The plots were hand-hoed five complete rotations through the plots and alleyways for weed management. There was light weed population by the end of the growing season

Introduction

The Early Season Corn Hybrid and Variety Trial is part of a statewide entry fee program. Seed companies wishing to test their hybrids pay an entry fee to help with the cost of running the test. Hybrids in this test should be in the maturity range of less than 107 days.

Objectives

- Test early season corn varieties and hybrids with a maturation period of less than 107 days for grain yield and yield components.
- Relate early season corn productivity at the Agricultural Science Center at Farmington with productivity at other sites within New Mexico.

Materials and methods

Thirty-three hybrids of early season corn were planted in a randomized block design with four replications on the Agricultural Science Center at Farmington on May 15, 2017. (Table 25) Plots were planted using cone seeders that fit on John Deere 71 flex planters. Individual plots were four 30-inch rows by 20 feet long.

Planting rate was approximately 36,590 seeds/acre and all hybrids were planted at the same rate.

Table 25. Procedures for the Early Season Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operation	Procedure
Number of Entries:	Thirty-three
Planting Date:	May 15, 2017
Planting Rate:	36,590 seeds per acre (42 seeds per 20 ft row)
Plot Design:	Randomized block with four replications
Plot Size:	Four 30-inch rows by 20 feet long
Harvest Date:	November 13 - 15, 2017.
Fertilization:	N 240 lb/acre, P_2O_5 59 lb/acre, K_2O 68 lb/acre
Herbicide:	Post-emergence: 16 oz/ac DiFlexx; 1 quart/ac Aatrex 4L; 12.8 oz/ac Super Spread MSO
Insecticide:	None
Soil Type:	Doak fine sandy loam
Irrigation:	Center pivot, watered as needed from May 17 through September 23, 2017. Irrigation water applied: 21.7 inches Total water received including precipitation: 26.3 inches.
Results and Discussion:	Yield and other characteristics are presented in Table 26.

Dry fertilizer was applied prior to planting on May 1, 2017 at the rate of N 12.5 lb/acre, P_2O_5 59 lb/acre, and K_2O 68 lb/acre. UAN fertilizer was applied 12 times during the growing season through the irrigation water for a UAN total of 227.5 lb/acre. Total nitrogen received was 240 lb/acre (including the dry fertilizer).

The plots were sprayed 33 days after planting on June 18, 2017. The plot area was chemically treated with the herbicide DiFlexx (16 oz/acre), Aatrex 4L (1 quart/acre) and Super Spread MSO (12.8 oz/acre) for weed control. Irrigation water was applied next day on June 19th after the herbicide application. Thereafter, the plot area and alleyways were hand-hoed for continued weed management to prevent weed infestation.

This trial was grown under a center pivot irrigation system and was watered from May 21 through September 23, 2017. During the growing season, the crop received a total 26.3 inches of irrigation water and precipitation.

The plots were harvested November 13-15, 2017 using a John Deere 4420 combine equipped with a special gathering box and weighing scale. Samples were taken from the center two rows of the plot for yield, moisture content, and bushel weight, number of plants per acre, plant height, and ear height. Data was taken from four replications.

The previous crop grown on this plot area was winter wheat grown during 2014-15 and was fallow in 2016.

Results and discussion

Yield results and other data collected from this trial are presented in Table 26. Yields of all hybrids were adjusted to a uniform 15.5% moisture content and a 56 lb/bu. The 15.5% moisture content is the level that corn can be stored to eliminate danger of spoilage and spontaneous combustion.

Mean yield of this trial (Table 26) was 200.6197.0 bu/acre. The highest yielding entry, at 235.8 bu/acre, was the hybrid. D39DC43 RIB from Dyna-Gro Seed. There was no significant difference in yield between the top yielding entry and the remaining 32 entries at the 95% probability level. The lowest yielding hybrid at 169.2 bu/acre was IC4570-3110 from Rob See Co. The test weights averaged 59.2 lb/bu (Table 26).

Stand counts at the end of the growing season averaged 32,449 plants/acre (Table 26). The plant heights averaged 104 inches (8.6 feet) and ranged from 98 to 111 inches. The moisture content of the grain at harvest averaged 11.0 % and ranged from 10.7 % to 11.6 % (Table 26).

The weed control from the DiFlexx, Aatrex, and Super Spread MSO applied on June 18th was effective on the first flush of weeds. The plots were hand-hoed five complete rotations through the plots and alleyways for weed management throughout the growing season. There was light weed population by the end of the growing season.

Table 26. Grain yield and other attributes of the Early Season Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Hybrid or Selection	Source	Grain Yield* (bu/acre)	Test Weight (lb/bu)	Moisture Content (%)	Plant Height (in)	Ear Height (in)	50% Silk (date)	Lodge** (%)	Plant Pop. (#/acre)	Relative Maturity (Days)
D39DC43 RIB	Dyna-Gro Seed	235.8	59.1	11.0	99	38	25-Jul	2.2	34,521	99
G03C84-3120	Syngenta Seeds	231.6	58.2	10.6	102	45	28-Jul	6.9	33,650	103
P0157AM	DuPont Pioneer	231.0	60.2	11.5	106	42	28-Jul	0.0	31,254	101
G05B91-3010	Syngenta Seeds	226.4	59.1	11.0	106	46	27-Jul	2.1	31,037	105
MY04Y97	Mycogen Seeds Dow Agro Sciences	215.2	57.7	10.9	100	41	28-Jul	16.7	31,363	104
P0365AM	DuPont Pioneer	213.6	59.3	11.2	108	42	28-Jul	7.1	29,948	103
D41SS71 RIB	Dyna-Gro Seed	213.2	59.2	10.9	104	47	28-Jul	6.7	33,759	101
MY00J47	Mycogen Seeds Dow Agro Sciences	212.4	59.3	11.4	101	42	26-Jul	13.6	34,848	100
G97N86-3110	Syngenta Seeds	211.7	59.8	10.5	103	48	24-Jul	0.7	33,106	97
P9608AM	DuPont Pioneer	211.0	60.0	10.8	103	39	26-Jul	2.7	33,432	96
MY97R57	Mycogen Seeds Dow Agro Sciences	210.5	59.1	11.3	98	38	25-Jul	0.0	32,017	97
G01D24-3120	Syngenta Seeds	209.9	57.6	11.1	104	44	26-Jul	5.7	33,541	101
MY01D87	Mycogen Seeds Dow Agro Sciences	206.5	60.4	11.6	101	43	24-Jul	0.0	32,997	101
P9998AM	DuPont Pioneer	204.1	59.3	10.9	100	39	27-Jul	2.0	32,452	99
D44VC36 RIB	Dyna-Gro Seed	203.8	59.0	10.9	104	43	28-Jul	8.7	33,759	104
EXP157997 AM	AgVenture	199.6	58.9	10.8	105	45	28-Jul	4.2	31,363	99
EXP163027 YHB	AgVenture	198.7	59.7	10.8	104	42	27-Jul	11.3	32,126	102
G96V99-3120	Syngenta Seeds	196.9	59.1	11.0	108	45	26-Jul	10.8	33,323	96
P9697AM	DuPont Pioneer	196.7	59.3	10.8	104	39	25-Jul	7.0	30,601	96
IC5203-3120	Rob See Co	196.3	60.6	10.8	108	49	27-Jul	8.7	32,126	102

Hybrid or Selection	Source	Grain Yield* (bu/acre)	Test Weight (lb/bu)	Moisture Content (%)	Plant Height (in)	Ear Height (in)	50% Silk (date)	Lodge** (%)	Plant Pop. (#/acre)	Relative Maturity (Days)
EXP167047 CYXR	AgVenture	194.5	59.6	10.8	104	42	27-Jul	0.0	26,136	104
IC4848-3000GT	Rob See Co	193.5	57.6	10.7	102	40	27-Jul	8.9	32,997	98
G95D32-3110	Syngenta Seeds	192.7	60.1	11.0	106	41	25-Jul	0.3	34,195	95
G98L17-3000GT	Syngenta Seeds	192.1	57.6	11.0	107	46	27-Jul	11.0	34,086	98
P0589AM	DuPont Pioneer	192.1	59.4	10.9	100	40	27-Jul	3.1	32,452	105
G06Z97-3102	Syngenta Seeds	185.1	59.2	10.8	101	43	26-Jul	9.4	32,561	106
MY05C67	Mycogen Seeds	183.9	58.9	11.0	110	49	29-Jul	5.0	33,323	105
IC5296-3120	Rob See Co	181.0	57.9	11.2	105	42	27-Jul	5.6	32,670	102
P0657AM	DuPont Pioneer	180.0	60.1	11.5	109	43	28-Jul	2.5	29,839	106
D45SS65 RIB	Dyna-Gro Seed	179.5	60.7	10.8	104	50	25-Jul	7.8	34,086	105
RC5112-3011A	Rob See Co	176.8	59.0	11.0	111	44	27-Jul	2.3	32,561	101
MY02J57	Mycogen Seeds	174.0	58.4	11.2	109	42	25-Jul	15.4	32,126	102
IC4570-3110	Rob See Co	169.2	60.9	10.9	104	39	24-Jul	0.3	32,561	95
Mean		**200.6**	**59.2**	**11.0**	**104**	**43**	**26-Jul**	**5.7**	**32,449**	**101**
LSD (0.05)		ns	1.04	0.34	ns	7.30		ns	2270.35	
CV (%)		20.03	1.25	2.20	5.48	12.08		145.16	4.98	
P Value		0.7220	0.0000	0.0000	0.1299	0.0493		0.1799	0.0000	

*Yields adjusted to 15.5% moisture and 56 lb/bu.
**Lodge % is an average over 4 replications of each entry.

Corn – Full Season Corn Hybrid and Variety Trial

M.K. O'Neill, M.M. West, D.G. Begay, S.C. Allen, and K. Djaman.

Abstract

The Full Season Corn Hybrid and Variety Trial is part of a statewide entry fee program. Seed companies intending to test their hybrids pay an entry fee to help with the cost of running the test. Hybrids in this test were of the maturity greater than 106 days. Twelve hybrids of full season corn were planted in a randomized block design with four replications on the Agricultural Science Center at Farmington on May 15, 2017 and harvested November 16, 2017. (Table 27) Mean yield of this trial was 210.0 bu/acre. (Table 28) The highest yielding entry, at 237.5 bu/acre, was the hybrid D52SS91 RIB from Dyna-Gro Seed. There was no significant difference in yield between the top yielding entry and the next eight entries at the 95% probability level. The lowest yielding hybrid, at 168.1 bu/acre, was D58QC72 RIB from Dyna-Gro Seed. The test weights averaged 58.0 lb/bu (Table 28).

Stand counts at the end of the growing season averaged 32,861 plants/acre (Table 28). The plant heights averaged 109 inches (9.1 feet) and ranged from 103 to 117 inches. The moisture content of the grain at harvest averaged 12.8 % and ranged from 11.1 % to 16.6 %. (Table 28).

The weed control from the DiFlexx, Aatrex, and Super Spread MSO applied on June 18th was effective on the first flush of weeds. The plots were hand-hoed five complete rotations through the plots and alleyways for weed management throughout the growing season. There was light weed population by the end of the growing season.

Introduction

The Full Season Corn Hybrid and Variety Trial is part of a statewide entry fee program. Seed companies wishing to test their hybrids pay an entry fee to help with the cost of running the test. Hybrids in this test should be in the maturity range greater than 106 days.

Objectives

Test full season corn varieties and hybrids with a maturation period greater than 106 days for grain yield and yield components.

Relate full season corn productivity at the Agricultural Science Center at Farmington with productivity at other sites within New Mexico.

Materials and methods

Twelve hybrids of full season corn were planted in a randomized block design with four replications on the Agricultural Science Center at Farmington on May 15, 2017 (Table 27). Plots were planted using cone seeders that fit on John Deere 71 flex planters. Individual plots were four 30-inch rows by 20 feet long. Planting rate was approximately 36,590 seeds/acre and all hybrids were planted at the same rate.

Table 27. Procedures for the Full Season Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operation	Procedure
Number of Entries:	Twelve
Planting Date:	May 15, 2017
Planting Rate:	36,590 seeds per acre (42 seeds per 20 ft row)
Plot Design:	Randomized block with four replications
Plot Size:	Four 30-inch rows by 20 feet long
Harvest Date:	November 16, 2017
Fertilization:	N 240 lb/acre, P_2O_5 59 lb/acre, K_2O 68 lb/acre
Herbicide:	Post-emergence: 16 oz/ac DiFlexx; 1 quart/ac Aatrex 4L; 12.8 oz/ac Super Spread MSO
Insecticide:	None
Soil Type:	Doak fine sandy loam
Irrigation:	Center pivot, watered as needed from May 17 through September 23, 2017. Irrigation water applied: 21.7 inches Total water received including precipitation: 26.3 inches.
Results and Discussion:	Yield and other characteristics are presented in Table 28.

Dry fertilizer was applied prior to planting on May 1, 2017 at the rate of N 12.5 lb/acre, P_2O_5 59 lb/acre, and K_2O 68 lb/acre. UAN fertilizer was applied 12 times during the growing season through the irrigation water for a Nitrogen total of 227.5 lb/acre. Total nitrogen received was 240 lb/acre (including the dry fertilizer).

The plots were sprayed 33 days after planting on June 18, 2017. The plot area was chemically treated with the herbicide DiFlexx (16 oz/acre), Aatrex 4L (1 quart/acre) and Super Spread MSO (12.8 oz/acre) for weed control. Irrigation water was applied next day on June 19th after the herbicide application. Thereafter, the plot area and alleyways were hand-hoed five times for continued weed management to prevent weed infestation.

This trial was grown under a center pivot irrigation system and was watered from May 21 through September 23, 2017. During the growing season, the crop received a total 26.3 inches of irrigation water and precipitation.

The plots were harvested November 16, 2017 using a John Deere 4420 combine equipped with a special gathering box and weighing scale. Samples were taken from the center two rows of the plot for yield, moisture content, and bushel weight, number of plants per acre, plant height, and ear height. Data was taken from four replications.

The previous crop grown on this plot area was winter wheat grown during 2014-15 and was fallow in 2016.

Results and discussion

Yield results and other data collected from this trial are presented in Table 28. Yields of all hybrids were adjusted to a uniform 15.5% moisture content and a 56 lb/bu. The 15.5% moisture content is the level that corn can be stored to eliminate danger of spoilage and spontaneous combustion.

Mean yield of this trial was 210.0 bu/acre. (Table 28) The highest yielding entry, at 237.5 bu/acre, was the hybrid D52SS91 RIB from Dyna-Gro Seed. There was no significant difference in yield between the top yielding entry and the next eight entries at the 95% probability level. The lowest yielding hybrid, at 168.1 bu/acre, was D58QC72 RIB from Dyna-Gro Seed. The test weights averaged 58.0 lb/bu. (Table 28).

Stand counts at the end of the growing season averaged 32,861 plants/acre. (Table 28) The plant heights averaged 109 inches (9.1 feet) and ranged from 103 to 117 inches. The moisture content of the grain at harvest averaged 12.8 % and ranged from 11.1 % to 16.6 %. (Table 28).

The weed control from the DiFlexx, Aatrex, and Super Spread MSO applied on June 18th was effective on the first flush of weeds. The plots were hand-hoed five complete rotations through the plots and alleyways for weed management throughout the growing season. There was light weed population by the end of the growing season.

Table 28. Grain yield and other attributes of the Full Season Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Hybrid or Selection	Source	Grain Yield*	Test Weight	Moisture Content	Plant Height	Ear Height	50% Silk	Lodge	Plant Pop.	Relative Maturity
		(bu/acre)	(lb/bu)	(%)	(in)	(in)	(date)	(%)	(#/acre)	(Days)
D52SS91 RIB	Dyna-Gro Seed	237.5	58.3	13.0	103	42	30-Jul	4.8	33,759	112
D54DC94 RIB	Dyna-Gro Seed	237.2	57.0	12.0	110	49	29-Jul	8.0	31,581	114
P1306 WHR	DuPont Pioneer	230.0	60.9	11.4	115	44	30-Jul	24.1	34,739	113
D57VP51 RIB	Dyna-Gro Seed	228.1	57.2	14.4	106	45	31-Jul	0.3	34,848	117
W4409 VT2PRIB	Warner Seeds, Inc.	218.8	57.9	11.9	113	45	28-Jul	2.2	31,254	109
P0805AM	DuPont Pioneer	206.2	60.8	11.8	108	42	29-Jul	5.9	32,017	108
D55VP77 RIB	Dyna-Gro Seed	204.6	56.7	13.4	103	43	31-Jul	5.3	33,868	115
W4622 VT2PRIB	Warner Seeds, Inc.	201.4	56.9	13.2	106	44	31-Jul	5.1	32,888	118
D58VC37 RIB	Dyna-Gro Seed	198.1	57.9	13.7	107	43	30-Jul	8.0	32,997	118

Hybrid or Selection	Source	Grain Yield*	Test Weight	Moisture Content	Plant Height	Ear Height	50% Silk	Lodge	Plant Pop.	Relative Maturity
		(bu/acre)	(lb/bu)	(%)	(in)	(in)	(date)	(%)	(#/acre)	(Days)
P0801AM	DuPont Pioneer	196.3	58.8	11.1	115	45	31-Jul	2.2	34,086	108
D49VC39 RIB	Dyna-Gro Seed	194.2	57.4	11.8	105	43	30-Jul	1.6	28,423	109
D58QC72 RIB	Dyna-Gro Seed	168.1	56.9	16.6	117	45	31-Jul	44.3	33,868	118
Mean		**210.0**	**58.0**	**12.8**	**109**	**44**	**30-Jul**	**9.3**	**32,861**	**113**
LSD (0.05)		39.56	1.01	0.71	7.49	ns		21.01	2,073.18	
CV (%)		13.09	1.22	3.86	4.78	8.68		156.67	4.39	
P Value		0.0328	0.0000	0.0000	0.0035	0.4703		0.0073	0.0000	

*Yields adjusted to 15.5% moisture and 56 lb/bu.
**Lodge % is an average over 4 replications of each entry.

Corn – Forage Corn Hybrid and Variety Trial

M.K. O'Neill, M.M. West, D.G. Begay, S.C. Allen, and K. Djaman.

Abstract

The Forage Corn Hybrid and Variety Trial is part of a statewide entry fee program in which seed companies wishing to test their hybrids pay an entry fee to help with the cost of running the test. Five hybrids of forage corn were planted in a randomized block design with four replications on the Agricultural Science Center at Farmington on May 15, 2017 and harvested September 11, 2017. (Table 29) The highest yielding entry during the 2017 growing season was D58QC72 RIB from Dyna-Gro Seed with a total yield of 17.1 ton/acre dry. The lowest yielding entry in the 2017 growing season was D55VP77 RIB from Dyna-Gro Seed with a total yield of 10.8 ton/acre dry. The mean yield of all 10 entries was 13.3 ton/acre dry (Table 30). The mean moisture content at harvest was 60.9% wet weight. The mean plant height was 109 inches. The mean date to 50% silk was July 29. The mean plants/acre was 38,028 (Table 30). D58QC72 RIB from Dyna-Gro Seed had the highest production of milk per acre with 51,725 lb milk/acre. The mean of all 10 entries of milk production per acre was 40,969 lb milk/acre (Table 31).

Introduction

The Forage Corn Hybrid and Variety Trial is part of a statewide entry fee program in which seed companies wishing to test their hybrids pay an entry fee to help with the cost of running the test.

Objectives

- Test forage corn varieties and hybrids for forage yield and yield components.
- Relate forage corn productivity at the Agricultural Science Center at Farmington with productivity at other sites within New Mexico.

