Northwestern Agricultural Research Center Field Day

July 13, 2017

2:00 pm Registration and Introductions

2:30 pm Field Tours

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Trent Krueger – Producer and Dr. Jessica Torrion—Northwestern Ag Research Center
David Lake – Producer

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Markus Braaten – Trimble

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Dr. Jessica Torrion & Anish Sapkota – Northwestern Ag Research Center
Matt Cottle – Producer

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Dr. Jessica Torrion – Northwestern Ag Research Center
Chris Fritz – Producer

5:00 pm Dinner Sponsored by CHS, RDO Equipment, and Northwest Farm Credit Services

Northwestern Agricultural Research Center

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Back Row: Mike Davis, Breno Bicego, Jordan Penney, Dawson Massey, Mark Byers, Scott Christensen, Anish Sapkota, Bob Stougaard, Brock Reiner, Don Edsall, Erik Echegaray.
Front Row: Dennis Graham, Dove Carlin, Abby Northrup, Jessica Torrion.

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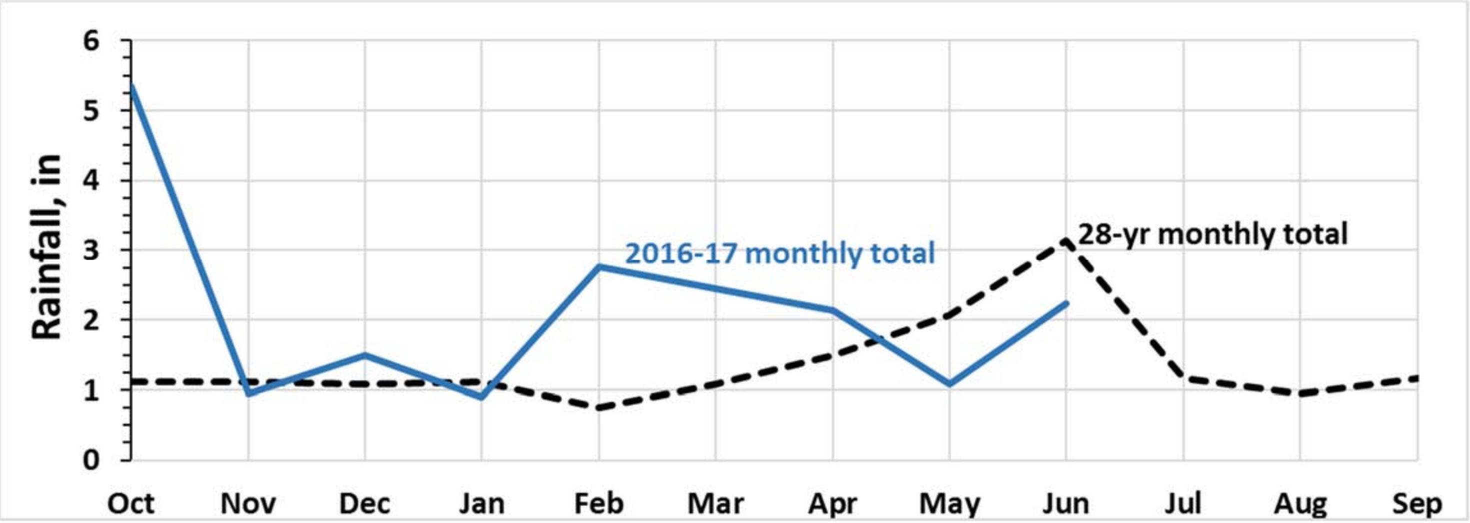
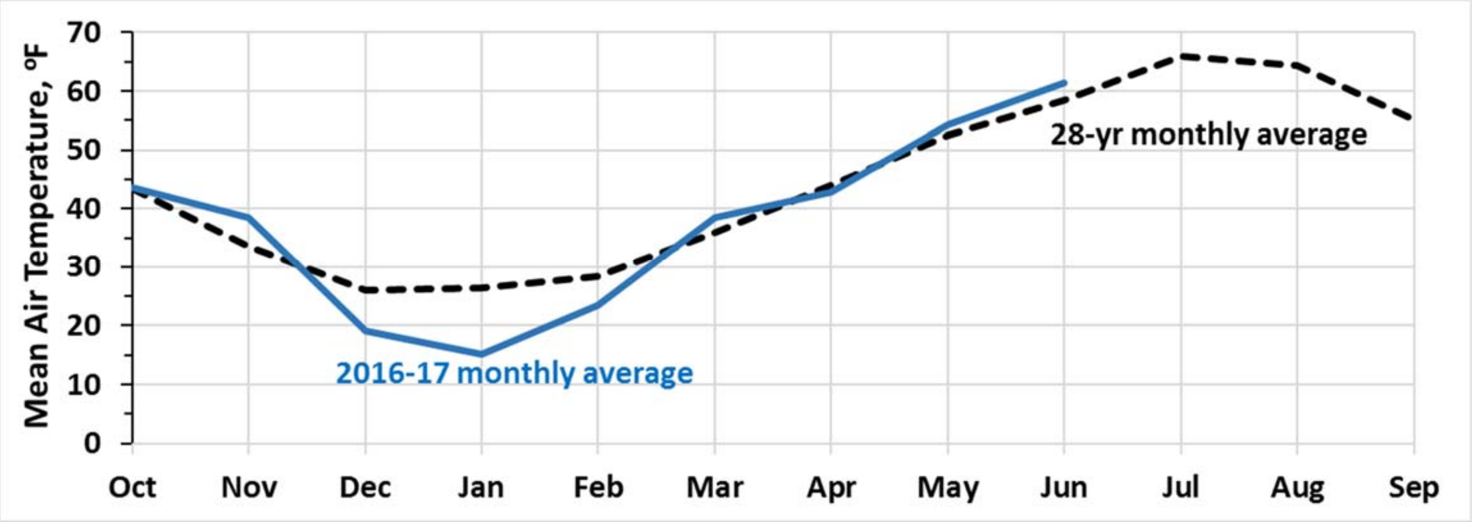
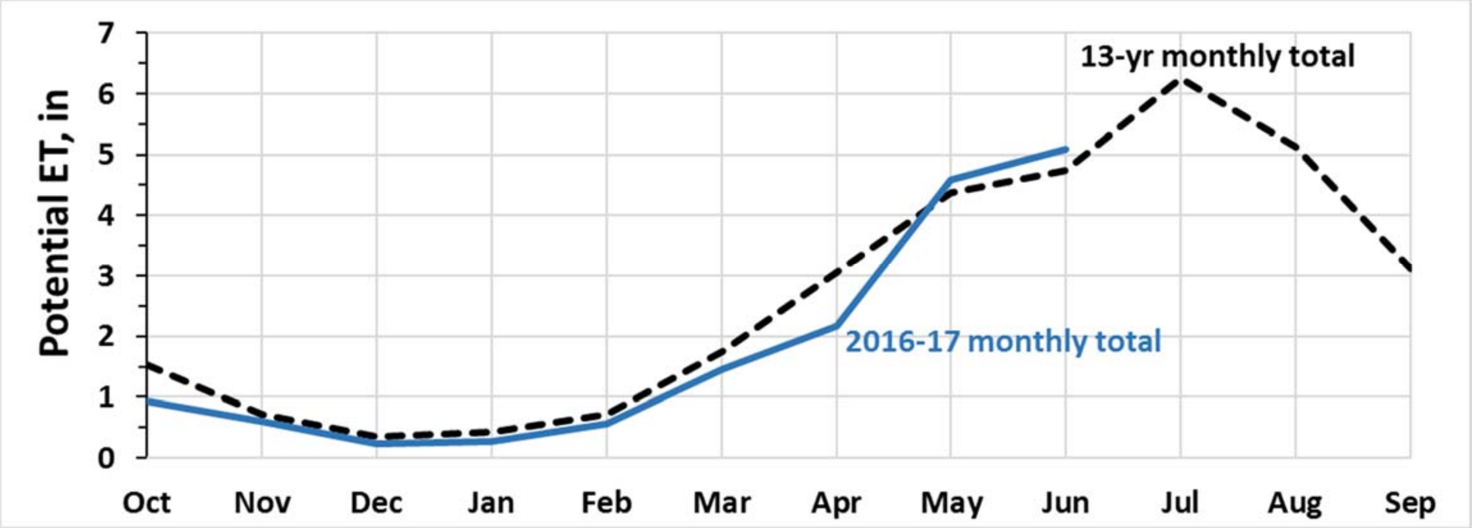
2016-2017 Weather Trend in Relation with the 28-year (1989-2016) Climate Data







Measuring soil moisture and estimating evapotranspiration

Jessica A. Torrion and Trent Krueger

Abbreviations: **ET**: evapotranspiration, **ETo**: grass-referenced ET, **ETc**: crop ET, **Kc**: crop cofficient

Water is lost through the atmosphere by these two processes: Evaporation (directly from a bare soil surface) and Transpiration (through leaf stomates). These two terms for water loss are combined into one term 'evapotranspiration, **ET**' (**Figure 1**) which denotes the total water loss of agricultural crops when scheduling irrigation. Estimating crop water use, or ET of a crop (**ETc**) is important to avoid over or under irrigating. To do that, a reference ET (ETo) can be used – this is an estimated total water use from a well-watered manicured grass available at the Agrimet Weather stations such as the Creston Agrimet (CRSM, https://www.usbr.gov/pn/agrimet/agrimetmap/crsmda.html).

Crops do not use the same amount of water as the **ETo** (well-manicured green grass). Crops start with low water demand early in the season, then peak at early reproductive stage and remain high until almost all of the economic yield (seeds) is formed. Water demand then decreases when approaching maturity. This water demand is estimated using crop coefficient (**Kc**) and is also available at the above link. The Kc value varies over the growing season. Kc is low at an early crop stage (0.2 Kc), then starts to increase when vegetation starts greening up, until the near reproductive stage (linear increase from 0.2 to 1.1 or 1.2), then remains high until all the economic yield is formed (1.1 or 1.2), and finally decreases (linear decrease from 1.1 or 1.2 to 0.4 or 0.2) as crops approach maturity. This Kc is multiplied with ETo to estimate ETc (**Figure 2**).