Materials and methods

Ten hybrids of forage corn were planted in a randomized block design with four replications on the Agricultural Science Center at Farmington on May 15, 2017. (Table 29). Plots were planted using cone seeders that fit on John Deere 71 flex planters. Individual plots were four 30-inch rows by 20 feet long. Planting rate was approximately 36,590 seeds/acre and all hybrids were planted at the same rate.

Table 29. Procedures for the Forage Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operation	Procedure
Number of Entries:	Ten
Planting Date:	May 15, 2017
Planting Rate:	36,590 seeds per acre (42 seeds per 20 ft row)
Plot Design:	Randomized block with four replications
Plot Size:	Four 30-inch rows by 20 feet long
Harvest Date:	September 11, 2017
Fertilization:	N 240 lb/acre, P_2O_5 59 lb/acre, K_2O 68 lb/acre
Herbicide:	Post-emergence: 16 oz/ac DiFlexx; 1 quart/ac Aatrex 4L; 12.8 oz/ac Super Spread MSO applied June 18, 2017.
Insecticide:	None
Soil Type:	Doak fine sandy loam
Irrigation:	Center pivot, watered as needed from May 17 through September 11; Irrigation water applied: 21.38 inches Total water received including precipitation: 24.34 inches.
Results and Discussion:	Yield and other characteristics are presented in Table 30.

Dry fertilizer was applied prior to planting on March 18, 2015 at the rate of N 12.5 lb/acre, P_2O_5 59 lb/acre, and K_2O 68 lb/acre. UAN liquid fertilizer was applied 12 times during the growing season through the irrigation water for a total of 227.5 lb/acre. Total nitrogen received was 240 lb/acre (including the dry fertilizer).

The plots were sprayed 33 days after planting on June 18, 2017. The plot area was chemically treated with the herbicide DiFlexx (16 oz/acre), Aatrex 4L (1 quart/acre) and Super Spread MSO (12.8 oz/acre) for weed control. Irrigation water was applied next day on June 19th after the herbicide application. Thereafter, the plot area and alleyways were hand-hoed five times for continued weed management to prevent weed infestation.

This trial was grown under a center pivot irrigation system and was watered from May171 through September 11, 2017. During the growing season, 24.34 inches of irrigation water and precipitation was received.

The previous crop grown on this plot area was winter wheat grown during 2014-15 and was fallow in 2016.

The plots were harvested for forage September 11, 2017 via hand harvesting 10 feet of 1 row within the plot by cutting the plants with a machete. The plants were counted and weighed and a single plant was run through a shredder and sacked to determine moisture content. This was accomplished by weighing each sample before and after oven drying. The samples were then sent to the University of Wisconsin Soil and Forage Analysis Laboratory for chemical analysis.

Results and discussion

Yield results and other data collected in this trial are presented in Table 29. Chemical analysis data for forage quality is presented in Table 31.

The highest yielding entry during the 2017 growing season was D58QC72 RIB from Dyna-Gro Seed with a total yield of 17.1 ton/acre dry. The lowest yielding entry in the 2017 growing season was D55VP77 RIB from Dyna-Gro Seed with a total yield of 10.8 ton/acre dry. The mean yield of all 10 entries was 13.3 ton/acre dry (Table 30). The mean moisture content at harvest was 60.9% wet weight. The mean plant height was 109 inches. The mean date to 50% silk was July 29. The mean plants/acre was 38,028 (Table 30). D58QC72 RIB from Dyna-Gro Seed had the highest production of milk per acre with 51,725 lb milk/acre. The mean of all 10 entries of milk production per acre was 40,969 lb milk/acre (Table 31).

The plots were sprayed 33 days after planting on June 18, 2017. The plot area was chemically treated with the herbicide DiFlexx (16 oz/acre), Aatrex 4L (1 quart/acre) and Super Spread MSO (12.8 oz/acre) for weed control. Irrigation water was applied next day on June 19th after the herbicide application. Thereafter, the plot area and alleyways were hand-hoed five times for continued weed management to prevent weed infestation.

Table 30. Forage yield (dry and green) and other attributes of the Forage Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Hybrid or Selection	Source*	Forage Dry	Forage Wet	Wet Weight	Plant Pop.	Plant Height	Ear Height	Silk 50%	Relative Maturity
		(ton/acre)		(%)	(plnt/ac)	(inches)		Date	#Days
D58QC72 RIB	Dyna-Gro	17.1	41.0	58.0	39,640	124	49	29-Jul	118
D53VC47 RIB	Dyna-Gro	14.7	36.9	60.2	40,511	109	39	28-Jul	113
G07B39-3111A	Syngenta	14.5	38.1	61.9	38,768	116	50	29-Jul	109
G01D24-3120	Syngenta	13.1	35.1	62.5	41,818	104	39	28-Jul	101
G11B63-3010A	Syngenta	13.0	31.9	59.6	30,056	112	42	29-Jul	111
G13N18-3111	Syngenta	12.9	37.1	65.6	43,996	107	45	31-Jul	113
D54DC94 RIB	Dyna-Gro	12.6	31.9	60.6	29,621	107	43	30-Jul	114
D58SS65 RIB	Dyna-Gro	12.5	35.6	64.6	37,897	107	46	1-Aug	118
G07H81-3010A	Syngenta	12.3	28.7	57.2	38,333	106	42	28-Jul	104
D55VP77 RIB	Dyna-Gro	10.8	29.4	62.8	42,253	102	43	31-Jul	115
Mean		**13.3**	**34.1**	**60.9**	**38,028**	**109**	**44**	**29-Jul**	**112**
LSD (0.05)		ns	ns	10.45	ns	19.68	ns		
CV		0.05	20.05	5.91	22.38	6.19	11.25		
P Value		23.44	0.1754	0.0316	0.3069	0.0073	0.0959		

*Dyna-Gro Seed, Syngenta Seeds Co.

Table 31. Chemical analysis for forage quality done at the University of Wisconsin on the Forage Corn Hybrid and Variety Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Hydrid or Selection	Source*	Forage Dry	CP	NDF	NDF 48hr	Starch	Ash	Fat DM	Milk/ton	Milk/ac
		(t/ac)	(%)	(%)	(%)	(%)	(%)	(%)	(lb/ton)	(lb/ac)
D58QC72 RIB	Dyna-Gro	17.1	8.0	43.5	63.7	23.6	5.8	2.3	3,013	51,725
D53VC47 RIB	Dyna-Gro	14.7	8.0	41.8	65.1	26.0	5.7	2.4	3,135	46,458
G07B39-3111A	Syngenta	14.5	7.9	44.3	65.6	22.8	6.3	2.4	3,080	44,902
G01D24-3120	Syngenta	13.1	6.9	42.0	62.0	23.5	5.8	2.4	2,811	36,964
G11B63-3010A	Syngenta	13.0	7.9	43.0	66.8	23.7	6.0	2.3	3,100	40,859
G13N18-3111	Syngenta	12.9	8.3	39.8	66.3	26.8	5.5	2.5	3,161	41,405
D54DC94 RIB	Dyna-Gro	12.6	7.7	44.5	64.7	23.3	6.2	2.3	3,056	38,793
D58SS65 RIB	Dyna-Gro	12.5	7.7	47.0	62.6	20.0	6.3	2.2	2,881	35,896
G07H81-3010A	Syngenta	12.3	7.7	41.8	63.8	26.0	5.7	2.5	3,070	37,712
D55VP77 RIB	Dyna-Gro	10.8	8.4	41.1	65.1	27.1	5.6	2.4	3,201	34,418
Mean		**13.3**	**7.9**	**42.9**	**64.7**	**24.5**	**5.9**	**2.4**	**3,070**	**40,969**
LSD (0.05)		ns	ns	ns	ns	ns	ns	ns	ns	ns
CV		23.38	9.42	7.85	3.02	15.98	8.51	9.44	5.70	26.06

*Dyna-Gro Seed, Syngenta Seeds Co.

Winter Wheat – Colorado State University Elite Winter Wheat Trial

M.K. O'Neill, M.M. West, D.G. Begay, and S.C. Allen

Abstract

The CSU Elite Winter Wheat Trial is a wheat breeder trial grown collaboratively with Dr. Scott Haley, Colorado State University. The results are compiled for the Colorado State University at Fort Collins. Twenty-six entries were planted in a randomized block design with three replications at the ASC - Farmington on September 14, 2016 and harvested July 14, 2017. (Table 32) The replicated trial average grain yield ranged from 50.3 to 17.8 bushels per acre with a mean yield 32.6 bushels per acre. The winter wheat average heights in the replicated trial ranged from 25.5 to 19.7 inches with a mean height of 21.8 inches. The mean moisture content of replicated entries was 8.4% and ranged from 8.9 to 7.9%. (Table 33)

Introduction

The CSU Elite Winter Wheat trial was grown collaboratively with Dr. Scott Haley, Colorado State University – Fort Collins, CO. The trial is a breeder study grown as an investigation to determine which winter wheat varieties could be developed for the Upper Colorado Plateau region.

Objectives

- Test CSU Elite winter wheat entries on grain yield and yield components.
- Relate CSU Elite winter wheat productivity at the NMSU's Agricultural Science Center at Farmington with other CSU Elite winter wheat sites in the country.

Materials and methods

The CSU Elite Winter Wheat trial was planted at Agricultural Science Center at Farmington (ASCF) on September 14, 2016 (Table 32). The trial consisted of 26 replicated winter wheat entries. The replicated trial at ASCF was established in a randomized block design with three replications. Individual plots were six 10-inch rows by 20 feet long. Planting rate was 120 lb/acre. The planter used was a Kincaid 6-row cone seeder equipped with discs that closed the seed trench directly after the seeds were dropped in the small furrow opening.

Table 32. Procedures for the Colorado State University (CSU) Winter Wheat Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operation	Procedure
Number of Entries:	26 replicated entries.
Planting Date:	September 14, 2016
Planting Rate:	120 lb/acre
Plot Design:	Randomized block with three replications
Plot Size:	Six 10-inch rows, 20 feet long
Harvest Date:	July 14, 2017
Fertilization:	August 31, 2016 preplant fertilizer application N 11 lb/ac, P_2O_5 40 lb/ac, K_2O 30 lb/ac, and Zinc 7 lb/ac. 2017 growing season UAN 105 lb/ac through irrigation.
Herbicide:	15.0 fluid oz/ac Huskie, R-11 3.2 oz/ac, and 4 oz/ac Mustang Maxx postemergence ground application April 6, 2017.
Insecticide:	None
Soil Type:	Doak fine sandy loam
Irrigation:	Center pivot, watered from September 12, 2016 through October 20, 2016 was 3.42 inches water and April 12, 2017 through June 29, 2017 with 12.52 inches water; 15.94 total inches irrigation water applied and total 3.88 inches precipitation for a total of 19.81 inches total water.
Results and Discussion:	Yield and other characteristics are presented in replicated trial Table 33. Trial cross reference identification number and pedigree Table 34.

Dry fertilizer was applied on August 31, 2016 prior to planting at a rate of N 11 lb/acre, P_2O_5 40 lb/acre, K_2O 30 lb/acre, 7 lb/ac Zine. During the 2017 growing season, 105.0 lb/acre of UAN (liquid nitrogen) fertilizer was applied through irrigation water. Total Nitrogen applied for the 2016-17 growing season was 116 lb/acre.

The plot area was chemically treated with the herbicide Huskie weed killer at a rate of 15.0 oz/acre, R-11 3.2oz/ac, and 4 oz/ac Mustang Maxx to help prevent weed infestation. The herbicide post-emergence was applied on April 6, 2017.

This trial was grown under a center pivot irrigation system and was watered from September 12 through October 20, 2016 and from April 12 through June 29, 2017. During the growing season, 15.94 inches of water was applied along with 3.88 inches of precipitation for a total amount of received water of 19.81 inches.

Plots were harvested July 14, 2017. A John Deere 4420 combine equipped with a special gathering box and weigh scale was used to harvest the plots. Samples were taken for yield, moisture content, and bushel weight.

Results and discussion

The weed control from the Huskie, R11, and Mustang Maxx weed killer was good. Some hand weeding was done in 2017. Yield results and other data collected in this trial are presented in Table 33. Yields of all entries were adjusted to a uniform 14% moisture content and a 60-pound bushel.

Mean grain yield of the CSU Elite winter wheat replicated trial was 32.6 bushels per acre. The grain yields ranged from 50.3 to 17.8 bushels per acre. The replicated trial mean plant height was 21.8 inches with a range of 25.5 to 19.7 inches. The mean moisture content of the replicated entries was 8.4% and ranged from 8.9 to 7.9%. (Table 33)

Table 33. CSU Elite winter wheat replicated trial average grain yield and other characteristics. NMSU Agricultural Science Center at Farmington, NM. 2017.

ID Number**	Putative Market Class	Grain Yield* (bu/acre)	Grain Yield (kg/ha)	Moisture Content (%)	Test Wt (lb/bu)	Plant Ht (in)	Plant Lodging (%)	Heading Date (date)
Byrd	HRW	50.3	3,603	8.5	56.9	23.0	3.3	2-May
CO12D1770	HRW	49.9	3,585	8.3	56.5	23.3	0.0	4-May
CO14A058	HRW	46.6	3,338	8.5	55.9	24.7	11.7	3-May
CO13D1783	HRW	45.2	3,249	8.1	55.8	22.2	11.7	6-May
CO13D0787	HRW	40.5	2,914	8.3	56.6	21.5	0.0	5-May
CO13D1479	HWW	39.9	2,867	8.2	55.9	21.3	0.0	2-May
CO14A065	HRW	39.4	2,832	8.1	53.5	22.0	0.0	5-May
CO13D1299	HWW	36.3	2,605	8.4	56.1	20.7	0.0	28-Apr
CO12D296	HRW	36.0	2,587	8.4	56.6	19.8	0.0	6-May
CO13003C	HRW	35.2	2,520	8.4	57.7	23.2	0.0	6-May
CO13D1379	HWW	34.3	2,463	8.2	55.3	21.3	0.0	5-May
Langin	HRW	32.4	2,316	8.4	55.7	22.2	3.3	29-Apr
CO13D1164	HWW	31.7	2,272	8.5	55.2	21.2	0.0	8-May
CO12D2011	HWW	29.9	2,151	8.7	57.1	22.2	0.0	8-May
CO13W187	HWW	29.4	2,114	8.3	55.4	23.5	0.0	3-May
Brawl CL Plus	HRW	28.9	2,069	8.3	55.2	21.7	0.0	4-May
LCS Mint	HRW	28.4	2,024	8.9	57.0	25.5	0.0	6-May
Denali	HRW	28.0	2,011	8.8	55.7	20.3	0.0	9-May
CO13D1714	HWW	26.6	1,907	8.4	56.5	20.5	0.0	2-May
CO13D2042	HWW	26.5	1,906	8.2	55.0	20.0	0.0	6-May
CO13D1383	HWW	26.0	1,861	8.9	55.3	20.8	0.0	5-May
CO13D1638	HWW	24.1	1,730	8.3	55.2	19.7	0.0	5-May
CO12M0367	HRW	21.9	1,570	8.5	55.0	21.3	0.0	5-May
Antero	HWW	21.3	1,523	8.5	54.9	21.0	0.0	8-May
Sunshine	HWW	20.5	1,482	7.9	53.6	20.0	0.0	2-May
Avery	HRW	17.8	1,283	8.3	56.3	24.7	0.0	4-May
Mean		**32.6**	**2,338**	**8.4**	**55.7**	**21.8**	**1.2**	**4-May**
LSD (0.05)		**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	
CV %)		**64.69**	**64.63**	**4.81**	**3.05**	**12.24**	**493.40**	
P Value		**0.9469**	**0.9463**	**0.3383**	**0.5162**	**0.4401**	**0.5287**	

*Yield adjusted to 14% moisture content and 60 lb/bu.
**ID Number cross referenced with Pedigree in Table 34

Table 34. CSU Elite winter wheat replicated trial cross reference identification number and pedigree. NMSU Agricultural Science Center at Farmington, NM. 2017.

Identification Number	Pedigree
Antero	KS01HW152-1/TAM 111
Avery	TAM 112/Byrd
Brawl CL Plus	Teal 11A/Above//CO99314
Byrd	TAM 112/CO970547-7
CO12D1770	Denali/Antero//Byrd
CO12D2011	Denali/HV9W07-482W//Antero
CO12D296	Denali/Antero//Byrd
CO12M0367	Bill Brown/OK Rising
CO13003C	CO06072/4*Byrd
CO13D0787	Antero/Snowmass//Byrd
CO13D1164	CO07W722-F5/Snowmass//Snowmass
CO13D1299	CO07W722-F5/Snowmass//Brawl CL Plus
CO13D1379	CO07W722-F5/Snowmass//CO07W722-F5
CO13D1383	CO07W722-F5/Snowmass//CO07W722-F5
CO13D1479	CO07W722-F5/Antero//Snowmass
CO13D1638	Clara CL/Antero//Snowmass
CO13D1714	Clara CL/CO07W722-F5//Snowmass
CO13D1783	CO08W218/Snowmass//Byrd
CO13D2042	CO08W218/Snowmass//CO07W722-F5
CO13W187	CO04W320/KS980512-2-2//CO03W054
CO14A058	(AF28/Byrd)//(AF10/2*Byrd)
CO14A065	(AF28/Byrd)//(AF10/2*Byrd)
Denali	CO980829/TAM 111
Langin	CO050270/Byrd
LCS Mint	Overley/CO980829
Sunshine	KS01HW152-6/HV9W02-267W

Drip-irrigated Chile Pepper Variety Trial in Northwestern New Mexico

M.K. O'Neill, S.C. Allen, M.M. West, and D. Smeal

Abstract

This study evaluated the yield of 13 varieties of chile peppers (*Capsicum* spp.) grown under drip irrigation on a small 0.1-acre plot at ASC Farmington in summer 2017. Our study included 11 relleños-type varieties, 1 jalapeño-type, 1 habanero-type, 1 tabasco-type, and 1 ornamental (Mirasol) which was represented by 4 entries from 4 separate seed-collection years, to test genetic integrity and long-term seed viability. Seedlings were transplanted to the field by hand on June 2, 2017 alongside a single line-source drip tape for each row (1-gph emitter; 12-in emitter spacing). Field layout consisted of 3 replications of 10 plants each (randomized complete block design) in a N/S orientation, divided over 6 rows at 12-inch spacing between plants, with 30-inch row spacing. A single row of tomatoes (*Solanum lycopersicum*) served as a border between replications, with one row each of four varieties. Peppers were hand-harvested on August 21/22 and September 14/15, 2017. An early killing freeze on September 25 effectively ended the growing season, although a final salvage harvest was conducted on September 29. Mature green (or red/yellow/orange) chile pods were harvested from the 10 plants within each 1-row plot. After a final culling, fresh marketable pods were counted and weighed for yield determination. In general, most pepper varieties produced good overall yields, considering the short growing season and phenotypic variations in pod maturity and weight. Seasonal marketable yields for the relleños types ranged from 954 sacks/acre (Anaheim Giant) to 114 sacks/acre (Chimayo). Big Jim Heritage and New Mexico #6 performed fairly well, along with other relleños varieties. The NuMex Jalmundo (the only jalapeño entry) exhibited fair yield, at 364 sacks/acre. The Mirasols also did reasonably well, ranging from 372 to 559 sacks/acre, with the oldest seed source (from 2008) surprisingly yielding the numerically highest amount, perhaps due to higher genetic integrity. Unfortunately, the habanero and tabasco entries did not produce marketable quantities during the season (in part due to their late maturity and small size/weight per pod). Overall, about 567 pounds (~14 sacks) of marketable chiles were harvested from the drip-irrigated trial in 2017. Chile plant health/survival ranged from good to fair, and was primarily impacted by overcrowding by tomatoes (despite trimming back) plus possibly occasional water or heat issues or gopher burrowing. Some varieties had mature fruit later in the season (e.g., habanero, tabasco), an indicator of their more tropical origins and longer growing seasons. There is still need for ongoing information about which varieties (new and old) grow best under local climate and watering conditions.