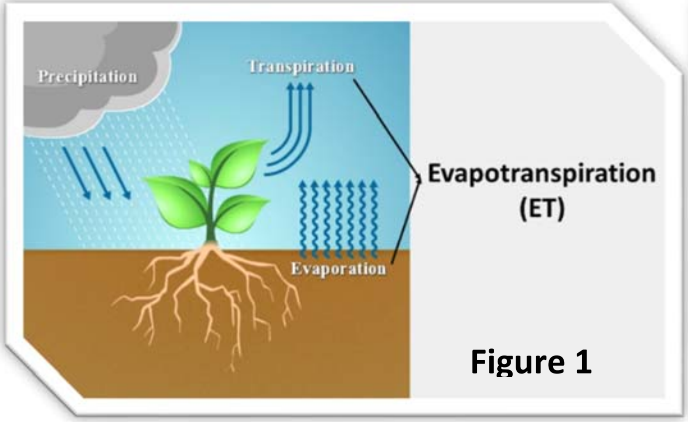


Figure 1

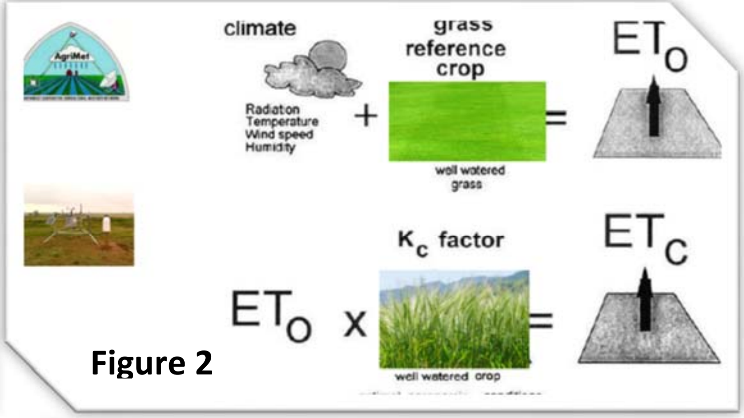


Figure 2

Knowing your soil type and how much water it can store (let us call this 'Bucket') is important information. Knowing your bucket size will provide information on how much irrigation to apply at each irrigation event. This will avoid overapplying irrigation and loss of water through gravitational movement (**Figure 3**). A full soil profile or bucket also hampers the ability to capture precipitation from

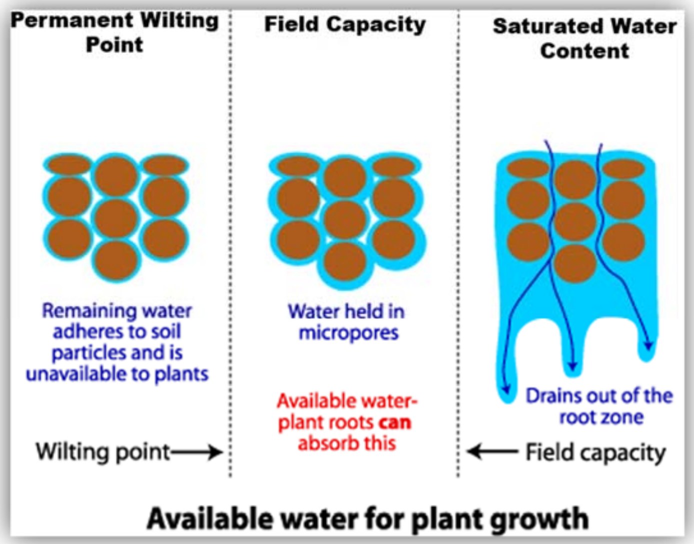
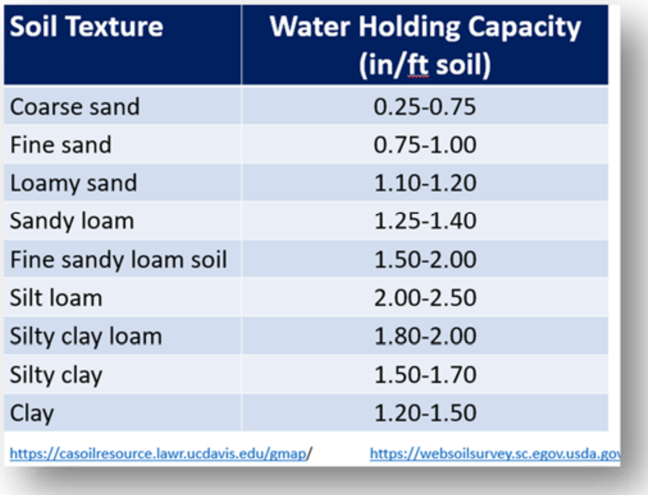


Figure 3

rains/thunderstorms. Each soil has a specific water holding capacity (**Table 1**).

Scheduling irrigation using an ET approach is a balancing act of variables: Yesterday's soil water (Ws), today's Ws, ETc, rainfall, irrigation, and (other water losses), see **Figure 4**. This method is sometimes referred to as the "Checkbook" method. Crops will experience water stress when 50% of the available water in your bucket is utilized. Thus, the irrigation trigger should be less than 50%. A depletion of 35-40% of the plant available water in the bucket can be used as an irrigation trigger. It is not uncommon to adjust irrigation trigger earlier than 35%, when considering the number of days for the pivot irrigation to complete a circle.

Table 1. Water holding capacity - Bucket



Soil Texture	Water Holding Capacity (in/ft soil)
Coarse sand	0.25-0.75
Fine sand	0.75-1.00
Loamy sand	1.10-1.20
Sandy loam	1.25-1.40
Fine sandy loam soil	1.50-2.00
Silt loam	2.00-2.50
Silty clay loam	1.80-2.00
Silty clay	1.50-1.70
Clay	1.20-1.50

https://casoilresource.lawr.ucdavis.edu/gmap/ https://websoilsurvey.sc.egov.usda.go

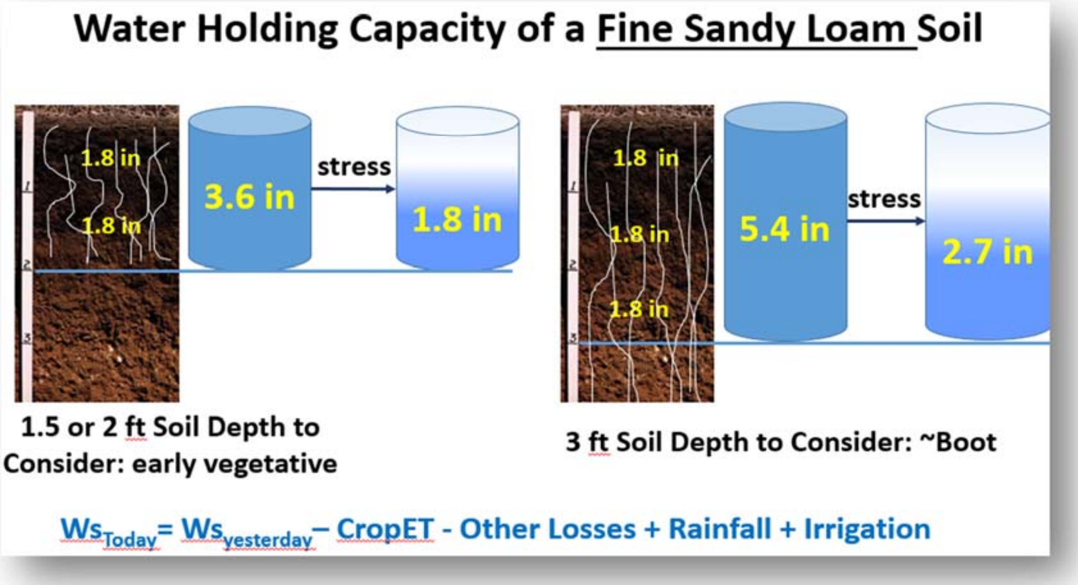


Figure 4. Schematic diagram on the bucket size of a fine sandy loam soil, irrigation trigger to choose, and how much water to apply.

Soil moisture sensors provide a direct estimate of soil water depletion. Most sensors require a snug fit contact to the soil. Sensors can be read through a handheld reader, data loggers, and web data access using telemetry. Depending upon the heterogeneity of a field, one soil moisture sensor site may not be enough to represent soil moisture depletion of a field. Location of the sensors is critical and is dependent on your irrigation prioritization in the field. In this demonstration, soil moisture sensors such as Crop x (https://cropx.com/), Watermark (http://www.irrometer.com/), and Sentek (http://www.sentek.com.au/) technologies will be discussed.

Breno Bicego and Jessica A. Torrion

Study 1. Nitrogen management of hard red spring wheat vs. soft whites

This study investigates whether total N input can be reduced when planting soft white spring wheat considering protein requirement is low (8.5 – 10.5 %) as compared to hard red spring wheat (>14%). Essentially, increasing yield is the main focus in soft white rather than managing both yield and protein as in the case of hard red spring wheats.

The study is duplicated in both dryland and irrigated conditions. **Four hard red spring wheat** varieties (Egan, McNeal, Solano, and Vida) and **four soft white** varieties (Alturas, Alpowa, Penewawa, UI-Stone) were randomly arranged within five total N levels (40 [check], 138, 178, 218 and 258 lbs N). Soil available nitrogen was determined as 33 lbs/A after a laboratory soil test. The total N for the check is 40 lbs/A (33 lbs + 7 lbs N associated with P-fertilization).

Table 1. Agronomic management information.

Planted : May 1st	Applied herbicide @4-leaf : Huskie
Emerged : May 11th	Fungicide @ Flag leaf : Tilt
Target plants : 25/ft^2	
Seed treatment: Cruiser Maxx Vibrance	Nutrient applied : K_2O = 33 lbs/A (KCl) P_2O_5 = 84 lbs/A (MAP)

Table 2. Yield, protein, falling number, and gross adjusted income means for each of the varieties. Same letter assignment denotes equivalent means (α = 0.05)

Variety	Yield (bu/acre)		Protein (%)		Falling Number (sec)		Gross Adj. Income per acre	
SWSW	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Alpowa	123^{b}	115^{bc}	11.6^{e}	11.2^{e}	356^{c}	412^{d}	377b	394^{c}
Alturas	134^{a}	125^{a}	10.7^{g}	10.7^{f}	283^{d}	322^{f}	357bc	374^{c}
Penewawa	118^{c}	107^{d}	11.3^{f}	11.2^{e}	318^{e}	349^{e}	320c	337^{d}
UI-Stone	132^{a}	124^{a}	10.7^{g}	10.9^{f}	289^{e}	351^{e}	317c	331^{d}
Average	**127**	**118**	**11.1**	**11.0**	**312**	**359**	**342**	**359**
HRSW								
Egan	115^{c}	107^{d}	16.1^{a}	15.6^{a}	479^{a}	502^{b}	619^{a}	536^{a}
McNeal	119^{bc}	108^{d}	14.6^{c}	13.8^{c}	471^{a}	526^{a}	609^{a}	484^{b}
Solano	117^{c}	110^{cd}	15.5^{b}	14.6^{b}	397^{b}	444^{c}	605^{a}	529^{a}
Vida	122^{b}	115^{b}	14.3^{d}	13.5^{d}	348^{c}	409^{d}	590^{a}	507^{ab}
Average	**118**	**110**	**15.8**	**14.4**	**424**	**470**	**606**	**514**

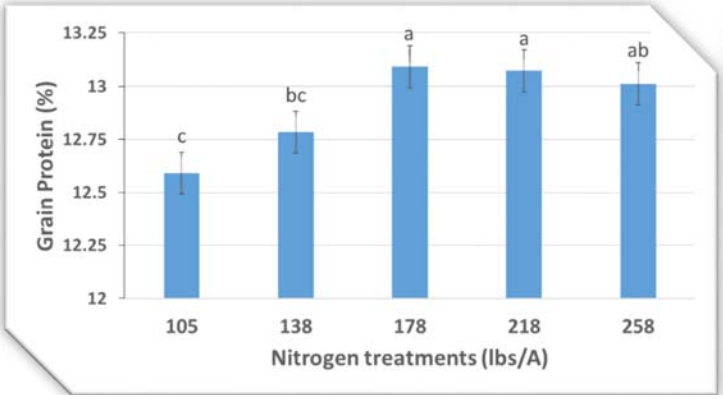
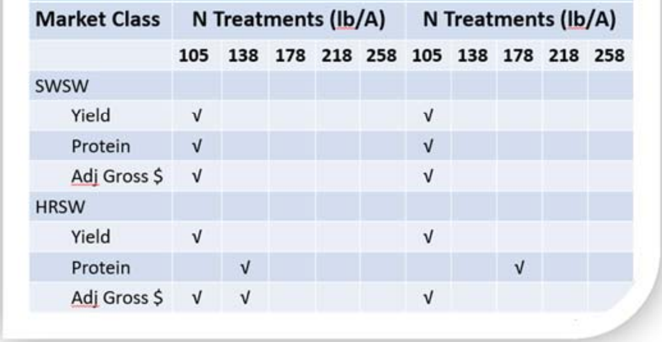


Figure 1. Nitrogen response for protein across cultivars and water regimes. Same letter assignment denotes equivalent means (α = 0.05).