Introduction

Chile peppers are an important horticultural crop in New Mexico, and people in the Four Corners region are showing increased interest in growing them for personal consumption as well as for resale at farmers' markets and other commercial outlets. In addition, the NMSU Chile Pepper Institute, in its mission to test and improve varieties appropriate for various locales, has solicited the aid of Ag Science Centers for local testing of different cultivars. Under the leadership of Dan Smeal, ASC Farmington has enjoyed a long tradition of growing chiles for varietal testing and refinement of irrigation BMPs. Chiles which have been generally favored by NMSU staff in the past based on taste and cooking quality are primarily the relleños types (e.g., Joe Parker, Sandia, Anaheim, Arizona), although Mirasol (an ornamental-type with a unique upward-growing habit of pods) is one of the most favored due to its colorful/attractive form and unique medium hot, berry-like flavor and excellent drying/cooking qualities. However, more information is needed about which varieties grow best in our area, and what methods are best for production.

Objectives

- Evaluate the yield of 13 chile varieties grown under drip irrigation in northwestern New Mexico.
- Implement study in part to accompany a larger chile production system grown by Navajo Agricultural Products Industry (NAPI) under a center pivot in an adjacent field at ASCF.

Materials and methods

This study evaluated the yield of 13 varieties of chile peppers grown under drip irrigation on a small 0.1-acre plot in summer 2017. Our study included 11 relleños-type varieties, 1 jalapeño-type, 1 habanero-type, 1 tabasco-type, and 1 ornamental (Mirasol) which was represented by 4 entries from 4 separate seed-collection years. Operations and procedures for the chile pepper trial are described in Table 35, and a complete list of types and varieties is presented in the yields table (Table 36). Seeds (or seedlings) for most varieties were obtained from the NMSU Chile Pepper Institute as well as from two commercial growers; seeds for Mirasols and Arizona-88 were from our in-house seed bank. All seeds were planted in recommended potting mix in early 2017 and germinated in a greenhouse setting until ready for planting.

Prior to transplanting, the garden area at ASC Farmington was disked and harrowed, and a single line-source drip tape was installed for each row (1-gph emitter; 12-in emitter spacing). Seedlings were transplanted by hand on June 2, 2017. Field layout consisted of 3 replications of 10 plants each (randomized complete block design) in a N/S orientation, divided over 6 rows at 12-inch spacing between plants, with 30-inch row spacing. A single row of tomatoes (*Solanum lycopersicum*) served as a border between replications, with one row each of four varieties—'Brandywine', 'Sweet Olive', 'Early Girl' and 'Roma'. Watermelon (*Citrullus lanatus*) vines were also planted on the north end of each dripline. Chiles were irrigated several times per week usually during morning hours as needed; in addition, 2.3 inches of rainfall was received during the growing season. Liquid fertilizer was applied on a weekly basis by hand (fish emulsion (5-1-1 NPK) for first two weeks at 1 tbsp/gal, and Miracle-Gro All Purpose Plant Food (24-8-16 NPK) at 1 tbsp/gal thereafter).

Peppers were hand-harvested on August 21/22 and September 14/15, 2017. An early killing freeze on September 25 effectively ended the growing season, although a final salvage harvest was conducted on September 29. Mature green (or red/yellow/orange) chile pods were harvested from the 10 plants within each 1-row plot. After a final culling, fresh marketable pods were counted and weighed for yield determination. Pods were separated into green and red colors, but it was decided to keep them together for reporting of total yields. Certain varieties (habanero and tabasco) were deemed to be best picked at full color (marketable) maturity, and thus were left on the plant for late-season picking (however, the early-fall freeze damaged the crop). The tomatoes and watermelons were picked by hand on a limited basis but yield was not measured as it was beyond the scope of the project.

Table 35. Operations and procedures for chile pepper trial, NMSU Agricultural Science Center at Farmington, NM. 2017.

Operations	Procedures
Number of Entries:	Thirteen varieties
Planting Date:	Transplanted on June 2, 2017
Plot Design:	Randomized complete block design with three replications
Plot Size:	10 pepper plants of each variety
Field Layout:	3 replications of 10 plants each in a N/S orientation, divided over 6 rows at 12-inch spacing between plants, with 30-inch row spacing. A single row of tomatoes (*Solanum lycopersicum*) served as a border between replications, with one row each of four varieties—‘Brandywine’, ‘Sweet Olive’, ‘Early Girl’ and ‘Roma’. Watermelon (*Citrullus lanatus*) vines were also planted on the north end of each dripline.
Harvest Dates:	Two harvest dates: August 21/22 and September 14/15, 2017.
Fertilization:	Liquid fertilizer was applied on a weekly basis by hand (fish emulsion (5-1-1 NPK) for first two weeks at 1 tbsp/gal, and Miracle-Gro All Purpose Plant Food (24-8-16 NPK) at 1 tbsp/gal thereafter).
Soil Type:	Doak fine sandy loam
Irrigation:	Chiles were irrigated several times per week usually during morning hours as needed; in addition, 2.3 inches of rainfall was received during the growing season.
Results and Discussion:	Yield and other characteristics are presented in Table 36.

Results and discussion

In general, most pepper varieties produced good overall yields (Table 36), considering the short growing season and phenotypic variations in pod maturity and weight. Marketable pods per plant (MPP), a common measure for varietal comparison, ranged from 36 MPP for Mirasol (2008) to 9 MPP for chimayo. Mirasols (all years) averaged 29 MPP, which compared favorably with the other varieties. MPP for certain relleños also compared favorably, particularly Española (24), New Mexico #6 (22), and Anaheim Giant (21). Fresh weight per pod, which gives an approximation of how large the pods are in comparison to each other, ranged from 1.7 oz for Anaheim Giant to 0.5 oz for a couple of the smaller chile varieties. This relationship is also seen in Fresh weight per plant. Total marketable yield ranged from 19.1 tons/acre for Anaheim Giant, to a very small yield for chimayo and others. The habanero and tabasco entries did not produce marketable quantities for the season, in part due to their late maturity and small size/weight per pod

Lastly, for a measure of practical production potential, (40-lb) sacks per acre is useful for visualizing potential yield from a small-scale production setting. Seasonal marketable yields for the relleños types ranged from 114 sacks/acre (Chimayo) to 954 sacks/acre (Anaheim Giant). Big Jim Heritage, and New Mexico #6 performed fairly well, along with other relleños varieties. The NuMex Jalmundo (the only jalapeño entry) exhibited fair yield, at 364 sacks/acre. The Mirasols also did reasonably well, ranging from 372 to 559 sacks/acre, with the oldest seed source (from 2008) yielding the numerically highest amount, surprisingly. The reasons for this are unclear, though yields of varieties may tend to drop from one season to the next, eventually requiring introduction of new germplasm, so the older germplasm may have been more "true to source." Overall, about 567 pounds (~14 sacks) of marketable chiles were harvested from the drip-irrigated trial in 2017. A neighboring commercial production area managed by NAPI at ASC Farmington exhibited similar good results for Anaheim Giant and Anaheim G76, producing thousands of pounds of healthy chiles in a large half-pivot plot. More chile production is planned for 2018.

Lessons learned include not planting tomatoes alongside chiles, as they tended to spread and overtake the chiles, and also suffered from root rot and pathogens; perhaps only the Roma could be planted somewhat near the chiles due to its well-behaved growth habit. Overall, chile plant health/survival ranged from good to fair, and was primarily impacted by overcrowding by tomatoes (despite trimming/training back) plus possibly occasional water or heat issues or gopher burrowing. Interestingly, the neighboring field of NAPI chiles largely escaped the late-September freezing fate; the reasons for this are unclear, but it may have had to do with a wind-drainage benefit of their field (which was on a slope) compared to our field (which sat in a flat semi-sheltered area that may have created a potential frost pocket). Also, some chile varieties had mature fruit later in the season (e.g., habanero, tabasco), an indicator of their more tropical origins and longer required growing seasons. Lastly, chile varieties that are "too hot to eat" are not generally recommended for non-specialized production in an experiment-station setting, as in many cases they may not have a viable market for local consumption, and are not suitable or safe to give to the general public or community food banks. These late-maturing types also tend to be small and difficult to weigh in a comparative way with the larger relleños types, making direct comparison difficult.

Table 36. Average seasonal yields of 13 varieties of chile peppers. NMSU Agricultural Science Center at Farmington, NM. 2017.

Type	Variety	Marketable Pods per Plant† (no.)	Fresh Weight per Pod (oz.)	Fresh Weight per Plant (lbs.)	Total Marketable Yield‡ (tons/acre)	Total Marketable Yield‡ (sacks/acre)
Relleños	Anaheim Giant	21	1.7	2.2	19.1	954
	Anaheim G76	18	1.1	1.3	11.2	559
	Arizona 88 (Yr. 2014)	19	1.0	1.2	10.3	513
	Big Jim	14	1.3	1.1	9.5	475
	Big Jim Heritage	19	1.4	1.7	14.7	736
	Chimayo	9	0.5	0.3	2.3	114
	Española	24	0.6	1.0	8.3	414
	Joe E. Parker	16	1.3	1.2	10.7	536
	New Mexico #6	22	1.1	1.4	12.5	627
	NuMex Sweet	18	1.2	1.4	11.8	590
	Sandia Select	17	1.1	1.2	10.3	516
	Mean	**18**	**1.1**	**1.3**	**11.0**	**549**
Jalapeño	NuMex Jalmundo	20	0.7	0.8	7.3	364
Mirasol	Mirasol (Yr. 2008)	36	0.6	1.3	11.2	559
	Mirasol (Yr. 2014)	25	0.6	0.9	7.7	386
	Mirasol (Yr. 2015)	28	0.7	1.2	10.5	524
	Mirasol (Yr. 2016)	28	0.5	0.9	7.4	372
	Mean	**29**	**0.6**	**1.1**	**9.2**	**460**
	Mean (Study)	**21**	**1.0**	**1.2**	**10.3**	**515**

† Original N=30 plants (3 reps x 10 plants/rep) for all varieties except Habanero (N=18), which is not included due to lack of harvest data, along with the Tabasco entry. Seasonal yield figures are based on sums of two harvest dates: August 21/22 and September 14/15, 2017.
‡ Yield per acre is based on a plant spacing of 12 inches between plants and 30 inches between rows, which scales up to 17,424 plants per acre. One ton = 2,000 lbs; one sack = 40 lbs. of fresh produce.

Conclusions

This topic of study remains of interest, and there are certainly ways of optimizing production through informed selection of chile varieties, efficient field design, and good irrigation and fertilizer management. The Mirasols deserve more study as a promising and under-utilized variety for specialty crop production and marketing, and some of the relleños (e.g., Anaheims, Big Jim Heritage, New Mexico #6) seem well-adapted to the area and may be considered for large-scale production.

Acknowledgments

Appreciation is extended to the NMSU Chile Pepper Institute (Las Cruces, NM) for supplying seeds for this study, and to Mannings Greenhouse (Kirtland, NM) and Margaret West, ASCF for growing chile transplants. Special thanks to Daniel Smeal for his pioneering work with chile peppers at ASC Farmington, and Joe Ward for his guidance and great help in the field. Thanks also to Shane Nezwood of NAPI for the collaborative work.

Horticultural Research, Development, and Education in the Four Corners Region

Our research is identifying grapes, hops, and other specialty crops that can be value added and branded "New Mexico True." We are the largest experimental vineyard in the northern half of New Mexico. More than 36 wineries produce approximately 350,000 gallons annually. The New Mexico Brewers Guild has 59 member breweries that produced 85,230 barrels in 2017, with an economic impact that grew to $340 million. In 2016–2017, we planted 20 acres of malting barley in response to industry demands. We also maintain an extensive hops variety trial, and have acquired two mechanical hops pickers to catalyze a regional "co-hop-erative."

Kevin A. Lombard[1], Beth LaShell[2], Franklin J. Thomas[1], Amy Germershausen[3], Kevin Smith[4],

[1]NMSU ASC-Farmington, [2]Fort Lewis College, Durango, CO, [3]Proximity Malt, LLC, [4]Coordinator National Winter Malted Barley Trial, University of Minnesota

Hops (*Humulus lupulus*) Field Evaluations

Funds provided by the New Mexico Department of Agriculture Specialty Crop Award, Colorado Department of Agriculture, USDA Hatch

Summary

We procured two mobile hops harvesters (Figure 2), which should aid in catalyzing a cooperative of regional growers. The Hopster 5G and 5P models are powered by gasoline generator and tractor power take off, respectively. We have tested the performance (Figure 3) and will continue to do so during our end-of-season harvests (usually in August) and will begin organizing a hops cooperative with our Fort Lewis College (Durango, CO) partners.

We thank the New Mexico Department of Agriculture for funding support through the USDA Specialty Crop state block awards to New Mexico.

Figure 2. **Hopster hops picker manufactured in Pennsylvania. Delivered in June 2017. The Hopster 5G (upper left) is powered by a gasoline generator. The Hopster 5P (upper right) is powered by tractor power take-off (PTO). Both units are mobile. The picker fingers and dribble belts (bottom). NMSU Agricultural Science Center at Farmington, NM. 2017.**

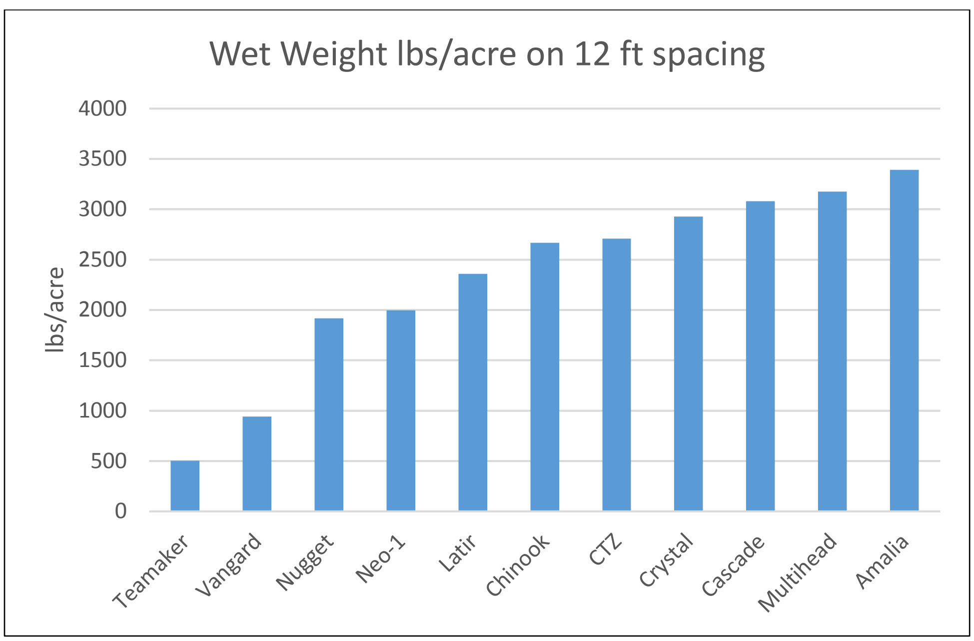


Figure 3. **Wet weight (lbs/acre) of hops harvested from NMSU-ASC Farmington test plots on a 12 ft row spacing x 3 ft spacing between plants or approximately 1,210 plants per acre. NMSU Agricultural Science Center at Farmington, NM. 2017.**

Malted Barley for New Mexico's Craft Brewing Industry

Funds and support provided by, USDA Hatch, Proximity Malt, Kevin Smith

We were able to secure seed for a large winter malting barley study comprised of 2 varieties out of Europe, and 2 standard varieties used in south-central Colorado in order to cover most of an 18-acre pivot located at the New Mexico State University Agricultural Science Center at Farmington, NM. The large plot study is in conjunction with the multi-entry, multi-state National Winter Malted Barley Trial (WMBT) administered through University of Minnesota. We planted the barleys in a freshly plowed and prepped field. Half the pivot was planted in potato in 2016 while the other half was fallow with the hypothesis that potato crop would deplete some residual nitrogen. Prep and planting posed some challenges due to the date of harvest of potato (late September) and the required planting dates of the barley, and lack of availability of large tillage equipment. We prepared the field with three smaller tractors. Prior to planting, we grid soil sampled. We started planting with the national trial on 10/4/16 and were done with the large plots by 10/11/16, with emergence occurring approximately 10 days later. Due to our attempt to achieve low protein brewer's barley, we applied no granular fertilizer and only 15 pounds per acre urea ammonium nitrate (UAN-32) one week before water turned off for the season/winter (October 19, 2016). An additional 15 pounds UAN-32 was applied on April 18, 2017, at the onset of the irrigation season. Drone aerial photos (Figure 4, Figure 5, Figure 6, and Figure 7) were taken periodically during the 2016/2017 growing season. Harvest occurred between July 6 and July 28, 2017. Postharvest samples were analyzed in the NAPI and Proximity Malt labs. (Table 37) We thank Proximity Malt (Milwaukee, WI), Limagrain Cereal Seeds (Fort Collins, CO), and Kevin Smith (University of Minnesota and U.S. National Winter Malted Barley Trial coordinator) for their support of this project.

Table 37. Procedures for two winter malted barley trials. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operations	Procedures
National Winter Malting Barley Trial	
Varieties:	30, 2-and 6-row winter malted barley cultivars
Planting Date:	October 4, 2016
Planting Rate:	76 lbs/acre (85 kg/ha)
Harvest date	July 6, 2017
Plot Size:	25 ft x 5 ft (125 ft^2) per variety entry
Proximity Malt Trial	
Varieties:	Calypso, Mission, Violetta and Flavia
Planting Date:	Calypso (10/05/2016), Mission (10/11/2016), Violetta (10/06/2016) and Flavia (10/10/2016)
Planting Rate:	100 lbs/acre
Harvest date	Calypso (7/10/2017), Mission (7/28/2017), Violetta (7/10/2017) and Flavia (7/12/2017)
Plot Size:	Calypso (5.53 acre), Mission (3.15 acre), Violetta (4.90 acre) and Flavia (4.46 acre)

Operations	Procedures
Management Practices	
Soil Test:	April 1, 2017
Fertilizer:	U-32 (32-0-0) liquid fertilizer injected into irrigation stream at 15 lbs of N per acre on October 19 2017 and 15 lbs of N April 18, 2017.
Drone photos:	Taken periodically
Fungicide:	None
Herbicide:	April 6, 2017: Huskie (Bayer Cro Sci; Restricted No; Warning; 29.6 a.i.; 15 oz/acre; total pesticide 3.2 gal) for the control of broadleaf weeds. R-11 Spreader Activator (Wilbur-Ellis; 3.2 oz/acre; total pesticide 0.7 gal).
Insecticide:	April 6, 2017: Mustang Maxx. (FMC; Restricted yes; 9.15 a.i.; 4 oz/acre; total pesticide 0.8 gal) for the control of Russian Aphids on adjoining wheat pivot.
Soil Type:	Doak sandy loam
Irrigation + Precip	Sprinkler/pivot plus winter precipitation
Irrigation 2016	October 10, 2016 October 29, 2016
Irrigation 2017	April 13, 2017 to June 6, 2017
Precipitation	7.67 inches
Results	Yield and protein characteristics are presented in (Table 38, Table 39, and Table 40)

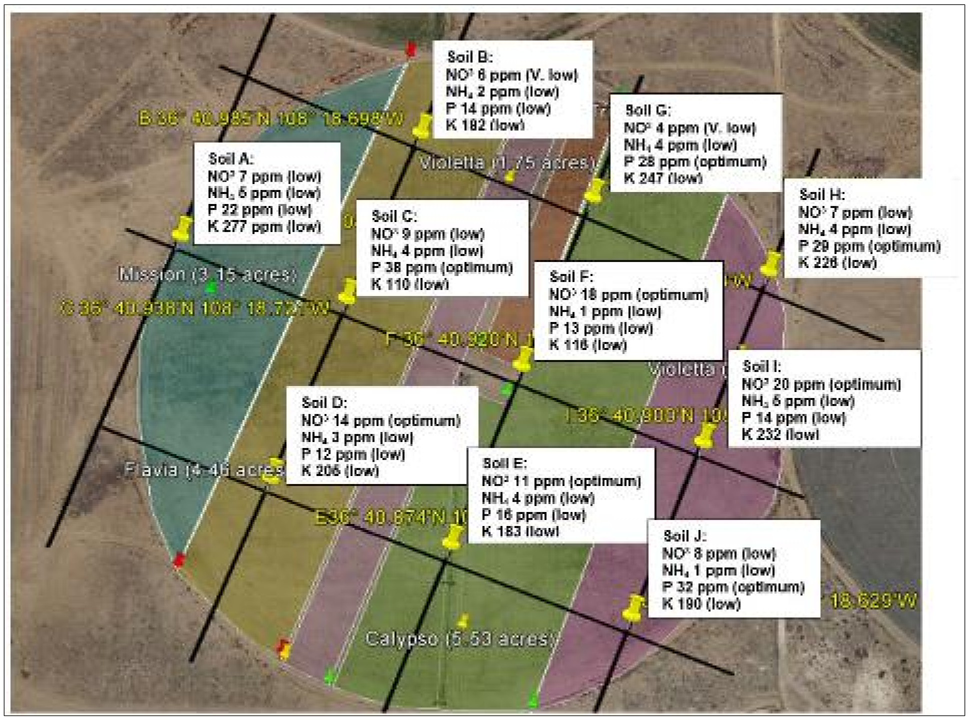


Figure 4. Aerial view of malted barley trial and GPS referenced soil sample points. The U.S. National Winter Malted Barley Trial (small brown rectangle) is surrounded by four cultivars (Violetta, Calypso, Flavia, and Mission) with support from Proximity Malt and Lima Seed Company. NMSU Agricultural Science Center at Farmington, NM. 2017.