Table 3. Fertilizer recommendation.



Based on 1-yr (2016) data alone

	IRRIGATED					RAINFED				
Market Class	N Treatments (lb/A)					N Treatments (lb/A)				
	105	138	178	218	258	105	138	178	218	258
SWSW										
Yield	√					√				
Protein	√					√				
Adj Gross $	√					√				
HRSW										
Yield	√					√				
Protein		√						√		
Adj Gross $	√	√				√				

Study 2. Nitrogen management of Egan with various water regimes

Egan – a high protein spring wheat variety was just released in 2016. This study investigates how much N is needed for yield as well as protein considering the presence of a high protein gene (*Gpc-B1*) in Egan. Water treatment of fully irrigated (100% evapotranspiration, ET), 75ET, 50ET and a rainfed check is the main plot factor and total N levels (40, 150, 200 and 250 lbs N) as a strip factor. Optimization of water and N on Egan is the main objective of this study. Egan was planted on May 3 and emerged on May 10, 2017. The P & K fertilization and biotic control are the same as with the first study (Table 1). No significant differences in yield for the N treatments.

Figure 2. (left) Nitrogen response for protein and (right) and yield response for water regimes.

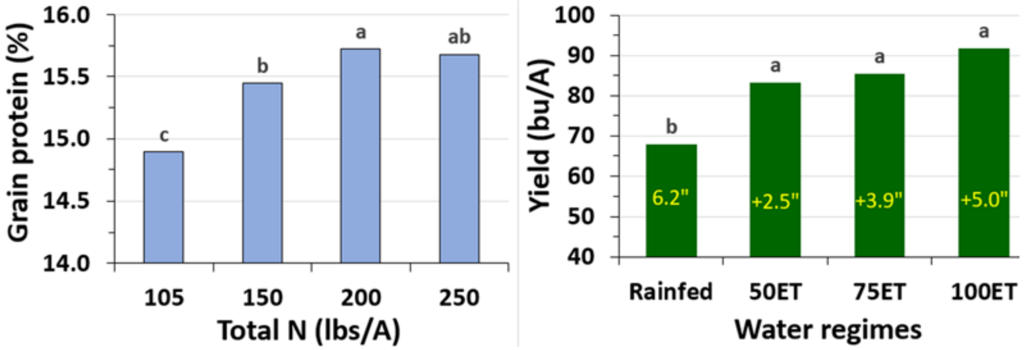


Table 4. Egan fertilizer and irrigation recommendation (based on 2016 data)

	N Treatment (total), lbs	Irrigation
Yield	105	50 ET (6.2” Rain + 2.5” Irr + 2.8” spring soil moisture)
Protein	200	
Adjusted gross Income	105 – 150	50 ET (6.2” Rain + 2.5” Irr + 2.8” spring soil moisture)

Optimum Seeding Rate for Spring Wheat: Does One Size Fit All?

Bob Stougaard

Seeding rate might sound like a standard management decision for wheat growers, but this topic is critical in maximizing profitability. Adjustments in population impact the capture of light, and this process is critical in achieving high yields.

Grain yield in cereals is often defined in terms of spikes per area, seeds per spike, and seed weight, which are collectively referred to as yield components. These components develop sequentially with late developing components controlled by early-developing ones. The degree to which these individual yield components contribute to final yield varies and is governed by competition for available resources. However, since spikes per area is the first yield component to develop, it generally exerts the greatest influence on yield.

Spikes per area is a largely a function of the population seeded. The optimum population is a function of the production environment and the planting date. However, genetic differences among varieties may also impact seeding rates. One varietal trait that impacts seeding rate is seed size. Knowing the number of seeds per pound, or thousand kernel weight, is required in order to determine the seeding rate for individual varieties.

$$\text{Seeding Rate (lbs/A)} = \frac{\text{(Desired Stand in plants/A) / (1- Expected Stand Loss)}}{\text{(Seeds/lb) x (\% Germination)}}$$

110 lbs per acre = ((1.1 million seeds per acre)/(1-0.15)) / ((12,500 seeds per lb)x(0.95))

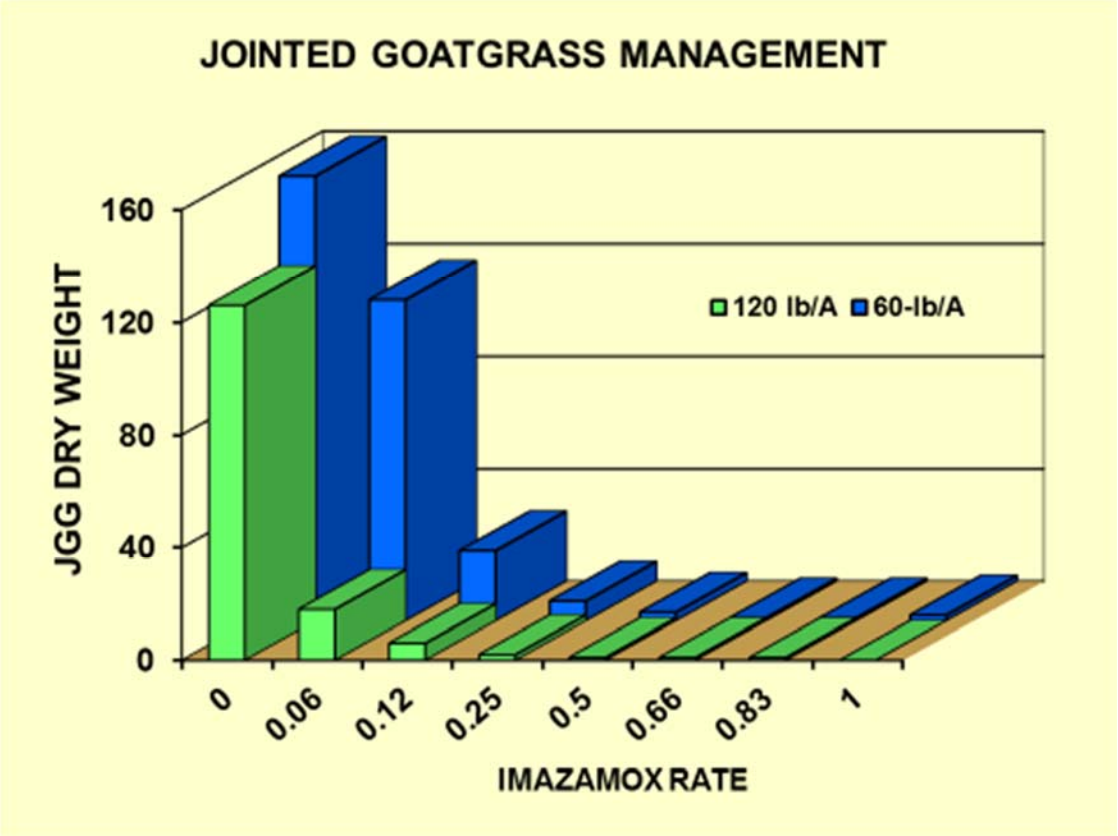
	Egan	Expresso	Solano	Soren	Tyra	Vida	average
	37	36	38	34	30	33	35
Plts/sqft	lb/A						
16	59	57	60	54	49	53	55
24	89	86	90	82	73	79	83
32	119	115	120	109	97	106	111
40	148	143	150	136	121	132	139
Plts/sqft	$/A						
16	17.20	16.91	17.76	16.07	14.32	15.36	16.27
24	25.78	25.35	26.62	24.10	21.47	23.02	24.39
32	34.39	33.81	35.51	32.15	28.64	30.71	32.54
40	42.97	42.25	44.38	40.18	35.78	38.38	40.66

Public: $29/cwt. Private: $29.50/cwt. Planted 5-3-17.

However, after adjusting for seed size, the question remains: Does there exists an optimal seeding rate that applies to all spring wheat varieties or do other varietal traits impact what seeding rate to use?

The objective of this study is to evaluate the effect of seeding rate on yield and grain quality among diverse spring wheat varieties.

Population not only impacts yield directly, but has an effect of weed control, crop maturity, lodging and disease severity. These also impact grain yield and quality and should be taken into consideration when discussing plant populations.



Wheat Midge Management Update

Bob Stougaard and Erik Echegaray

Genetic resistance offers an ideal method for control of the wheat midge. Resistance is due to a single gene called ‘Sm1’. The Sm1 gene confers both a higher constitutive level and a more rapid induction of two phenolic compounds, coumaric acid and ferulic acid. Once the larvae feed on the seed, the plant produces higher levels of these phenolic acids, which is associated with insect mortality. However, there appears to be a lag phase that occurs following the initial feeding damage and the point when production of the active insecticidal compound is synthesized. So, while mortality is nearly complete, some yield loss still occurs. Priming the plant’s defense response could shorten the lag phase and minimize yield loss.

	Midge Larvae (No/spike)			Yield (bu/A)		
Cultivar	Check	Treated	*DIFF*	Check	Treated	*DIFF*
REEDER	46	18	*27*	34	56	*22*
HANK	102	10	*92*	15	44	*30*
mean	***74***	***14***	***60***	***24***	***50***	***26***
CAP34-1	0	0	*0*	49	58	*9*
CAP84-1	1	0	*1*	41	59	*18*
CAP84-2	0	0	*0*	42	58	*16*
CAP108-3	0	0	*0*	51	67	*16*
CAP197-3	0	0	*0*	51	61	*11*
CAP201-2	0	0	*0*	46	61	*15*
CAP219-3	0	0	*0*	42	56	*14*
CAP400-1	0	0	*0*	52	75	*23*
mean	***0***	***0***	***0***	***47***	***62***	***15***

Priming is a physiological process where a plant becomes predisposed to a stress, and then rapidly responds to the same stress with an inducible defense mechanism. Such plants respond with enhance resistance and/or with a shorter lag time, similar to being vaccinated.

Salicylic acid (SA) is a plant hormone that has been shown to prime the plants’ defense machinery against certain diseases and insects. Salicylic acid has been shown to enhance resistance of Norway spruce to bark beetle and wheat seedlings to Hessian fly. Since the wheat midge and Hessian fly are related, the same response might occur with the wheat midge. We have a study which evaluates different concentrations of methyl salicylate applied at three different wheat growth stages in an effort to prime the Sm1 gene.