Figure 5. Aerial photo taken May 2, 2017. Note that half of the 18 acre pivot was under potato for the 2016 growing season (south half). The north half was fallow (bare soil) in 2016. NMSU Agricultural Science Center at Farmington, NM. 2017.

Figure 6. Aerial photo taken May 12, 2017. NMSU-ASC Malted Barley Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

Figure 7. Aerial photo close-up of U.S. National Winter Malted Barley Trial taken June 8, 2017. NMSU-ASC Farmington Malted Barley Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

RESULTS

Table 38. National Winter Malted Barley Trial. NMSU Agricultural Science Center at Farmington, NM. 2017.

	Cultivar	2/6 Row	Yield bu/acre		Moisture %		Protein %	
1	Charles	2	93	abc	5.6	a	12.1	a
2	McGregor	6	113	abc	5.7	a	11.2	a
3	Thoroughbred	6	67	bc	5.8	a	11.5	a
4	Endeavor	2	94	abc	5.8	a	10.7	a
5	Wintmalt	2	103	abc	5.8	a	12.6	a
6	Violetta	2	116	abc	5.7	a	12.6	a
7	Calypso	2	143	abc	6.0	a	10.2	a
8	Puffin	2	113	abc	5.4	a	11.4	a
9	LGBB13-W102	6	132	abc	5.7	a	9.9	a
10	05ARS561-208	2	104	abc	5.7	a	10.4	a
11	06ARS633-3	2	104	abc	5.5	a	10.8	a
12	06ARS617-25	2	97	abc	5.9	a	10.4	a
13	07ARS515-7	2	150	ab	5.8	a	9.7	a
14	DH130004	2	75	abc	5.5	a	13.7	a
15	DH130939	2	137	abc	5.8	a	12.4	a
16	DH130718	2	71	abc	5.7	a	11.6	a
17	DH130910	2	139	abc	5.9	a	10.7	a
18	MW12_4028-007	6	61	c	5.9	a	11.1	a
19	MW12_4007-001	6	76	abc	5.6	a	11.5	a
20	MW13_4159-012	6	121	abc	5.7	a	10.3	a
21	MW13_4107-010	6	82	abc	5.8	a	11.1	a
22	2WI14-7462	2	90	abc	5.5	a	11.9	a
23	2WI14-7465	2	95	abc	5.6	a	11.2	a
24	2WI14-7577	2	79	abc	5.5	a	13.0	a
25	2WI14-7581	2	81	abc	5.4	a	11.9	a
26	Flavia	2	157	a	5.7	a	10.6	a
27	SU-Mateo	2	138	abc	5.8	a	10.3	a
28	AC09/327/2	2	136	abc	5.8	a	10.1	a
29	Mission	2	126	abc	5.9	a	10.2	a
30	Hirondella	6	117	abc	5.6	a	10.8	a

Means within a column followed by the same letter are not significantly different according to Tukey's honestly significant difference (HSD) pairwise comparison test at $P \leq 0.05$.

Table 39. Proximity Malt Winter Barley Trial Yield. NMSU Agricultural Science Center at Farmington, NM. 2017.

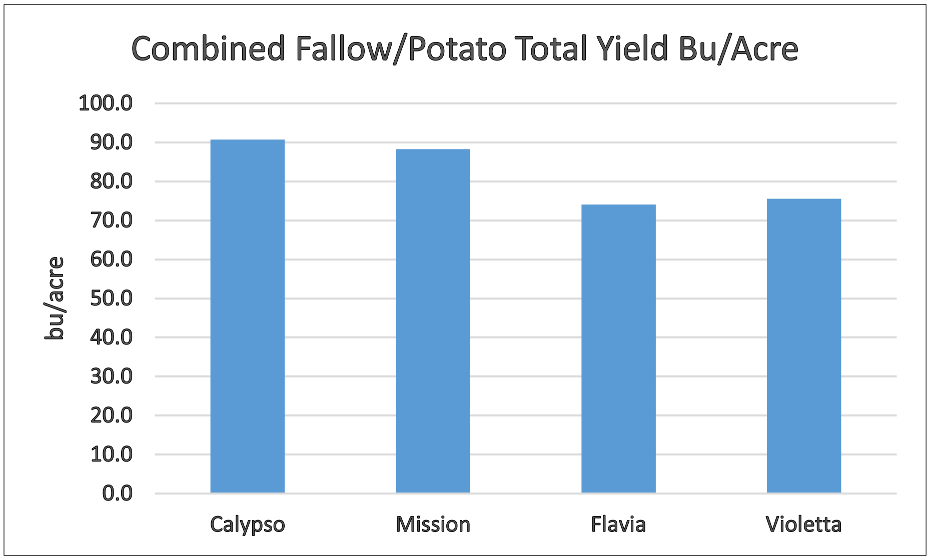


Table 40. Proximity Malt Winter Barley Trial Protein. NMSU Agricultural Science Center at Farmington, NM. 2017.

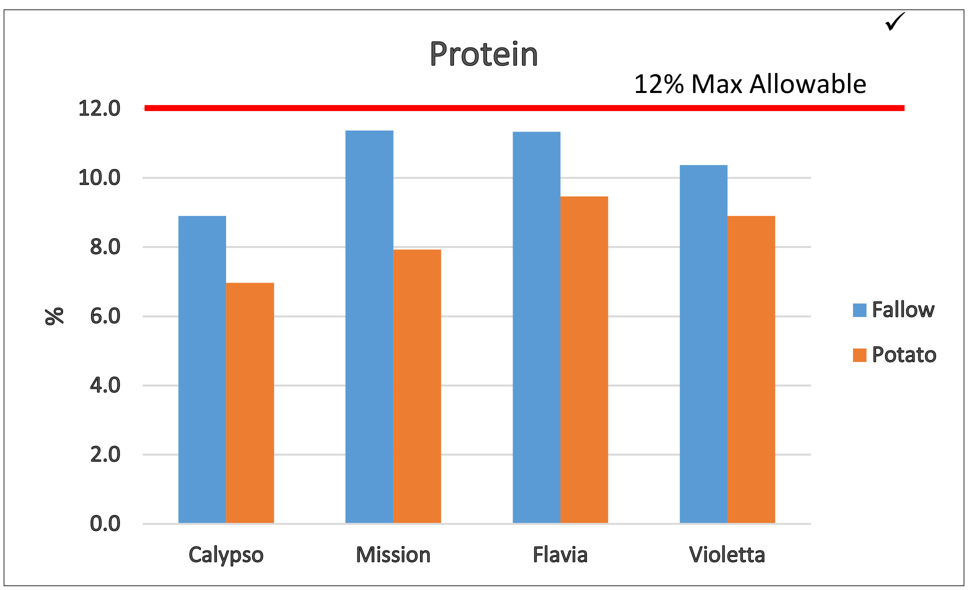


Table 41. Proximity Malt Winter Barley test weight and other components. NMSU Agricultural Science Center at Farmington, NM. 2017.

		Protein		Moisture		Test Weight		S/B
Treatments	**Cultivar**	**(%)**	**(12% max.)**	**(%)**	**(13% max.)**	**(lbs.)**	**(49.5 lbs. min.)**	
Fallow	Calypso	8.9	✓	9.7	✓	47.8	X	6.4
	Mission	11.4	✓	13.8	X	37.9	X	1.5
	Flavia	11.3	✓	9.6	✓	45.9	X	10.3
	Violetta	10.4	✓	9.4	✓	48.4	X	9.6
Mean		**10.5**		**10.7**		**45.0**		**6.9**
Potato	Calypso	8.1	✓	9.5	✓	47.8	X	12.8
	Mission	7.6	✓	13.1	X	41.3	X	1.7
	Flavia	9.9	✓	10.0	✓	44.2	X	11.6
	Violetta	9.2	✓	9.3	✓	48.5	X	13.3
Mean		**8.7**		**10.5**		**45.4**		**9.9**

Table 42. Proximity Malt Winter Barley plump, thin, and dockage. NMSU Agricultural Science Center at Farmington, NM. 2017.

		Plump			Thin		Dockage
Treatments	**Cultivar**	**(%)**	**90% min**	**80% min**	**(%)**	**5% max**	
Fallow	Calypso	79.8	X	✓	8.8	X	1.2
	Mission	62.8	X	X	17.5	X	0.2
	Flavia	86.3	X	✓	7.0	X	0.8
	Violetta	82.2	X	✓	8.0	X	0.5
Mean		**77.8**			**10.3**		**0.7**
Potato	Calypso	91.0	✓	✓	5.1	X	1.8
	Mission	94.3	✓	✓	2.7	X	0.2
	Flavia	88.2	X	✓	6.4	X	0.8
	Violetta	90.0	✓	✓	5.2	X	1.0
Mean		**90.9**			**4.8**		**1.0**

Yield: Potato and Fallow plots were combined for total yield by cultivar: Calypso (90.8 bu/acre), Mission (88.2 bu/acre), Violetta (75.5 bu/acre) and Flavia (74.0 bu/acre). (Table 41) Yields were similar to the three year mean for western North Dakota grown test plots (Ransom, Brueggeman et al. 2017). Yields can be increased with better nitrogen (N) management but should not come at the expense of meeting protein % standards for malting. Nitrogen fertilization will increase yields but also boost protein content. If malting industry standards are not met in this category, the crop is rejected and the return on investment is lowered to feed-grade.

Protein: Excess protein leads to poor quality beer. Protein levels all were below the 12% maximum allowable threshold for malting standards. Good news. Barley grown after a potato crop generally had lower protein than fallow plots even though in general, soil nitrates (NO_3) and ammonium (NH_4) were higher in potato vs fallow plots. This observation may indicate that less fertilizer inputs would be needed for a barley after potato crop rotation if the barley is consuming whatever residual N may be remaining as part of a previous potato crop input. Future work should involve replicated plots to better test this hypothesis. We may have been able to boost the yields and still come under the 12% protein limit by applying more N. But protein content is a significant determinant of the value of the grain at harvest. As return on investments are considered for malted barley, lower yields can be off-set by acceptable protein levels (Ransom, Brueggeman et al. 2017).

Moisture content: Only Mission exceeded the moisture content standards as >13% moisture. Monsoonal rains occurred at the time of harvesting the last plot, Mission, which was likely the reason. If we had been able to harvest on the same day as the other cultivars, we probably could have achieved lower moisture content for Mission.

Test Weight: A measure of the density of the grain. Weight per bushel (2,150.42 cubic inches) of dockage-free portion. Causes of reduced kernel filling resulting in lower test weight include climate and sub-optimal management.

Plumpness: Plump and uniform kernels contain higher starch which produces more beer from a given weight of malt. Plumpness is assessed by sieving over a 6/64" slotted screen with greater than 80% kernel retention being ideal for a two rowed barley. Six rowed varieties are generally less plump than two rowed (Macleod). Percent Plump was lower in Fallow (77.8%) than following a potato crop (90.9 %). Proximity Malt has a Plump standard of 90% min. (Table 42) Plump standards were not reached for any of the cultivars under Fallow following Proximity Malt standards.

Thin: Six-row malting barley that passes through a 5/16 x ¾ slotted hole sieve and two-row malting barley passing through a 5.5/64 x ¾ slotted-hole sieve.

No more than 5% of the kernels should be peeled or broken.

Dockage is defined as material passing through an 8/64 triangle screen, and all other foreign material.

Gold King Mine Animas River Spill Preliminary Assessment of Surface Water, Sediments and Irrigation Ditches

We were among the first to respond in evaluating and monitoring the impacts of the 2015 Gold King Mine spill into the Animas River. We are continuing to reach out to local farmers and the Navajo Nation through soil, irrigation ditch, and water quality monitoring. Our dissemination of data is helping farmers to make informed decisions and raising awareness of the potential impacts from upstream legacy mining in the Silverton Caldera.

Funds provided by the NMSU Experiment Station, Natural Resources Conservation Service, NM Division (USDA), and New Mexico Environment Department.

Kevin Lombard[1], April Ulery[2], David Weindorf[3]

[1]NMSU-ASC Farmington, [2]NMSU Department of Plant and Environmental Sciences, [3]Department of Plant and Soil Science, Texas Tech University

Introduction

“On August 5, 2015, EPA was conducting an investigation of the Gold King Mine near Silverton, Colorado, to: assess the on-going water releases from the mine, treat mine water, and assess the feasibility of further mine remediation. While excavating above the old audit (a mine tunnel), pressurized water began leaking above the mine tunnel, spilling about three million gallons of water stored behind the collapsed material into Cement Creek, a tributary of the Animas River” (EPA 2015).

Tasks 2017

Quality Assurance Project Plan (QAPP) Task Deliverables approved by EPA on March 8, 2017.

Stream Sediment and Irrigation Ditch Sampling and Analyses

- Sample sites selected; farm contacts and consent forms initiated.
- Irrigation ditch reconnaissance and sampling March 19-26, 2017 - field work in Aztec and Farmington, NM (collect sediment samples from irrigation ditches and conduct pre-season PXRF readings on agricultural fields in the Animas River watershed.
- Composited and processed samples for analysis - air drying, sieving, for acid digestion and ICP analysis in NMSU soils lab (March 27 - May 26, 2017).
- PXRF and soil samples (every 10th site) to NMSU lab initiated in late-March (Figure 8 and Figure 9).

- Agricultural fields selected, permission to sample and PXRF reading time adjusted for measurement of nine metals of interest (March 27 - April 14, 2017).
- Field work continued in Farmington and Aztec, PXRF readings for metal concentrations in agricultural fields (April 15 - May 30, 2017).
- PXRF "wet" sample data uploaded.
- Surface water/irrigation water samples were collected (May 1-2, 2017); one set sent to EPA R6 Houston Lab May 3-4, 2017, and one set to NMSU lab for Total Suspended Solids (TSS). NMSU TSS analyses completed (May 5, 2017).
- Sediment samples analyzed using ICP-OES for eight metals (not including As) on August 16, 2017.
- Arsenic analysis on sediment samples completed using ICP-MS August 22, 2017.
- Chromium analysis completed using ICP-MS to check PXRF interferences 9/12/17.

Agricultural Sampling and Analyses.

- Plant sampling of alfalfa and pasture grass fields began May 30, 2017.
- Rinsate collected from plant samples and oven dried at NMSU Agricultural Science Center (ASC), Farmington (June 1-2, 2017).
- TSS analyses completed for plant rinsates (alfalfa and pasture) at NMSU Soils Lab in Las Cruces, NM. (June 5, 2017).
- Completed arsenic (As) troubleshooting for interferences on ICP-OES (4 different wavelengths) (July 18, 2017).
- Vegetable mature leaf samples were collected from crop fields in Aztec and Farmington. Rinsate was collected from the plant samples and the clean samples were oven dried (~60°C) at NMSU ASC, Farmington (July 20, 2017).
- Surface/irrigation water was collected from the Animas and San Juan River watersheds in the mid-growing season (July 21, 2017). One set of water samples was packed on ice and delivered via overnight express to the EPA Lab, Houston, TX for ICP-MS analyses of total metals and one set taken to NMSU soils lab, Las Cruces, NM for TSS analyses.
- TSS analyses were completed for plant vegetable leaf rinsates at NMSU Soils Lab (July 25, 2017).
- TSS analyses were completed for surface irrigation water samples at NMSU Soils Lab, Las Cruces (July 26, 2017).

- Iron interference on As correction attempted by installing Multiple Spectral Fitting (MSF) on the Inductively Coupled Plasma - Optical Emission Spectrograph (ICP-OES). Corrections for As readings on ICP-OES were ineffective, so a method was developed to analyze As in plant (alfalfa and pasture) digests using ICP-Mass Spectroscopy (Perkin Elmer Elan DRC-E ICP-MS) July 31 - August 1, 2017.

- Vegetable samples collected from Navajo Nation. Rinsate collected from these samples and plant samples were oven dried (60°C) at NMSU ASC, Farmington. Calibrated a lower arsenic concentration standard curve for resolving interferences and difficulty with arsenic detection on the ICP-OES (August 16, 2017).

- Arsenic analysis on vegetable leaf samples from Aztec and Farmington started using ICP-MS August 29, 2017.

- Arsenic analysis on vegetable samples from Navajo Nation completed using ICP-MS September 5, 2017.

- Plant samples (vegetable leaves from Aztec and Farmington) analyzed using ICP-OES at NMSU Soils Lab (except for As, which will be analyzed using ICP-MS) September 11-12, 2017.

- Continuing digestion of plant and sediment samples and analyses in the Soils lab using both ICP-OES and ICP-MS as needed for metal detection limits. 9/12 - present Alfalfa, pasture and vegetable fields scanned for metals using PXRF in soil mode in Aztec and Farmington. (November 19-20, 2017)

- Irrigation ditch sediments sampled for analysis and comparing the changes in metal concentration sampled before the growing season. (November 21-22, 2017)

- Alfalfa, pasture and vegetable fields scanned for metals using PXRF in soil mode in Farmington and Shiprock. (November 11-13, 2017)

Outreach

- NMSU- Water Resources and Research Institute (WRRI) 2nd Annual Environmental Conditions of the Animas and San Juan Watersheds with Emphasis on Gold King Mine and Other Mine Waste Issues June 20-22, 2017, San Juan College, Farmington, NM. Abstracts for two posters and two oral presentations submitted on PXRF sampling and were presented by NMSU graduate students S. Fullen, G. Jha and B. Francis.