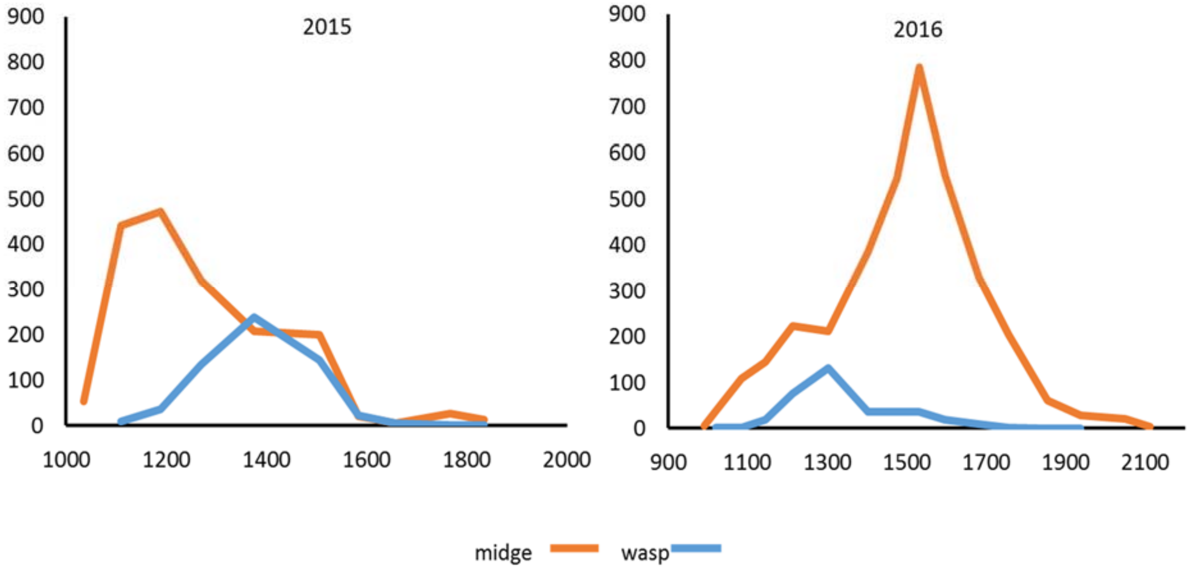
The Sm1 gene has been crossed into a genetic background adapted to northwest Montana, resulting in a midge-resistant variety called ‘Egan’. In addition to midge resistance, Egan has shown resistance to stripe rust and it has higher grain protein and falling numbers than other widely grown varieties.

Unique guidelines for growing Egan have been developed. The Sm1 gene causes complete mortality of the midge, except for those rare midge that may have obtained a mutation to allow them to overcome the gene. Mating of these resistant midge would quickly lead to development of population dominated by resistant midge. A strategy of blending has been developed to allow long-term use of the Sm1 gene. This strategy requires growers to blend Egan with a 10% ratio of a susceptible variety. The susceptible variety provides a refuge, which allows susceptible midge to reproduce and maintain a diverse genetic background in the population as a whole. As a result, the gene that allowed the mutant midge to survive should remain in the population at a very low frequency. Thus, Sm1 will provide good control of the midge for the long-term.

One question that has been raised is if it matters what susceptible variety is paired with Egan? To address that issue, we have an experiment where Egan is being grown as a 9:1 blend with either Cabernet, Expresso, Solano, Soren, Tyra, Vida or WB9518.

Biological control is another management tactic. A small parasitic wasp, *Macroglenes penetrans*, attacks the wheat midge, helping to regulate populations. This parasitoid is credited with controlling about 25 to 40 percent of the midge population in parts of Canada and North Dakota. In some instances, parasitism rates of greater than 75 percent have been documented!

In an effort to provide growers with additional pest management tools, this wasp was introduced from North Dakota into Flathead County in 2008. After the initial release, the parasitoid population slowly increased, and by 2014, high numbers of the wasp could be found throughout Flathead County. Protecting this management tool requires that we understand its emergence patterns so that we don’t unintentionally injury the population with insecticide applications. In 2015 a monitoring program was initiated to document the distribution of the wasp throughout Flathead County as well to help predict wasp emergence patterns.



Eight fields were monitored throughout Flathead County in 2015 and 2016. Wasps were found at each location, indicating that the wasp is widely distributed in the area. The wasp emerged about five days after the midge and over a narrower period compared to the midge. Eventually this information can help to guide the application of insecticides in this area.

This effort produced an unexpected outcome; we discovered that another species of parasitoid was present in the area. *Euxestonotus error* was identified at eight different sights in Flathead County. This indicates that these other parasitoid species should survive and multiply in Montana and provide additional help in managing the wheat midge.

Monitoring for these biocontrol agents involves the use of a sweep net and requires 100 sweeps along a linear transect in each field to be sampled. The insects are then collected in a ziplock bag and placed in a freezer for later identification. While effective, this process is time consuming, so we are working on an attractant-based system that would be specific for the biocontrol agents. We have identified such a compound and are now trying to develop this into an easy to use, lure system.

Pushing the Limits of Fertilizer N Recovery in Montana with Improved N management

Principal Investigators and Cooperators

Dr. Richard Engel, Carlos Romero, Dept. of Land Resources and Environmental Sciences
Dr. Jessica Torrion, Research Center Dept., Creston

Project purpose

Nitrogen (N) is a major annual cost input for cereal grain growers in Montana. Recovery of N fertilizer can vary tremendously depending on the source, method and timing of applications. Previous research conduct at field sites near Coffee Creek Montana (Fergus County) have shown that N fertilizer recovery by winter wheat was affected by N fertilizer form (below) with nitrate sources > urea or urea + Agrotain. (see **Figure 1**). Several factors may explain this response including ammonia volatilization and nitrogen immobilization differences between nitrate forms and ammonium forms of fertilizer N. This study will build on existing studies conducted in central Montana by making direct comparisons among different fertilizer nitrogen sources (some commercial available others not) including sodium nitrate (Chilean nitrate), ammonium nitrate (YARA CAN-27), urea and urea+ Agrotain®, and urea + Agrotain® + Instinct.