- Soil Science Society of America (scheduled October 2017) - Poster

- "Agricultural Factsheet" for distribution to consumers at farmers' markets (May 2017); Available online at the NMED Animas River Gold King Mine Wastewater Spill Response website: https://www.env.nm.gov/wp-content/uploads/2016/01/Agricultural-Use-of-Animas-and-San-Juan-River-water.pdf

- M.S. Thesis defense (Arsenic and Lead Total Concentrations in New Mexico Irrigation Ditch Sediments, S. Fullen, July 13, 2017)

- Second Shiprock Community Teach-in on Gold King Mine Exposure to Navajo Nation: Update on sediment results (July 19, 2017)

- Third Shiprock Community Teach-in on Gold King Mine Exposure to Navajo Nation: Update on alfalfa and pasture grass metal concentrations (August 22, 2017)

- First Upper Fruitland Community Teach-in on Gold King Mine Exposure to Navajo Nation: Update on sediment and plant sampling (August 23, 2017)

- First Aneth Community Teach-in on Gold King Mine Exposure to Navajo Nation: Update on sediment and plant sampling (August 23, 2017)

- Proceedings from the 2017 WRRI Conference, including presentations on this project, can be found at the website: https://animas.nmwrri.nmsu.edu/2017/

- Fourth Shiprock Community Teach-in on Gold King Mine Exposure to Navajo Nation: Update on vegetable leaf tissue metal concentrations (November 6, 2017)

- Interactive session at Dine College. In attendance were representatives from the NIH, Dine College, University of AZ Tri-state cooperative extension, Navajo Nation EPA, Navajo Nation Human Research Review Board, Navajo Nation Community Health Representative Program, NMSU, and the University of AZ (Dr. Karletta Chief's team updated the committee on water and food frequency data research). Other topics discussed included Farm resiliency projects, the need to engage CHR program, Navajo language dissemination, and furthering collaborative efforts to disseminate data. Dr. Kevin Lombard and Brandon Francis represented NMSU. (December 6, 2017).

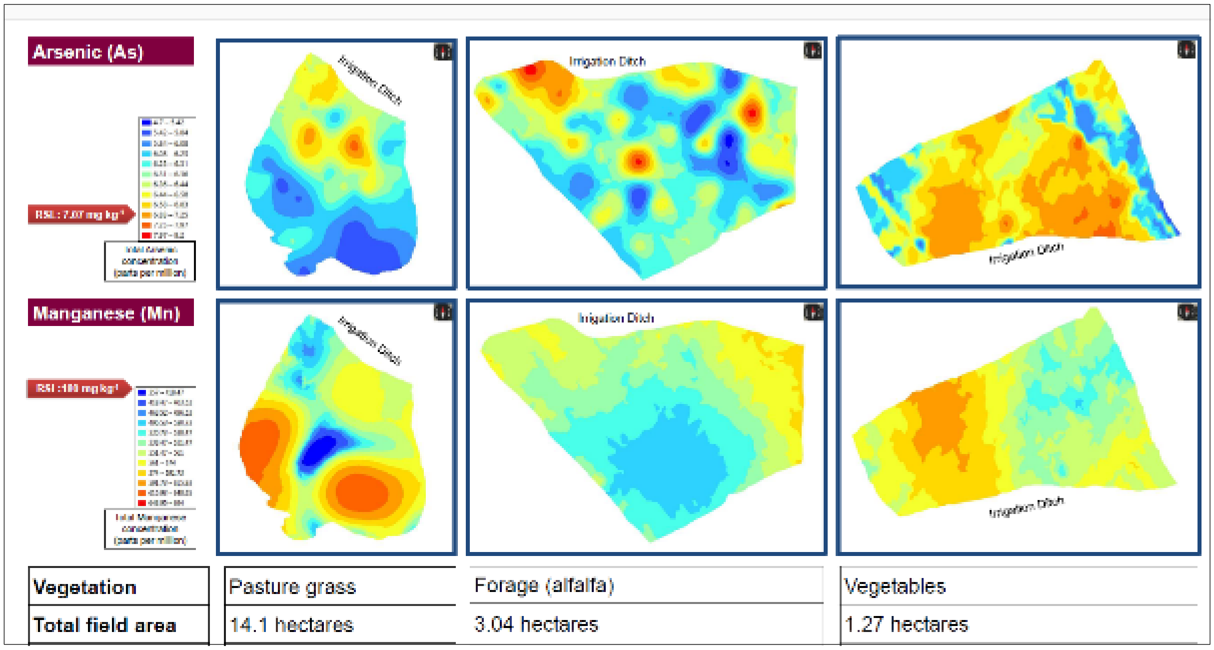


Figure 8. Example soil maps created from PXRF data. NMSU Agricultural Science Center – Farmington, NM. 2017.

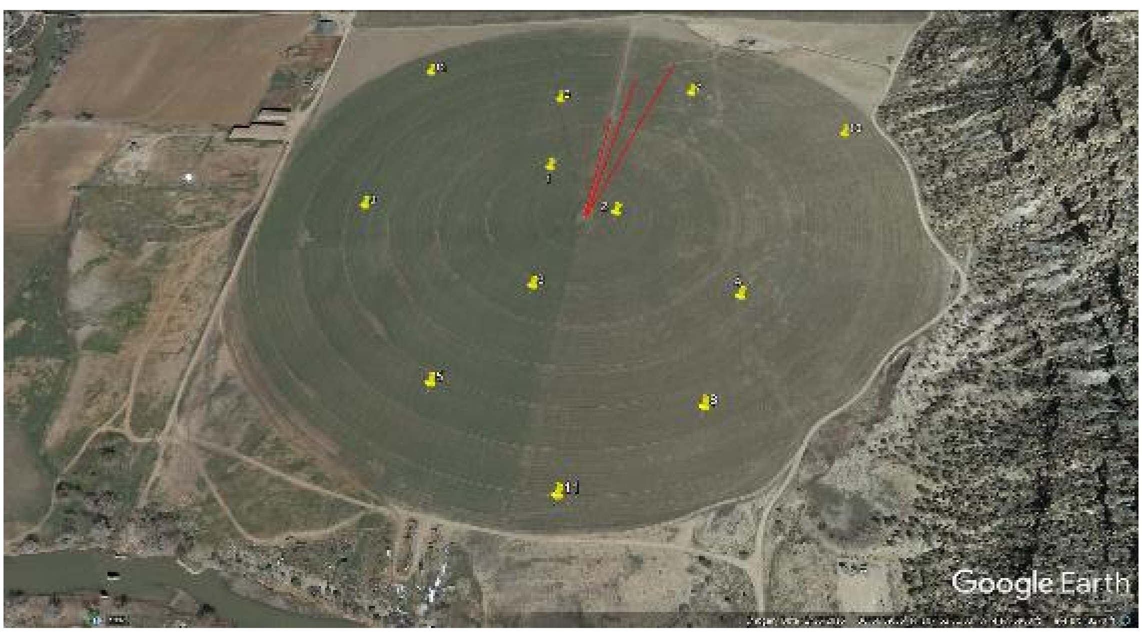


Figure 9. Example maps and quadrant division for agricultural vegetation sampling. NMSU Agricultural Science Center – Farmington, NM. 2017.

Engaging School and Family in Navajo Gardening for Health

Our outreach research on the Navajo Nation is increasing the number of community and backyard gardens, and shows the potential for modest increases of healthy foods in the diet. The prevalence of diabetes among the American Indian and Alaska Native populations (15.9%) is more than double the rates of the non-Hispanic/Caucasian population (7.6%; National Diabetes Statistics Report, 2014).

Funds provided by the U-54 Partnership for the Advancement of Cancer Research (PACR) partnership between the National Cancer Institute, the Fred Hutchinson Cancer Research Center and NMSU.

Kevin Lombard[1], Shirley A.A. Beresford[2], India Ornelas[2], Desiree Deschenie[1], Brandon Francis[1], Tiffany Charley[1], Sonia J. Bishop[2]

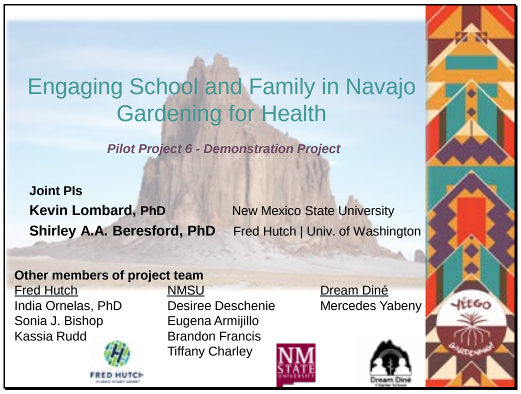
[1]NMSU-ASC Farmington, [2]University of Washington School of Public Health/Fred Hutchinson Cancer Research Center

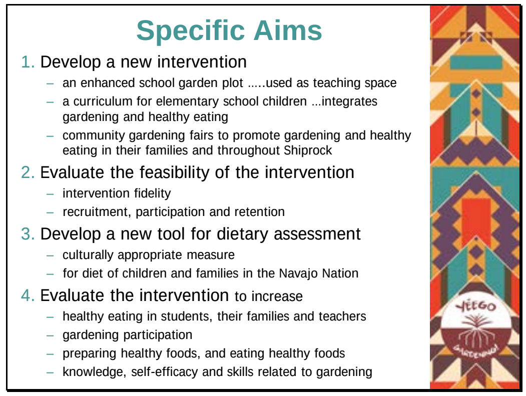
Specific Aims

Develop a new intervention that includes an enhanced school garden plot used as teaching space, a curriculum for elementary school children integrating gardening and healthy eating, and community gardening fairs to promote gardening and healthy eating in their families and throughout Shiprock. (Table 43)

1. Evaluate the feasibility of the intervention: intervention fidelity, recruitment, participation and retention.
2. Develop a new tool for dietary assessment for diet of children and families in the Navajo Nation.
3. Evaluate the intervention to increase healthy eating in students, their families and teachers, gardening participation, preparing healthy foods, and eating healthy foods, and knowledge, self-efficacy and skills related to gardening. (Table 44)

Table 43. Engaging School and Family in Navajo Gardening for Health specific aims, accomplishments, and outcomes. NMSU Agricultural Science Center – Farmington, NM. 2017.





1. Introduction / Planting a Garden	1. Introduction / Kitchen Safety
2. Sowing & Transplanting	2. Food Sovereignty
3. Garden Maintenance	

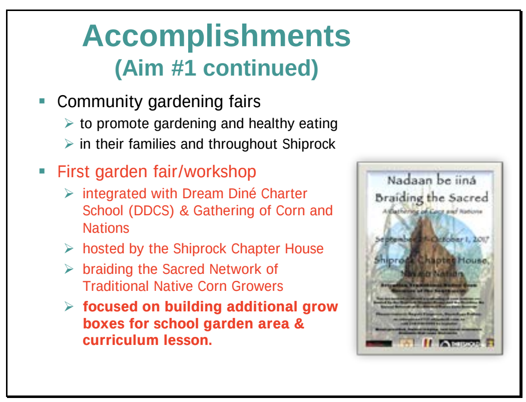
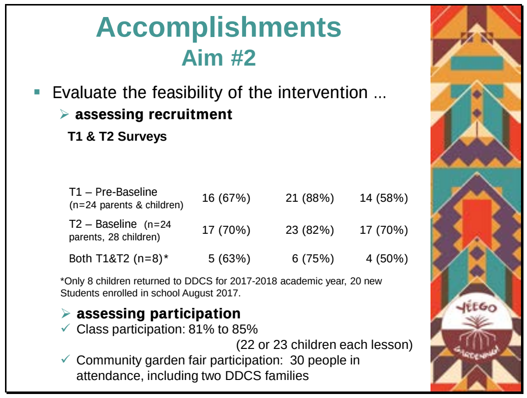
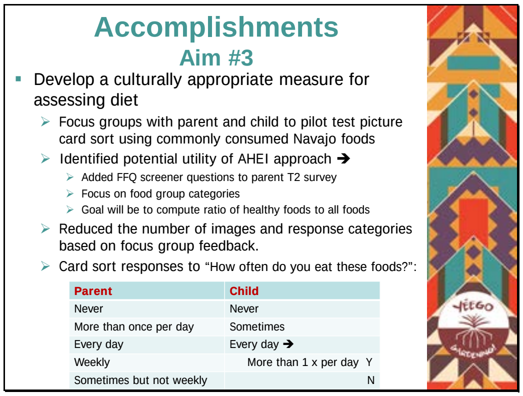
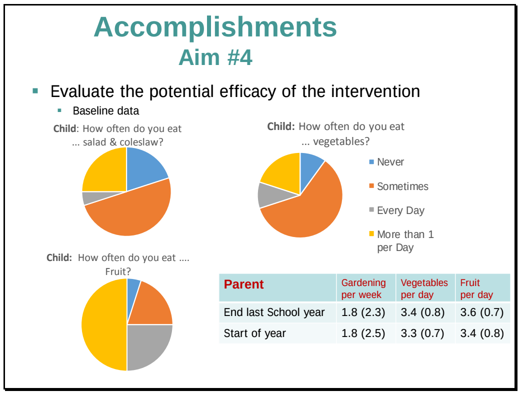
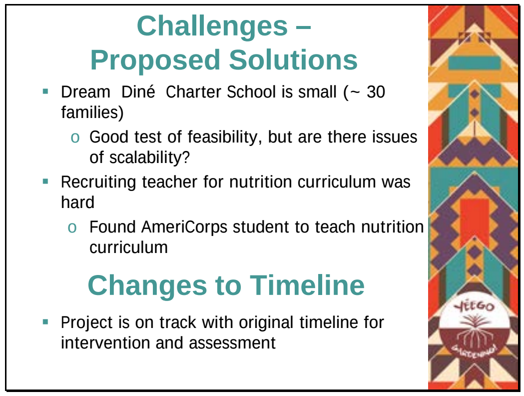


Table 44. Engaging School and Family in Navajo Gardening for Health accomplishments, challenges, and proposed solutions. NMSU Agricultural Science Center – Farmington, NM. 2017.









Development and Evaluation of Drip Irrigation for Northwest New Mexico

Hybrid Poplar Production under Drip Irrigation in the Four Corners Region

Funds provided by USDA through the Hatch Program, the State of New Mexico through general appropriations, US Bureau of Indian Affairs, and the José Fernández Memorial Chair in Crop Production.

M.K. O'Neill, K.A. Lombard, and S.C. Allen

Abstract

Hybrid poplar (*Populus* spp.) is one of the fastest-growing temperate trees, capable of producing merchantable products in rotations of 3-15 years. Hybrid poplar grown in the Four Corners region could supplement aspen supplies for wood products and provide environmental benefits such as wildlife habitat and windbreaks. To evaluate hybrid poplar for the Four Corners region, 10 hybrid poplar clones were obtained from nurseries in Oregon and Washington for establishment of an initial trial on 1.1 acres (0.45 ha) at ASC Farmington on May 15, 2002. Sixteen cuttings per clone per plot were planted in a 10 x 10 foot (3 x 3 m) grid spacing. The clonal entries were replicated in three blocks for a total of 480 trees. During the 2017 growing season, irrigation for the 2002-planted trees ran from June 15 to October 6, and was targeted at replacing the trees' evapotranspiration (ET) demand. (Irrigation was started late for these trees, as they were originally scheduled for harvest this year, and driplines had to be re-installed.) Total poplar ET for the growing season (April 17 – October 16) was estimated to be 42.8 inches (108.7 cm) while total mean irrigation amounted to 57.1 inches (145.0 cm), plus an additional 5.0 inches (12.7 cm) was received in rainfall during the growing season. Sixteenth-year survival, tree height, and diameter at breast height (DBH) were measured for all study trees on December 13, 18-20, 2017. Clone OP-367 remained the tallest clone after 16 seasons, reaching a mean height of 83.8 feet (25.5 m), with remaining clone heights ranging from 71.0 feet (21.7 m) (clone 49-177) to 53.5 feet (16.3 m) (Eridano). OP-367 had the largest mean DBH at 13.4 inches (34.1 cm). The remaining 7 clones ranged in diameter from 11.1 inches (28.2 cm) (311-93) to 7.6 inches (19.4 cm) (Eridano). Maximum wood volume was obtained by OP-367 at 13,135 ft^3/acre (919 m^3/ha) and total aboveground biomass for OP-367 was 247 tons/acre (554 Mg/ha).

Introduction

Hybrid poplar (*Populus* spp.) is one of the fastest-growing temperate trees, capable of producing merchantable products in short rotations of 3-15 years. Hybrid poplar grown in the Four Corners region could supplement aspen for use in excelsior production, and could provide wood for fuel and biochar, poles for traditional Navajo construction, and tradable carbon credits that may create incentives for plantation development around coal-burning power plants. The Agricultural Science Center is located on land farmed by the Navajo Agricultural Products Industry (NAPI), a large 85,000-acre commercial operation administered by the Navajo Nation. NAPI represents our largest target community to address agricultural improvement and market development issues. NAPI and Western Excelsior Corporation of Mancos, CO had expressed interest in the production of poplar as a sustainable substitute for aspen currently harvested from the nearby national forest. This project can provide an opportunity for collaboration between producers and manufacturers for the development of hybrid poplar production under drip irrigation in the Four Corners.

Objectives

- Identify hybrid poplar clones suitable for alkaline soils inherent to the region.
- Determine water use requirements and growth rates of poplar species grown in high pH soils.
- Identify potential post-harvest markets for the material.

Materials and methods

During spring 2002, 10 hybrid clones were obtained from nurseries in Oregon and Washington (Table 45). These clones were various crosses between *Populus deltoides*, *P. maximowiczii*, *P. nigra*, and *P. trichocarpa*. Establishment and maintenance procedures for the hybrid poplar production trial are presented in Table 46. Prior to planting, the field was disked, leveled, and spot sprayed with Roundup (glyphosate) herbicide. Netafim Ram pressure-compensating surface drip line (flow rate of 0.42 gal/hr and with emitters every ~3 feet) was installed with two lines per row of trees. Sixteen cuttings per clone per plot were planted May 15, 2002 on 10 x 10 foot (3 x 3 m) grid spacing. Holes were prepared for cuttings using a soil probe of 0.5-inch diameter, on pre-moistened ground. The 7-inch cuttings with four buds were planted leaving only the topmost bud exposed above soil level. Clone entries were replicated in 3 blocks, for a total of 480 trees. Excess cuttings were kept in the greenhouse for replanting purposes.

Table 45. Taxonomy of ten hybrid poplar clones grown under drip irrigation. NMSU Agricultural Science Center at Farmington, NM. 2002–2017.

		Female			Male		
Clone	Taxon	Parent	*Populus* sp.	Provenance	Parent	*Populus* sp.	Provenance
Eridano†	DM	Unknown	*deltoides*	France	Unknown	*maximowiczii*	Japan
OP-367†	DN	Unknown	*deltoides*	Unknown	Caudina	*nigra*	Unknown
NM-6†	NM	Unknown	*nigra*	Unknown	Unknown	*maximowiczii*	Unknown
58-280	TD	GF 93-972	*trichocarpa*	Granite Falls, WA	ILL 129	*deltoides*	Illinois
49-177	TD	ORT 81-3	*trichocarpa*	Orting, WA	S7C1	*deltoides*	Texas
52-225	TD	GF 93-968	*trichocarpa*	Granite Falls, WA	ILL 101	*deltoides*	Illinois
195-529	TD	IFA 94-872	*trichocarpa*	Old plantation (WA)	OK 21-7	*deltoides*	Oklahoma
50-194‡	TD	GF 93-968	*trichocarpa*	Granite Falls, WA	ILL 005	*deltoides*	Illinois
184-411‡	TD	RAN 91-568	*trichocarpa*	Randle, WA	OK 17-10	*deltoides*	Oklahoma
311-93	TN	NIS 8-1046	*trichocarpa*	Nisqually River, WA	F22	*nigra*	France (Loire Valley)

* N=48 for each clonal entry (16 trees per plot x 3 replications). Survival assessed December 2017.
† Hybrid came from a breeding program other than Washington State University.
‡ Hybrid dropped from analysis after first season due to poor survival.

Although poplar consumptive-use estimates were not available for the Farmington area, monthly water-use rates of first, second, and third season poplar grown at a site having similar climatic characteristics in Oregon were reported by Gochis and Cuenca (2000). These values were used to generate crop coefficients relating to each year of poplar growth as related to growing degree days (GDD). The crop coefficients are used to modify the Penman-Monteith reference evapotranspiration value for a given day (ET_{TALL}) and the subsequent values are used to program irrigation. Equation 1 is for first season, Equation 2 is for second season, and Equation 3 is for third and subsequent year hybrid poplar production at Farmington. Equation 4 calculates the ET value for a given day in a given year of production.

$$K_{C(1)} = 3.93\text{x}10\text{-}1 - 2.58\text{x}10\text{-}5\ (\Sigma GDD) + 5.39\text{x}10\text{-}8(\Sigma GDD^2) - 8.98\text{x}10\text{-}12(\Sigma GDD^3) \quad (1)$$

$$K_{C(2)} = 3.71\text{x}10\text{-}1 + 1.38\text{x}10\text{-}4\ (\Sigma GDD) + 2.95\text{x}10\text{-}8(\Sigma GDD^2) - 8.20\text{x}10\text{-}12(\Sigma GDD^3) \quad (2)$$

$$K_{C(3)} = 5.18\text{x}10\text{-}1 + 4.57\text{x}10\text{-}5\ (\Sigma GDD) + 1.19\text{x}10\text{-}7(\Sigma GDD^2) - 2.40\text{x}10\text{-}11(\Sigma GDD^3) \quad (3)$$

$$ET = K_{C(year)} \text{ x } ET^{TALL} \quad (4)$$

where

$K_{C(year)}$ = Crop coefficient for a given year;

ΣGDD = Cumulative growing degree days (calculated in degrees Fahrenheit); and

ET = Evapotranspiration replacement rate (inches).

For the 2017 growing season, irrigation was started on June 15 (late) and programmed according to estimated ET demand, with irrigation concluding on

October 6. For the purposes of delineating the growing season, significant tree ET demand was estimated to begin April 17 and to end October 16 with the usual cessation of the irrigation season due to the possibility of freezing weather. Total poplar ET for this period was estimated to be 42.8 inches, while total mean irrigation amounted to 57.1 inches, plus an additional 5.0 inches was received in rainfall.

The soil at the experimental site was originally classified as a Kinnear sandy loan (fine-loamy, mixed, calcareous mesic Typic Camborthid) (Anderson 1970) and later re-classified as a Doak sandy loam (fine-loamy, mixed, mesic Typic Haplargid) (Keetch 1980). Water holding capacity in a three-foot profile is 4.98 inches (1.66 in/ft) and pH averages 8.2, resulting in a moderately calcareous soil that might not be conducive to production of certain poplar species. At high soil pH, iron availability is reduced, resulting in possible leaf chlorosis (Brady and Weil 1999; Havlin et al. 1999). To encourage green growth, U-32 (32-0-0) liquid fertilizer was injected into irrigation stream at 30 lbs of N per acre on June 20 and 20 lbs of N per acre on September 20, 2017 (i.e., total of 50 lbs of N per acre applied for season) (Table 46).

Sixteenth-year survival, tree height, and diameter at breast height (DBH) were determined for all study trees on December 13, 18-20, 2017. For 2017 clinometer readings, a 60-ft horizontal distance from tree was maintained for the readings.

Wood volume per tree was calculated after Browne (1962) using Equation 5 below and scaled to ft^3/acre:

$$V = 10^{(-2.945047+1.803973*Log(DBH) + 1.238853*Log(Ht))} \quad (5)$$

where

V = Bole wood volume expressed without branches (ft^3/tree);

DBH = Diameter at breast height (inches); and

Ht = Tree Height (feet).

Statistical analysis was carried out using the ANOVA procedure (for randomized blocks) in the CoStat software package version 6.400 (CoHort 2008). Least significant differences were determined at the 0.05 level.

Table 46. Operations and procedures for 2002-planted hybrid poplar trial under drip irrigation. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operations	Procedures
Varieties:	8 hybrid poplar (*Populus* spp.) clones
Planting Date:	May 15, 2002
Planting Rate:	10 x 10 ft (3 x 3 m) spacing (436 trees/acre)
Plot Size:	40 x 40 ft (12.2 x 12.2 m) each containing 16 trees/plot (no borders)
Fertilization:	U-32 (32-0-0) liquid fertilizer injected into irrigation stream at 30 lbs of N per acre on June 20 and 20 lbs of N per acre on September 20, 2017 (total of 50 lbs of N per acre applied for season)
Fungicide:	None
Herbicide:	None
Insecticide:	None
Rodenticide:	None
Chlorine:	None
Soil Type:	Doak sandy loam
Irrigation:	Surface drip irrigation managed via Rain Bird control system
Irrigation Commenced:	June 15, 2017
Irrigation Concluded:	October 6, 2017

Results and discussion

Of the 10 *Populus* spp. evaluated (**Error! Reference source not found.**) for production in the semi-arid Four Corners region, 7 had *P. trichocarpa*, 2 had *P. deltoides*, and 1 had *P. nigra* female parentage. There were two clones each with *P. maximowiczii* and *P. nigra* male parentage and six clones with *P. deltoides* male parentage. Johnson and Johnson (2003) suggest that hybrid poplar breeding programs for the semi-arid regions of eastern Washington and Oregon should include *P. nigra* as one of the parents to increase resistance to poplar-and-willow borer (*Cryptorhynchus lapathi*) and reduce water stress. In this trial, NM-6, OP-367, and 311-91 all had *P. nigra* parentage; NM-6 was developed from a female *P. nigra* parent while OP-367 and 311-93 were derived from male *P. nigra* parents. Two clones (50-194 and 184-411) were eliminated after the initial 2002 season due to poor survival, and were substituted with clones PC-06 and DN-34 in the second year (thus not part of the formal study).

Water applications

Cumulative crop ET (ET_C) and water application (Table 46) plus rainfall for sixteenth-year hybrid poplar were determined. Application rates were historically based on equations derived from Gochis and Cuenca (2000) and developed at the Center for relating ET to day of year (DOY) (Smeal, Personal Communication, 2001). During the 2017 growing season, total crop ET was estimated to be 42.8 inches, while total mean irrigation amounted to 57.1 inches, plus 5.0 inches was received in rainfall. As these trees had originally been scheduled for harvest, driplines that had been removed were reinstalled (one side of tree only) and irrigation was started on June 15; under these conditions, it was decided to err on the side of general over-application to ensure health of trees, and target irrigation hours were eventually attained.

Growth

Clone OP-367 remained the tallest clone after 16 seasons, reaching a mean height of 83.8 feet (25.5 m), with remaining clone heights ranging from 71.0 feet (21.7 m) (clone 49-177) to 53.5 feet (16.3 m) (Eridano). OP-367 had the largest mean DBH at 13.4 inches (34.1 cm). The remaining 7 clones ranged in diameter from 11.1 inches (28.2 cm) (311-93) to 7.6 inches (19.4 cm) (Eridano). Maximum wood volume was obtained by OP-367 at 13,135 ft^3/acre (919 m^3/ha) and total aboveground biomass for OP-367 was 247 tons/acre (554 Mg/ha). At the end of 16 seasons, OP-367, 58-280, and 311-93 still maintained 90% or higher survival, with mean survival for the entire trial population at 81.5% (Table 47). Two clones, 195-529 and 52-225, experienced severe mortality shortly after the start of the study, losing practically all trees in one replicate each. Interestingly, the other two replicates of these clones did not experience this. The two plots with high mortality were adjacent and located in an area of high pH (8.5) and $CaCO_3$ concentrations (4,200 ppm) (Lombard, 2007).

Table 47. Growth and survival of 2002-planted hybrid poplar clones grown under drip irrigation. NMSU Agricultural Science Center at Farmington, NM. 2017.

Clone	Survival (%)	DBH† (in)	DBH (cm)	Height (ft)	Height (m)	Wood Vol. (ft^3/acre)	Wood Vol. (m^3/ha)	Biomass (ton/acre)	Biomass (Mg/ha)
OP-367	100.0	13.4	34.1	83.8	25.5	13,135	919	247	554
311-93	93.8	11.1	28.2	68.9	21.0	7,486	524	160	359
58-280	97.9	10.9	27.7	61.3	18.7	6,175	432	150	336
49-177	85.4	10.0	25.4	71.0	21.7	6,418	449	125	280
52-225	60.4	9.3	23.6	59.1	18.0	4,572	320	109	244
195-529	56.3	9.1	23.2	66.8	20.4	5,283	370	105	236
NM-6	77.1	8.6	21.7	60.3	18.4	4,076	285	87	195
Eridano	81.3	7.6	19.4	53.5	16.3	2,998	210	68	152
Mean‡	**81.5**	**10.2**	**25.9**	**66.3**	**20.2**	**6,593**	**461**	**138**	**309**
CV%	44.0	17.6	17.6	11.8	11.9	37.3	37.4	41.4	41.4
LSD (0.05)	0.1	1.0	2.4	4.2	1.3	1,313.7	91.9	30.5	68.4
p>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

† DBH = Diameter at breast height (~ 4.5 ft or 1.37 m).
‡ Mean is calculated from 8 clonal entries, each originally consisting of 3 replications of 16 study trees per plot.

Elevated soil pH reduces the availability of iron, which is needed to produce chlorophyll, while chelation renders it more available (Brady and Weil 1999; Havlin et al. 1999). Studies have demonstrated reduced growth of hybrid poplar at elevated soil pH. Timmer (1985) found that optimum growth of a single poplar clone was between pH 6.0 and 7.0. Working in south-central Oregon, Leavengood et al. (2001) attributed reduced height of OP-367 by 73%, in various sections of a field, to increased soil pH from 7.7 to 8.5. The pH of the soil used in this trial was ~8.2, similar to that used by Shock et al. (2002) at Malheur Experiment Station in Oregon.

OP-367 remains superior in all characteristics measured after sixteen years, with several other entries showing good performance and survival, including clones 311-93, 58-280, and 49-177. The loss of a number of trees from clones 195-529 and 52-225 in previous years shifts their means slightly, since dead trees are eliminated from the analysis; the majority of these lost trees were in two plots where high soil calcium carbonate had been documented. Clone PC-06, though not part of the formal study, amassed a total aboveground biomass of 128 tons/acre (286 Mg/ha) for 2017, surpassing certain clones planted the year before. Survival for PC-06 after 15 years was 75.0%, and survival of clone DN-34 was 89.6%. Eridano, while a marginal performer at our site, is still an attractive tree (with bark similar to aspen), so perhaps it may perform better under moister/warmer conditions.

Based on our observations, it appears that the hybrids OP-367, 311-93, 58-280 and 49-177 show the most promise for good growth on high pH soils typical of the area. These clones exhibit the least chlorosis and greatest growth potential.

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Evaluation of Hybrid Poplar Amended with Composted Biosolids

K.A. Lombard, M.K. O'Neill, and S.C. Allen

Abstract

In Spring 2005, a 1.2-acre (0.5-ha) trial was initiated at ASC Farmington to test whether composted biosolids (a municipal waste) can serve as a suitable fertilizer for hybrid poplars growing on a chlorosis-prone, high-pH soil. Prior to planting, plots received a one-time application of biosolids in composted form at 10 and 20 tons/acre [22.8 and 45.5 metric tons/hectare (Mg/ha)]; Sprint 138, a chelated iron, served as a fertilizer check, and control plots received no amendments. Cuttings of the hybrid poplar clone OP-367 (a Populus deltoides x P. nigra cross) were subsequently planted in a 12 x 12 foot (3.6 x 3.6 m) grid spacing. For 2017, trends of non-significance continued for most measured variables, except for tree height: surprisingly, average height for biosolids-treated trees (86.3 ft or 26.3 m) at 20 tons/acre treatment was significantly higher than Sprint-treated or control trees (average of 79.8 ft, or 24.4 m). This may be due an actual treatment difference, or it may be due to block/plot differences. Other variables did not show a treatment difference. Average diameter at breast height (DBH) for all study trees in 2017 was 10.9 inches (27.7 cm). Average wood volume was 6,183 ft3/acre (433 m3/ha), and average biomass was 103.8 tons/acre (232.7 Mg/ha), reflecting modest growth from the previous year. A lack of fertilizer treatment differences is explainable given natural soil turnover combined with strong growth of clone OP-367. Some minor statistical significance was noted for some plot and block locations, with trees in exterior plots tending to have slightly lower DBH and height, likely due to wind and drying effects from closer proximity to stand edges. In addition, water pressure difficulties and an extended non-irrigation period resulted in under-application of ET replacement. Overall, the use of biosolids-amended soil appears to have been useful in addressing initial chlorosis issues, and resulted in adequate subsequent growth. To date, the study trees appear to be the healthiest and tallest on the station, with several specimens exceeding 100 feet, so more study of their success is warranted.

Introduction

Hybrid poplars grown on high-pH, calcareous soils typical of the Four Corners region may exhibit iron chlorosis to varying degrees. Accordingly, plots established at ASC Farmington have occasionally been given supplemental Fe fertilizer during irrigations, a costly process that provides temporary alleviation of chlorosis symptoms. Composted biosolids, a byproduct of municipal sewage treatment plants, have been shown to increase levels of plant-available Fe on calcareous soils (Moral et al. 2002) and have received attention in horticultural applications (Bowman and Durham 2002). However, they may also create public health and environmental concerns (which could translate into political opposition to land use) if not managed properly (Committee on Toxicants and Pathogens in Biosolids Applied to Land 2002; Iranpour et al. 2004). Agricultural land application of biosolids has been encouraged by the US EPA as an alternative to land filling.

In a greenhouse study conducted at NMSU in 2004, two hybrid poplar clones (NM-6 and OP-367) amended with biosolids at 2 rates remained the least chlorotic as indicated by a Minolta SPAD 502 meter, and compared favorably with poplar amended with expensive chelated Fe. A second greenhouse study in 2005 confirmed these results, which served as the impetus for conducting a field trial of hybrid polar cultivated in soil amended with composted biosolids.

Materials and methods

The 1.2-acre (0.5-ha) trial was staked out at ASC Farmington on February 21-24, 2005 using a transit and tape measure. Baseline soil samples augured to a depth of 8 inches (20 cm) were taken April 6, 2005 prior to the addition of treatments. Composites of four soil samples from each plot were made and air dried in a greenhouse. Chemical traits of soil and biosolids samples are shown in Table 48.

Biosolids originating from the City of Albuquerque Pilot Composting Facility (Waste Water Utilities Division) were produced by mixing dewatered sewage sludge with yard waste. The mixture was then composted at their facility to reduce pathogen concentrations in accordance with US EPA public health standards. The resultant products are categorized as 'Class A' biosolids (Albuquerque 2010). Furthermore, stringent guidelines are followed to ensure that heavy metal contents are below regulatory limits, thus permitting agricultural land application. The biosolids arrived from Albuquerque on April 1, 2005 via drop-bottom truck (Haven's Trucking, Farmington) and were unloaded by hand due to compaction during transit.

Table 48. Baseline chemical traits of soil and biosolids samples collected in 2005. NMSU Agricultural Science Center at Farmington, NM, 2017.

Parameter	Soil *	Biosolids †
pH (1:2)	8.3	7.5
Soil Electrical Conductivity (EC) (mS/cm)	0.7	14.0
Sodium Adsorption Ratio (SAR)	0.5	4.8
NO_3-N (ppm)	7.1	99.9
P (ppm)	5.0	340.0
Zn (ppm)	1.2	42.2
Fe (ppm)	4.8	476.0
Mn (ppm)	4.6	42.0
Cu (ppm)	1.5	14.6
Ca (ppm)	3,492.0	4,540.0
Mg (ppm)	201.0	603.0
Na (ppm)	9.9	456.0
K (ppm)	224.0	3,740.0

* Mean of 12 samples was taken April 6, 2005 and analyzed at the NAPI lab except for EC and SAR which were analyzed in Las Cruces, NM.

† All parameters for biosolids except EC and SAR were taken from one composite sample and analyzed at the NAPI lab (EC and SAR means of 3 samples were analyzed from same batch in Las Cruces, NM).

Two application rates were applied for the study: 10 and 20 tons/acre (22.8 and 45.5 metric tons per hectare [Mg/ha], respectively). English units for the application rates will be used from this point forward. Biosolids were added to plots beginning with Block 1 on April 6-7, 2005 using a John Deere tractor-pulled drop-type fertilizer spreader with a capacity of 600 pounds per load (272 kg per load). The fertilizer spreader was loaded using a small Kubota front-end loader. Small rocks picked up from the road during an earlier consolidation of the biosolids pile were initially a problem for operation of the fertilizer spreader and had to be sifted out during the loading process. To apply the 10 tons/acre rate based on plot area, 3.5 loads were required, and 7 loads for the 20 tons/acre rate were used. After biosolids applications to Block 1 were completed, the entire block was rototilled to a depth of 5 inches (13 cm) to incorporate amendments and to prevent windborne movement. The biosolids were applied to Block 2, but were not incorporated due to a slight easterly wind and the concern that rototilling would exacerbate windborne movement. As a precaution, a low fabric wind barrier was erected along the boundary of Block 2 until incorporation was achieved the following day. Block 3 was prepared similarly as Block 1 application and incorporation was carried out on the same day. These procedures are summarized in Table 49 along with current cultural practices.

Table 49. Operations and procedures for 2005-planted hybrid poplars in biosolids application trial. NMSU Agricultural Science Center at Farmington, NM, 2017.

Operations	Procedures
Variety:	Hybrid poplar clone OP-367 (*Populus deltoides* x *P. nigra*)
Biosolids Application:	April 6-7, 2005. Composted biosolids spread at 10 and 20 tons/acre (22.75 and 45.5 Mg/ha) rate using tractor-pulled fertilizer spreader. Plots rototilled to a depth of 5 inches (13 cm).
Planting Date:	April 27-28, 2005
Planting Rate:	12 x 12 ft (3.6 x 3.6 m) spacing (302 trees/acre)
Plot Size:	48 x 96 ft = 4,608 ft^2 (14.5 x 31 m = 450 m^2) with 12 study trees/plot
Treatments (2005):	Control, 10 tons/acre of biosolids, 20 tons/acre of biosolids, baseline Sprint Fe-chelate application (applied annually by hand through 2010)
Fertilization:	None in 2017
Fungicide:	None
Herbicide:	None
Insecticide:	None
Rodenticide:	None
Chlorine:	None
Soil Type:	Doak sandy loam
Pruning:	Pruned to a single leader
Irrigation:	Surface drip irrigation managed via Rain Bird control system
Irrigation Commenced:	May 16, 2017
Irrigation Concluded:	October 13, 2017

Cuttings of OP-367 (a *Populus deltoides* x *P. nigra* cross) were obtained in spring 2005 and planted on moistened soil at 12 x 12 foot (3.6 x 3.6 meter) spacing on April 27-28. Cuttings were placed at a drip emitter, and an iron stake pushed into the ground aided in planting. Five people planted the entire trial. By May 11, 2005 most of the cuttings had shown dormancy break with the emergence of 1-2 new leaves.

Irrigation application rates were historically based on equations derived from Gochis and Cuenca (2000) and developed at the Center for relating ET to growing degree days (GDD) (Smeal, Personal Communication, 2001). For the 2017 growing season, irrigation was started on May 16 and programmed according to estimated ET demand, with irrigation concluding on October 13. Total poplar ET for the growing period (April 17 – October 16) was estimated to be 42.8 inches, while total mean irrigation was estimated to be 10.5 inches, plus an additional 5.0 inches was received in rainfall during the growing period. No fertilizer was applied to these trees in 2017.

Current-year diameter at breast height (DBH) and tree height (Ht) were assessed on December 12-13, 2017 at 72-ft clinometer distance from tree. Wood volume per tree was calculated after Browne (1962) using Equation 1 below and scaled to ft^3/acre:

$$V = 10^{(-2.945047+1.803973*Log(DBH) + 1.238853*Log(Ht))} \qquad (1)$$

where

V = Bole wood volume expressed without branches (ft^3/tree);

DBH = Diameter at breast height (inches); and

Ht = Tree Height (feet).

Experimental design and statistical analysis

The experiment was a randomized block design with two Biosolids rates, an iron (Fe) fertilizer treatment, and a non-amended control, in each of 3 blocks, for a total of 12 plots. Statistical analysis was carried out using the ANOVA procedure in the CoStat software package version 6.400 (CoHort 2008). Least significant differences were determined at the 0.05 level.

Results and discussion

For the 2017 growing season, irrigation began on May 16 and concluded on October 13, and was targeted at meeting tree ET demand. Total poplar ET for the growing period (April 17 – October 16) was estimated to be 42.8 inches while total mean irrigation was estimated to be 10.5 inches, plus an additional 5.0 inches was received in rainfall during the growing period. Trees received water several times weekly during the growing season, although water pressure difficulties (and a month-long delay due to harvesting plan changes) resulted in under watering and possible under-measurement of irrigation numbers. As in the past few years, a number of trees in the roadside and middle sections of the stand (running east to west) exhibited stunting of leaves, with some limb die-back and a couple of non-study tree mortalities. This is believed to have been caused by exposure to residual herbicide leached from an adjacent crop field in previous years during heavy rains, or possibly water stress from under watering. However, some of the affected trees seem to have recovered. The herbicide, likely dicamba (3,6-dichloro-2-methoxybenzoic acid), is persistent in soil and also prone to leaching, and has a half-life of up to 6 weeks.

For 2017, trends of non-significance continued for most measured variables, except for tree height: surprisingly, average height for biosolids-treated trees (86.3 ft, or 26.3 m) at 20 tons/acre treatment was significantly higher than Sprint-treated or control trees (average of 79.8 ft, or 24.4 m) (Table 50). While this may be an actual treatment difference, it is more likely due to block/plot differences, as such significance has not been noted in mature trees in previous years. Interestingly, by the end of 2017, four trees in the study were over 100 ft (30 m) tall (three in a control plot and one in 10-ton/acre treatment plot, being the tallest tree at 108.6 ft, or 33.1 m). Overall, average height for all study trees in 2017 was 81.9 ft (25.0 m) compared to 78.1 ft (23.8 m) in 2016. Other growth variables did not show a treatment difference. Average diameter at breast height (DBH) for all study trees in 2017 was 10.9 inches (27.7 cm) compared to 10.6 inches (26.9 cm) in 2016. Across all study trees, average wood volume was 6,183 ft^3/acre (433 m^3/ha), and average biomass was 103.8 tons/acre (232.7 Mg/ha), reflecting modest growth from the previous year. Some statistical significance was noted for some plot and block locations, with trees in exterior plots tending to be slightly smaller, irrespective of treatment, likely due to greater wind stresses and drying near the stand's edges (Bascuñán et al. 2006) or possibly greater mid-stand competition response, although survival was 100% for all study trees. Less-than-ideal growth possibly due to herbicide exposure and underwatering may have also impeded significant top growth. This general lack of treatment differences is understandable given conditions of natural soil turnover, under-watering, and, most notably, the vigorous growth of clone OP-367 under varied treatments. When viewed as a whole, the use of biosolids-amended soil appears to have been marginally useful in addressing chlorosis issues in the initial establishment window, though long-term effects on growth are inconclusive, with competition and tree placement likely being major factors influencing growth.

Table 50. Selected growth parameters for hybrid poplars amended with composted biosolids. NMSU Agricultural Science Center at Farmington, NM. 2017.

Treatment*	DBH[†] (in)	DBH (cm)	Height (ft)	Height (m)	Wood Vol (ft^3/acre)	Wood Vol (m^3/ha)	Biomass (ton/acre)	Biomass (Mg/ha)
Bio-10	10.9	27.6	81.7	24.9	6,081	425	102	229
Bio-20	10.9	27.7	86.3	26.3	6,571	460	104	234
Fe	11.1	28.2	79.9	24.4	6,104	427	108	241
Control	10.7	27.1	79.7	24.3	5,976	418	101	226
Mean[‡]	**10.9**	**27.7**	**81.9**	**25.0**	**6,183**	**433**	**103.8**	**232.7**
CV%	13.2	13.2	12.5	12.5	149.7	28.1	26.0	26.0
LSD (0.05)	0.7	1.7	4.8	1.5	5.0	56.7	12.6	28.1
P	0.6036	0.6273	0.0250	0.0259	0.4279	0.4760	0.7560	0.7541

* Treatments = Biosolids at 10 & 20 tons/acre, Fe (Sprint 138), and Control.
[†] DBH = Diameter at breast height (~ 4.5 ft or 1.37 m).
[‡] Mean is calculated from 3 replications with 12 study trees for each plot.

Conclusions

Initial first-season results indicated that biosolids-amended soil possibly had positive effects on chlorosis alleviation and biomass production for clone OP-367, but statistically significant differences in measured parameters (aside from height) are lacking in the mature stand. A possible reason for lack of differences may be attributed to depletion of amended-soil constituents or possibly under-watering. Moreover, clone OP-367 may be too vigorous to show treatment differences in this trial; it has consistently been among the least chlorotic and most tolerant of soil conditions in the region. In line with US EPA recommendations, the use of biosolids may be considered for similar land applications and by cities seeking alternative waste disposal options, but more study is needed. One caution with the use of biosolids—excessive levels of salinity could develop especially with repeated applications, though this did not appear to be a factor affecting study trees. Likewise, use of herbicides in nearby fields must be considered in light of potential impacts on nearby trees. To date, the trees appear to be the healthiest and tallest on the station, with several trees exceeding 100 feet, so more study of their success is warranted.

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Evaluation of Hybrid Poplar Grown Under Four Irrigation Treatments

M.K. O'Neill and S.C. Allen

Abstract

This study aims to identify best irrigation regimes for high-performing hybrid poplar clones suited to the semi-arid climate and alkaline soils of the Four Corners region. Four top-yielding clones (*Populus deltoides* x *P. nigra* crosses) from ongoing trials at the Center were planted on 6.8 acres (2.75 ha) on April 27, 2007 in a 12 x 12 foot (3.6 x 3.6 m) grid spacing, and drip irrigated from 2007 to 2012 at four target levels (70, 80, 120 and 130%) of reference poplar evapotranspiration (ET). Beginning in spring 2013, target levels were increased to 80, 100, 120 and 140% of ET with the installation of new hosing, to provide for a wider delineation of irrigation effects on tree growth. Total ET at 100% replacement for the 2017 growing season was calculated at 42.8 inches (108.7 cm) for the eleventh-year hybrid poplar, while actual applications (plus 5.0 inches (12.7 cm) of rainfall) for the respective treatments were estimated to be 34.7, 44.3, 52.0 and 56.5 inches (i.e., 88.1, 112.5, 132.0 and 143.6 cm), respectively. Challenges posed by possible root desiccation/freezing during the previous five winters (as well as irrigation issues) are believed to have contributed to tree damage (dieback of main leader) in >5% of study trees and to mortality in >5% of study trees. Looking at eleventh-year results, tree productivity was greatest for the 120 and 140% irrigation levels, which were not significantly different for biomass (average of 96 tons/acre, or 215 Mg/ha). However, for wood volume, the 140% irrigation level resulted in the highest wood volume (5,463 ft^3/acre or 382 m^3/ha), compared to 4,801 ft^3/acre (336 m^3/ha) for the 120% level; this difference may be due in part to the top dieback problem that negatively affected height measurements in all clones except 544. Across clones, entry 544 led for height (75.2 ft; 22.9 m), surpassing entry 433 (clone OP-367) at 71.4 ft (21.7 m) for the fourth year in a row; again, this difference is partially due to top dieback in >8% of trees in entry 433, necessitating height determinations based on highest observable living secondary leader. However, both clones were statistically similar and highest for DBH (average of 10.2 inches, or 25.9 cm), wood volume (average of 4,863 ft^3/acre, or 340 m^3/ha), and biomass (average of 90 tons/acre, or 201 Mg/ha). Interestingly, clone 544 seemed to show most resilience to physiological stress based on the fact that only ~1% or less of these trees exhibited dieback of primary leader, compared to ~6% average dieback in all other clones. It is hoped that the majority of trees will recover and show satisfactory performance in coming years.

Introduction

Previous hybrid poplar research on the station has focused mainly on evaluating a large volume of germplasm for adaptation to the semi-arid climate and alkaline soil conditions. Irrigation of these trials has followed from similar work done in eastern Oregon, where hybrid poplar cultivation has a more entrenched history. Daily evapotranspiration (ET), and thus irrigation, is derived from a number of climatic parameters (including minimum and maximum temperatures, relative humidity, solar radiation and wind speeds, etc.). For this study, the mathematical estimation of ET is the same as in our previous studies, with target irrigation calculated to be applied at 80, 100, 120 and 140% of our baseline replacement ET value. Four of our top-yielding clones from previous trials are being evaluated across these irrigation regimes. Because first-year results offer only limited insights, this long-term trial allows us to determine the relative merits of our previous irrigation strategies and to develop water management programs for larger and older plantations.

Materials and methods

The trial was established in the spring of 2007 using 4 hybrid clones (433, 544, 910 and 911) (all *Populus deltoides* x *P. nigra* crosses) that had been among the leading producers in a 2005 biomass study. Operations and procedures for the trial are presented in Table 51. Prior to planting, the field was disked, leveled, and a pre-emergent herbicide was applied. Netafim Ram pressure-compensating surface drip line with four emitter sizes (0.53, 0.62, 0.92 and 1.00 gal/hr with emitters every 3 ft) was installed with one line per row of trees, to provide for the four irrigation regimes. A whole-plot was set up as four 384-foot long, 12-foot wide rows of a single emitter size (or irrigation level) across which four split-plots (comprised of the four clones, randomly assigned) were superimposed. On April 27, 2007, 32 cuttings of a single clone per plot were planted in a 4 tree x 8 tree grid on 12 x 12 foot (3.6 x 3.6 m) spacing. Holes were prepared for cuttings using a metal rebar (0.5-in diameter) on moistened ground. The ~7-inch cuttings were planted leaving the topmost bud exposed. Irrigation treatments and clone entries were replicated in four blocks for a total of 2,048 trees across 6.8 acres (2.75 ha).

Although poplar consumptive-use estimates were not available in the Farmington area, monthly water-use rates of first, second, and third season poplars grown at a site with similar climatic conditions in Oregon were reported by Gochis and Cuenca (2000). These values were used to generate crop coefficients relating to each year of poplar growth and to growing degree days (GDD). The crop coefficients then modify the Penman-Monteith Evapotranspiration value for a given day (ET_{TALL}) and these values are historically used to program irrigation. Equation 1 is for first season, Equation 2 is for second season, and Equation 3 is for third and subsequent year hybrid poplar production used at Farmington. Equation 4 calculates the ET value for a given day in a given year of poplar production.

$$K_{C(1)} = 3.93\text{x}10^{-1} – 2.58\text{x}10^{-5} (\Sigma GDD) + 5.39\text{x}10^{-8}(\Sigma GDD^2) – 8.98\text{x}10^{-12}(\Sigma GDD^3) \quad (1)$$

$$K_{C(2)} = 3.71\text{x}10^{-1} + 1.38\text{x}10^{-4} (\Sigma GDD) + 2.95\text{x}10^{-8}(\Sigma GDD^2) – 8.20\text{x}10^{-12}(\Sigma GDD^3) \quad (2)$$

$$K_{C(3)} = 5.18\text{x}10^{-1} + 4.57\text{x}10^{-5} (\Sigma GDD) + 1.19\text{x}10^{-7}(\Sigma GDD^2) – 2.40\text{x}10^{-11}(\Sigma GDD^3) \quad (3)$$

$$ET = K_{C(year)} \text{ x } ET_{TALL} \quad (4)$$

where

$K_{C(year)}$ = Crop coefficient for a given year;

ΣGDD = Cumulative growing degree days (calculated in degrees Fahrenheit); and

ET = Evapotranspiration replacement rate (inches).

The output ET replacement value was then further modified by multiplying by our treatment levels: 80, 100, 120 or 140%. This was accomplished in practice by running all units for the same time period each day, while the differential irrigation levels were applied by the differing emitter sizes (i.e., each dripline has a pre-specified gph emitter rate from the manufacturer). Irrigation was started on May 1 and ended on October 6, 2017. For purposes of delineating the growing season, significant ET demand was estimated to begin April 17 and to end October 16 with the usual cessation of the irrigation season due to the possibility of freezing weather. To encourage green growth, U-32 (32-0-0) liquid fertilizer was injected into the irrigation stream at 30 lbs of N per acre on June 20 and 20 lbs of N per acre on September 20, 2017 (i.e., total of 50 lbs of N per acre applied for season).

Tree growth data was collected on December 20 (2017) and January 3-5 and 9-11 (2018), with survival, DBH and height recorded for the central 12 trees in each experimental unit (subplot=clone within irrigation treatment), with clinometer readings at 60-ft from tree. In the course of height determinations, study trees were assessed for possible tree damage (dieback of primary leader attributed to cold-season root desiccation), with notations made of damaged/dead trees. In the case of visibly damaged trees, the highest living secondary leader was used as the highest reference point. Wood volume for each tree was determined after Browne (1962) and scaled to an acre basis, and biomass was calculated on an acre basis. Growth parameters were analyzed using the CoStat ANOVA procedure (split-plot analysis) with mean separation by Fisher's LSD (CoHort, 2008).

Table 51. Operations and procedures for 2007-planted hybrid poplars grown under four irrigation regimes. NMSU Agricultural Science Center at Farmington, NM. 2017.

Operations	Procedures
Varieties:	4 hybrid poplar clones (*Populus deltoides* x *P. nigra*): 433, 544, 910, 911
Planting Date:	April 27, 2007
Planting Rate:	12 x 12 ft (3.6 x 3.6 m) spacing (303 trees/acre)
Plot Size:	48 x 96 ft = 4,608 ft^2 (14.5 x 31 m = 450 m^2) with 12 study trees/plot
Fertilization:	U-32 (32-0-0) liquid fertilizer injected into irrigation stream at 30 lbs of N per acre on June 20 and 20 lbs of N per acre on September 20, 2017 (total of 50 lbs of N per acre applied for season)
Fungicide:	None
Herbicide:	None
Insecticide:	None
Rodenticide:	None
Chlorine:	None
Soil Type:	Doak sandy loam
Irrigation (current):	Surface drip irrigation at 4 different rates based on estimated Evapotranspiration (80%, 100%, 120% and 140% of reference ET), managed via Rain Bird control system
Irrigation Commenced:	May 1, 2017
Irrigation Concluded:	October 6, 2017

Results and discussion

For the 2017 growing season, total ET at 100% replacement was calculated at 42.8 inches (108.7 cm) for the eleventh-year hybrid poplar, while actual applications (plus 5.0 inches (12.7 cm) of rainfall) for the respective treatments were estimated to be 34.7, 44.3, 52.0 and 56.5 inches (i.e., 88.1, 112.5, 132.0 and 143.6 cm), respectively. While tree survival varied somewhat by irrigation level, results appear to be influenced in part by alley location, as all four irrigation treatments resulted in 95.8% or higher survival except in alleys 3 and 5 (77.1% average survival). Survival also varied by clone, ranging from 99.5% for clone 544 to 90.1% for clone 911. In addition, challenges posed by possible root desiccation/freezing during the previous five winters (plus irrigation issues) are believed to have contributed to tree damage (dieback of main leaders) in >5% of living study trees. Trees with damaged primary leaders thus presented a problem in gathering height data. This problem of damaged primary leaders was originally addressed in 2013 by establishing a ratio between 2013 DBH and 2012 height and DBH; however, for the 2014-2017 growing seasons, it was decided to use the actual height data from the highest living secondary leaders, since that is viewed as the best long-term approach for comparing height increases across years. Interestingly, clone 544 seemed to show most resilience to physiological stress from root desiccation based on the fact that only ~1% or less of these trees exhibited dieback of primary leader, compared to >6% average dieback in all other clones. In the course of height measurements, trees with secondary leaders exceeding the original height of the damaged primary leader, were not formally counted as damaged trees. It is hoped that data for 2018 and onward will be able to reference data for healthy and tall leader stems, given the characteristic fast growth of leaders in these clones.

Across water treatments, the 120% and 140% target irrigation levels produced the highest average DBH (average of 10.5 inches, or 26.7 cm); however, tree height was highest for the 140% irrigation level (75.6 ft, or 23.0 m) (Table 52). Mean wood volume for the irrigation treatments ranged from a high of 5,463 ft^3/acre (382 m^3/ha) for the 140% irrigation level to 4,801 ft^3/acre (336 m^3/ha) for the 120% irrigation level, to 3,676 ft^3/acre (257 m^3/ha) and 3,328 ft^3/acre (233 m^3/ha) for the 100% and 80% target irrigation levels, respectively. The two higher irrigation treatments also yielded the most aboveground biomass, averaging 96 tons/acre (215 Mg/ha).

Across clones, entry 544 led for height (75.2 ft; 22.9 m), surpassing entry 433 (clone OP-367) at 71.4 ft (21.7 m) for the fourth year in a row; again, this difference is partially due to top dieback in >8% of trees in entry 433, necessitating height determinations based on highest observable living secondary leader (Table 52). However, both clones were statistically similar and highest for DBH (average of 10.2 inches, or 25.9 cm), wood volume (average of 4,863 ft^3/acre, or 340 m^3/ha), and biomass (average of 90 tons/acre, or 201 Mg/ha). Thus, while there was some interaction between clones and irrigation treatments, and root desiccation may have impacted growth, the 120-140% ET irrigation treatments produced the most biomass growth in clones.

In addition, a tree damage assessment was done during the annual tree inventory, to assess the significant damage noted during the growing season to a sizeable portion of study trees (>5%). The assessment was depicted in terms of presence or absence of a living primary leader (whose height was not exceeded by a secondary leader).

The damage was likely due to root desiccation/freezing experienced during previous winters (and possibly in part to irrigation issues), which resulted in dieback of primary and secondary leaders (although many secondary leaders had surpassed the original primary leader in terms of height). The ability to overcome this freeze-drying problem is challenging, given the mechanical limitations of PVC-based irrigation that must be shut down from mid-to-late October to early April (over a 5-month period) to avoid possibility of freezing damage to pipes. Thus, while clone 433 (OP-367) is generally the fastest-growing clone at ASC-Farmington, clone 544 seems most resilient in surviving this long non-irrigated period with minimal adverse effects on growth and health in the 2013-2017 growing seasons. The application of this knowledge to other hybrid poplar growers will depend on their particular growing conditions, irrigation capabilities, and chosen poplar material. Irrigation regimes should be planned accordingly to meet tree ET demand and provide for ample and excess soil moisture, as well as to buffer for periods of potential under- or over-watering as may occur in any imperfect system.

Table 52. Mean DBH, height, wood volume and biomass of four 2007-planted hybrid poplar clones grown under four irrigation regimes. NMSU Agricultural Science Center at Farmington, NM. 2017.

Irrigation Factor* or Clone	DBH† (in)	DBH (cm)	Height (ft)	Height (m)	Wood Vol (ft^3/acre)	Wood Vol (m^3/ha)	Biomass (ton/acre)	Biomass (Mg/ha)
1	9.0	22.9	64.4	19.6	3,328	233	67	150
2	9.4	24.0	64.6	19.7	3,676	257	74	167
3	10.4	26.5	71.0	21.6	4,801	336	93	209
4	10.6	26.8	75.6	23.0	5,463	382	99	221
433	10.1	25.6	71.4	21.7	4,765	333	89	200
544	10.3	26.1	75.2	22.9	4,961	347	90	202
910	9.5	24.2	64.0	19.5	3,718	260	77	172
911	9.5	24.1	64.5	19.7	3,743	262	76	170
Mean‡	**9.9**	**25.0**	**68.9**	**21.0**	**4,316**	**302**	**83**	**187**
CV% (interact)	14.8	14.8	16.5	16.5	36.4	36.4	30.9	30.9
LSD (0.05) irr.	0.3	0.8	2.4	0.7	329.9	23.1	5.4	12.1
LSD (0.05) clone	0.3	0.9	1.8	0.5	275.9	19.3	5.5	12.4
P (irr.)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
P (clone)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
P (interact)	0.4210	0.4337	0.0001	0.0001	0.0807	0.0810	0.6958	0.6924

* Water applied equivalent to 1=80%, 2=100%, 3=120%, or 4=140% of reference Evapotranspiration (ET) rate.
† DBH = Diameter at breast height (~4.5 ft or 1.37 m).
‡ Mean is calculated from 4 replications with 12 study trees for each plot.

Conclusions

Similar to the previous year, the 120-140% water application levels emerged as statistically similar for DBH and biomass, resulting in the most productivity in this trial. The effects of possible root desiccation in previous years was still evident, but it is hoped that many of the affected trees will continue to recover in 2018. Clones OP-367 and 544 had highest DBH, wood volume and biomass, and 544 emerged as the tallest and most drought-resistant clone in the trial. It will be interesting to observe these and other trends for these *P. deltoides* x *P. nigra* crosses in subsequent years of the trial. Overall, clonal material should be carefully selected for local conditions, and irrigation regimes should be planned accordingly to meet tree ET demand and provide for ample and excess soil moisture, as well as to buffer for periods of potential under- or over-watering or unusually intense or prolonged dry conditions.

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New Mexico State University Chip Potato Variety Trial Protocol - 2017

Sponsored by Potatoes USA growers and processors

Financial Support: Potatoes USA will provide unrestricted grants of $7,850 and $15,000.

C. Higgins, K.A. Lombard, K. Djaman

Introduction

The goal was to find better fresh chip varieties for direct field harvest than the standard Atlantic and to find better storage varieties than the current checks of Lamoka and Snowden. Seed came from nationwide public universities. Vine maturity data, yield, specific gravity, chip color, chip defects, tuber sugars and other data were provided to Potatoes USA's data bank for use by all growers, processors and breeders.

Methods & Procedures

Field Production

Tillage and other operations were provided by NMSU in a manner common to the commercial industry. Seed pieces were cut to 2.5 ounce average size and planted at ten inch seed spacing in NMSU PLOT #15. Irrigation was scheduled by ET. One final hilling operation occurred prior to first emergence. The plots were mechanically lifted then picked up by hand. Weight by size, specific gravity and other data were gathered. Storage and lab analysis provided by Navajo Mesa Farms.

Fertility

Fertilizer was applied according to soil test readings. Wilbur-Ellis provided and applied fertilizer. Usual production needs for potatoes are 240 pounds per acre Nitrogen, 120 pounds P_2O_5 and 300 pounds K_2O less soil residual as determined by soil test.

Pesticides

All pests were monitored and pesticide application was scheduled and posted with NMSU 24 hours in advance when pest thresholds were exceeded. Wilbur-Ellis provided pesticides and applications. Insect traps were monitored. Average annual pesticide application needs shown in Table 53.

Results

NMSU SNAC Trial 2017 March Sugar Analysis shown in Table 54.

Table 53 . Pesticide program as common to the commercial potato industry*. NMSU Agricultural Science Center – Farmington, NM. 2017

------- Chemical ------			Restrict-use	EPA	AI	Rate/ acre	Unit‡	Acre	Total	Re-entry	Date
Name	Type †	Company	(Yes/No)	(No.)	(%)	(ac)				(hrs.)	(est.)
Glory	Herb.	Mana	No	66222-106	75.00	0.5	lbs.	0.33	0.165	12	1-May
Tifluex HFP	Herb.	Mana	No	66222-46	42.70	0.66	pt.	0.33	0.2178	12	1-May
Dual Mag	Herb.	Syngenta	No	100-816	83.70	1.5	pt.	0.33	0.495	24	1-May
Matrix SG	Herb.	Dupont	No	352-768	25.00	1.5	oz.	0.33	0.495	24	20-May
Quadris Top	Fung.	Syngenta	No	100-1313	29.60	12	oz.	0.33	3.96	12	25-Jun
Bravo Weather Stik	Fung.	Syngenta	No	50534-188-100	54.00	8	pt.	0.33	2.64	12	25-Jun
Actara	Insec.	Syngenta	No	100-938	25.00	3	oz.	0.33	0.99	12	6-Jun
Bravo Weather Stik	Fung.	Syngenta	No	50534-188-100	54.00	8	pt.	0.33	2.64	12	2-Jul2
Actara	Insec.	Syngenta	No	100-938	25.0	3	oz.	0.33	0.99	12	2-Jul
Revus Top	Fung.	Syngenta	No	100-1278	43.60	7	oz.	0.33	2.31	12	9-Jul
Sivanto Prime	Insect.	Bayer	Yes	264-1141	17.09	14	oz.	0.33	4.62	4	9-Jul
Status	Fung.	BASF	No	7969-242	61.10	10	oz.	0.33	3.3	24	22-Jul
High Load	S-CO	Wilbur Ellis	No	N/A	N/A	6.4	oz.	0.33	2.112	N/A	22-Jul
Minecto Pro	Insect.	Syngenta	Yes	100-1592	15.38	10	oz.	0.33	3.3	12	6-Aug
Scala SC	Fung.	Bayer	No	264-788	54.60	7	oz.	0.33	2.31	12	6-Aug
Bravo Weather Stik	Fung.	Syngenta	No	50534-188-100	54.00	8	pt.	0.33	2.64	12	6-Aug
Tanos	Fung.	Dupont	No	352-604	50.00	8	oz.	0.33	2.64	12	13-Aug
Bravo Weather Stik	Fung.	Syngenta	No	50534-188-100	54.00	8	pt.	0.33	2.64	12	13-Aug
Sivanto Prime	Insect.	Bayer	Yes	264-1141	17.09	14	oz.	0.33	4.62	4	13-Aug
Tanos	Fung.	Dupont	No	352-604	50.00	8	oz.	0.33	2.64	12	19-Aug
Bravo Weather Stik	Fung.	Syngenta	No	50534-188-100	54.00	8	pt.	0.33	2.64	12	19-Aug
Movento	Nema.	Bayer	No	264-1050	22.40	5	oz.	0.33	1.65	24	19-Aug
Tanos	Fung.	Dupont	No	352-604	50.00	8	oz.	0.33	2.64	12	26-Aug
Bravo Weather Stik	Fung.	Syngenta	No	50534-188-100	54.00	8	pt.	0.33	2.64	12	26-Aug
Mustang Max	Insect.	FMC	Yes	279-3426	9.15	4	oz.	0.33	1.32	12	26-Aug
Reglone	Desic.	Syngenta	No	100-1061	37.30	32	oz.	0.33	10.56	24	1-Sep
Brimstone	SO	Wilbur Ellis	N/A	N/A	N/A	12	oz.	0.33	3.96	N/A	1-Sep
Super Tim 4L	Fung.	United Phosphorus	No	70506-212	40.00	4	oz.	0.33	1.32	48	1-Sep
Ranier EA	SO	Wilbur Ellis	No	2935-50200	NA	6.4	oz.	0.33	2.112	N/A	1-Sep

------- Chemical ------			Restrict-use	EPA	AI	Rate/ acre	Unit‡	Acre	Total	Re-entry	Date
Name	**Type †**	**Company**	**(Yes/No)**	**(No.)**	**(%)**	**(ac)**				**(hrs.)**	**(est.)**
Reglone	Desic.	Syngenta	No	100-1061	37.30	32	oz.	0.33	10.56	24	6-Sep
Brimstone	SO	Wilbur Ellis	N/A	N/A	N/A	12	oz.	0.33	3.96	N/A	6-Sep
Super Tim 4L	Fung.	United Phosphorus	No	70506-212	40.00	4	oz.	0.33	1.32	48	6-Sep
Ranier EA	SO	Wilbur Ellis	No	2935-50200	N/A	6.4	oz.	0.33	2.112	N/A	6-Sep

† Desic. = desicant; Fung. = fungicide; Herb. = herbicide; Insec. = insecticide; Nema. = nematicide; S-CO = spreader - crop oil; SO = surfactant oil.
‡ lbs. – pounds; oz. = ounce; pt. = pint.

*This plan adjusted depending on insect traps and scouting/ Wilbur-Ellis ground applications/ see www.agrian.com for MSDS and labels. EPA application sheet emailed to NMSU 24 hours before application.

Table 54. NMSU SNAC Trial 2017 March Sugar Analysis. NMSU Agricultural Science Center – Farmington, NM. 2017.

Date	Variety	YSI Dextose	0.25	YSI	1,000
		(Glucose)	(mg/g)	(Sucrose)	(mg/g)
16- Mar	NY152	0.000	0.000	0.203	0.279
16- Mar	NY157	0.000	0.000	0.171	0.235
16- Mar	Lamoka	0.009	0.012	0.291	0.400
16- Mar	NDA-2C	0.144	0.198	0.735	1.011
16- Mar	W998-5	0.005	0.007	0.297	0.408
16- Mar	MSV358-3	0.002	0.003	0.193	0.265
16- Mar	W59551	0.002	0.003	0.151	0.208
16- Mar	Snowden	0.011	0.015	0.195	0.268
16- Mar	CO07670-13W	0.035	0.048	0.149	0.205
16- Mar	MSW485-2	0.005	0.007	0.280	0.385
16- Mar	2727-2	0.009	0.012	0.419	0.576
16- Mar	AF5040-8	0.008	0.011	0.197	0.271
16- Mar	Waneta	0.003	0.004	0.213	0.293
16- Mar	MSV0304	0.001	0.001	0.182	0.250
16- Mar	AC01144-1W	0.001	0.001	0.174	0.239
16- Mar	NDTX-13W	0.013	0.018	0.213	0.293
16- Mar	MSR127-2	0.003	0.004	0.217	0.298
16- Mar	MSX540-4	0.001	0.001	0.329	0.452

Dissemination and Professional Development

Peer Reviewed Journal Articles *indicates student working with author

Ornelas I, Deschenie D, Bishop S, Lombard K.A., Beresford SA. 2017. Yéego Gardening!: A Community Garden Intervention to Promote Health on the Navajo Nation. Progress in Community Health Partnerships. 11(4).

Abstracts, Posters and/or Oral Presentations (in chronological order)

Lombard, K.A., I.J. Ornelas, D. Deschenie, S. Bishop, S. A. A. Beresford. 2017. Yéego Gardening!: Results from a Pilot Community Garden Intervention to Promote Health on the Navajo Nation. American Public Health Association Annual Meeting and Expo. Atlanta, GA. November 4-8, 2017.

*Jha, G., A.L. Ulery, **K.A. Lombard**, D.C. Weindorf, S. Fullen, and B. Francis. 2017. Metal Concentration in Agricultural Fields Downstream from the Gold King Mine Spill (2015). Soil Science Society of America, American Society of Agronomy and Crop Science Society of America International Annual Meeting. October 23, 2017. Tampa, FL.

Lombard, K.A., D. Deschenie, I. Ornelas, S. Bishop, S.A.A. Beresford. 2017. Where health and horticulture intersect: A Navajo Wellness Collaboration Pilot (Yéego Gardening!). Navajo Nation Human Research Review Board 2017 Conference. October 18-19, 2017, Window Rock, Arizona.

Lombard, K.A. and F.J. Thomas. 2017. New Mexico State University Winter Malted Barley Trial. Master Brewers Association of the Americas, Rocky Mountain District Annual Meeting. August 18, 2017. Albuquerque, NM.

O'Neill, M.K., M.M. West, D. Smeal, J. Joe, S.C. Allen, K.A. Sarpong and **K.A. Lombard. 2017**. Forty-eight Years of Meteorological Data (1969-2016): NMSU Agricultural Science Center –Farmington. 66nd Annual New Mexico Water Conference. Water Resources Research Institute. New Mexico Tech. Socorro, NM. August 15-16, 2017.

*Jha, G., A. Ulery, **K.A. Lombard**, B. Francis, B. Hunter, *H. Winsor. 2017. Metal Concentrations in Soil and Sediments after Gold King Mine Spill. 2nd Annual Conference on Environmental Conditions of the Animas and San Juan Watersheds with Emphasis on Gold King Mine and Other Mine Waste Issues. Water Resources Research Institute. Farmington, NM. June 20-22, 2017.

*Fullen, S., **K.A. Lombard**, A. Ulery, B. Hunter, *G. Jha, and B. Francis. 2017. Lead and Arsenic Concentrations in the Lower Animas Irrigation Ditch Sediments. 2nd Annual Conference on Environmental Conditions of the Animas and San Juan Watersheds with Emphasis on Gold King Mine and Other Mine Waste Issues. Water Resources Research Institute. Farmington, NM. June 20-22, 2017.

Lombard, K.A., S. Fullen, A. Ulery, B. Hunter, D. VanLeeuwen, *G. Jha, B. Francis. 2017. What are the effects of the Gold King Mine Spill on San Juan County, NM agricultural irrigation ditches and farms? University Council on Water Resources/The National Institutes for Water Resources (UCOWR/NIWR) 2017 Annual Conference. June 13-15, 2017. Fort Collins, CO.

Lombard, K. A. and F.J. Thomas, F. 2017. Mobile Hops Harvester for 4-Corners. 2017. 4th What's Hop'n-Winter Workshop. March 25, 2017. Bayfield CO.

Lombard, K.A. 2017. Trellising. New Mexico Organic Farming Conference. February 17-18, 2017. Albuquerque, NM.

Proposals and Grants

Grants Received

Lombard, K.A. (PI). 2016. Improved Viticulture and Specialty Horticultural Crop Systems for the San Juan River Valley of Northwest New Mexico. Hatch Project $5,000

Ongoing/Completed Research Support in 2017

Lombard, K. A. (Co-Principal), Sponsored Research, "Internal Award - Yr 9 PACR-P6 Gardening for Health", Sponsoring Organization Is: Other, Research Credit: $86,529.00, PI Total Award: $86,529
Current Status: Funded. (September 1, 2016 - August 31, 2017).

Ulery, A. L. (Co-Principal), Lombard, K. A. (Co-Principal), Sponsored Research, "Internal Award - What are the Effects of the Gold King Mine Spill on San Juan County, NM Agricultural Irrigation Ditches and Farms?", Sponsoring Organization: New Mexico Water Resources Research Institute, Sponsoring Organization Is: Local, Research Credit: $44,799.00, PI Total Award: $82,200
Current Status: Funded. (March 1, 2016 - February 28, 2017).

Ulery, A. L. (Co-Principal), Lombard, K. A. (Co-Principal), Sponsored Research, "Monitoring of Irrigated agricultural lands potentially impacted by Gold King Mine spill", Sponsoring Organization: USDA/Natural Resources Conservation Service, Research Credit: PI Total Award: $75,000
Current Status: Funded. (August 19, 2016 - December 31, 2019).

Ulery, A. L. (Co-Principal), Lombard, K. A. (Co-Principal)"Gold King Mine Spill - Gold King Mine Spill - Sediment and Agricultural Sampling MOA NO.17-667-1210-0004" New Mexico Environment Department, $112,193, Description: Proposal solicited by NMED as part of a consortia of NM Universities to monitor the impacts of the Gold King Mine Spill, Status: Funded, Effective Start Date: 2016, Effective End Date: 2017. Research Credit: $56,096.50, PI Total Award:...$112,193

LaShell (Principal), Lombard (Co-Investigator). "Evaluating high altitude production of hops varieties and creating grower alliances to assist with production and marketing," Colorado Specialty Crop Block Grant through USDA, ...$53,977
Status: Funded, Effective Start Date: 2016, Effective End Date: 2017.

Stories from the Popular Press

As Fresh and Local as You Can Get

Durango TV, September 7, 2017
"Hops grow well in the area, but the pungent cones are difficult to harvest. A new, portable hops harvester make the potential cash crop more economically viable."
http://www.durangotv.com/video-detail.php?ID=1590

Hop harvest arrives at Steamworks Brewing Co. to make special beer.

Colorado Proud brew should be ready to drink in three weeks
Mary Shinn, Durango Harold, Aug 23, 2017.

A sweet and calming aroma filled the air in front of Steamworks Brewing Co. on Wednesday morning as a mobile hop harvester stripped cones from vines. The harvester rumbled as the tines removed the hops and leaves, and the conveyor belts separated leaves and cones and spit out buckets of hops, destined for the mash tun, a huge metal pot, where they will steep, Steamworks Head Brewer Ken Martin said. In 17 or 18 days, Steamworks will be ready to pour its Colorado Proud Pale Ale with a distinct flavor derived from the hops, he said.

Cascade hops recently harvested from the farm he manages in the Pine River Valley for the ale, he said. Steamworks also plans to use Colorado-produced yeast and barley grown in the San Luis Valley.

"We just wanted to showcase the ingredients that are made here locally," he said. The company expects to make about 10 barrels of the ale.

mshinn@durangoherald.com

https://durangoherald.com/articles/180029-hop-harvest-arrives-at-steamworks-brewing-co-to-make-special-beer

On Friday, August 18th Rio Bravo Brewing hosted the MBAA Rocky Mountain District Out of Towner in Albuquerque, New Mexico. Master Brewers Association of the Americas, September 5, 2017
http://rockymountainmbaa.com/mbaa-rmd-press-release-august-2017

MBAA District Rocky Mountain Press Release August 2017

http://rockymountainmbaa.com/mbaa-rmd-press-release-august-2017

On Friday, August 18, the Rio Bravo Brewing hosted the MBAA Rocky Mountain District Out of Towner in Albuquerque, New Mexico.

The meeting began with opening remarks by President Dana Jonson, and John Seabrooks of Rio Bravo Brewing. Dana then introduced John Gozigian from the New Mexico Brewers Guild, who spoke about craft brewing in New Mexico.

After John's segment, Jake Capron from Proximity Malting was introduced. He spoke about flavor development during malting, and opened the floor to questions.

Dr. Kevin Lombard from New Mexico State University then spoke about the AMBA winter barley trials. After questions for Dr. Lombard were concluded, Dr. Lance Lusk was introduced. Dr. Lusk went over Sci-Tech for Improving shelf life.

Dr Lusk was then followed by Amber Beye, who covered hop growing in Southern Colorado. Amber was followed by John Seabrooks, who spoke about hop flavor in beer.

Closing remarks were given afterward by John Seabrooks, and Dodie Doyle. The group then left Rio Bravo Brewing for lunch and tours at Boxing Bear. Lunch was followed by tasting and tours at Le Cumbre, and Marble Brewery.

MBAA District Rocky Mountain Press Release
August 2017

The next MBAA Rocky Mountain District meeting will be held in November at Crazy Mountain Brewing in Denver.

Cheers,
Brynn Keenan, Publicity Chair
Master Brewers Association of the Americas – District Rocky Mountain
August, 2017