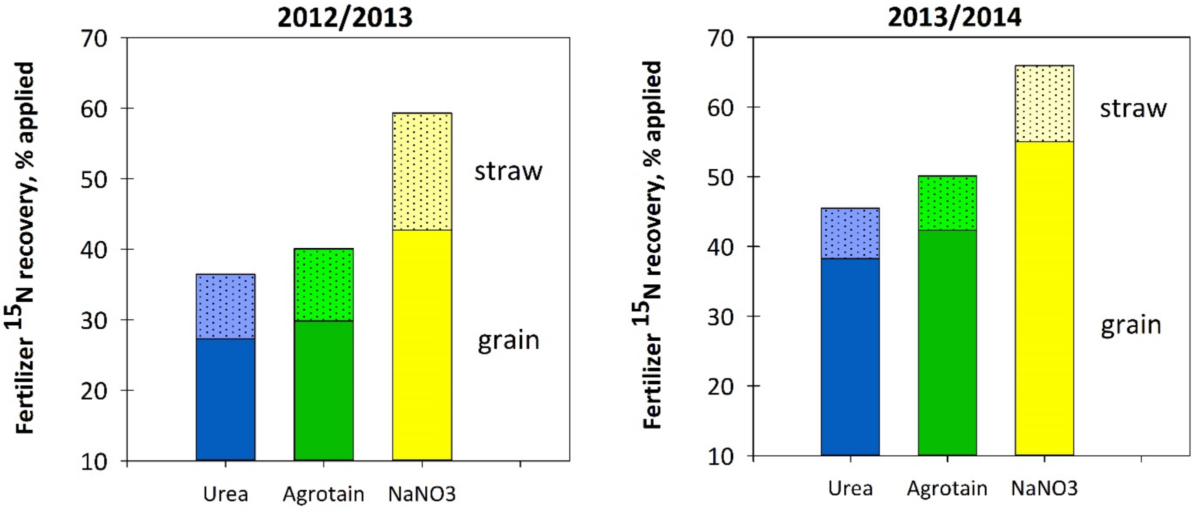


Figure 1. Fertilizer N recovery (FNR) by winter wheat was greater for sodium nitrate compared to urea and urea+Agrotain® over three years (only two years shown) at Coffee Creek, Montana. FNR was determined from ^{15}N enriched fertilizer microplots. Higher FNR in 2013/2014 vs. 2012/2013 lead to higher grain protein.

Objectives

1. To compare fertilizer recovery of nitrogen among a number of different N sources (applied two rates or 54 and 108 lb N/acre) including sodium nitrate, ammonium nitrate, urea, urea+Agrotain®, urea+Instinct®, and urea+Agrotain®+Instinct®.

2. To provide Montana growers fertilizer management strategies that result in the greatest N recovery, economic return and lowest N loss for production of winter and hard red spring wheat.

Study description - components

- Two locations - shallow soil profile (Moccasin-CARC); deep soil profile (Creston-NWARC)
- Six N fertilizer sources (including additives) all applied as spring broadcast application
- Two N rates (54 and 108 lbs N/ac at Creston)
- Agrotain® = minimize ammonia volatilization; Instinct® - nitrification inhibitor
- These trials rely on the perks of using of fertilizer-N enriched with a specific form of N called "15N", which is very stable and allows the tracking of the added fertilizer in the system. This is very important to directly quantify the fate of N, and identify the principal sinks of N (plant, soil, air).

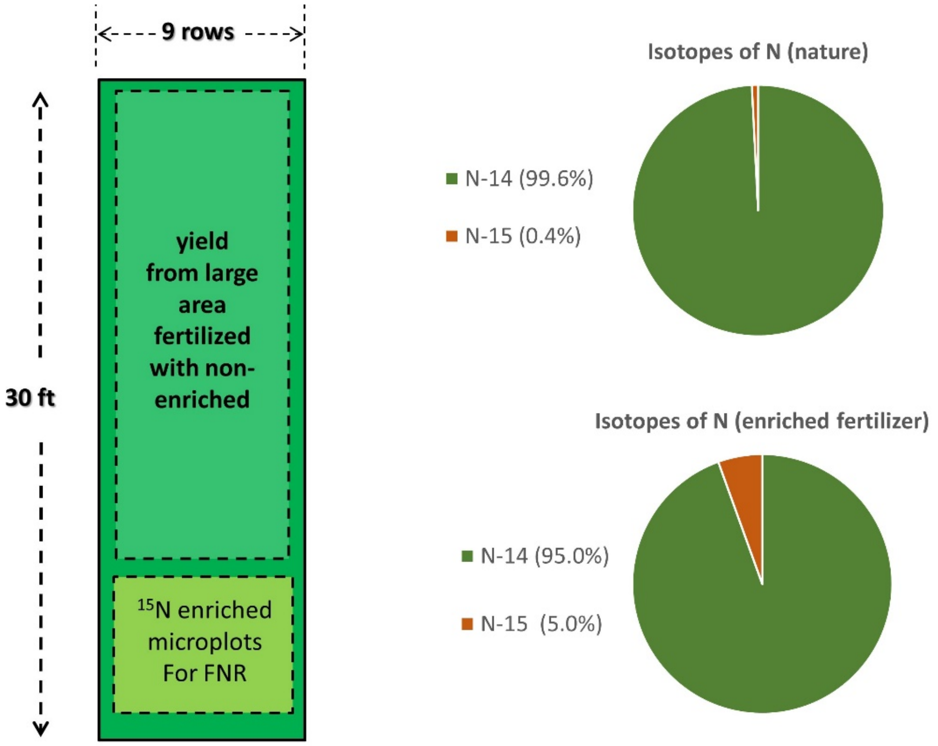


Figure 2 - ^{15}N microplots are placed inside of larger plots (left). Distribution of N forms (15N and 14 N in nature and enriched fertilizer (right).

Expected results

- Fertilizer N recovery, yield, and protein of Egan spring wheat among the different N sources
- Fertilizer N recovery of spring applied sodium nitrate > than other sources if Creston is consistent with studies from Coffee Creek.

Acknowledgements and a big thank you to ……

- Montana Fertilizer Advisory Committee (Montana Fertilizer check-funds) and International Plant Nutrition Institute
- Professionals and staff at Northwest Agricultural Research Center for field site preparation/care/harvest.

Effects of irrigation and boron fertilization on yield and forage quality of alfalfa

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[2]Northwestern Agricultural Research Center, Montana State University, Kalispell, MT

The purpose of this study is to evaluate the effect of irrigation and boron (B) on yield and forage quality of alfalfa. Alfalfa is a major perennial forage crop which is known for its high dry matter yield and hay quality. Boron is an essential micronutrient and its deficiency affects growth and yield in alfalfa. Since alfalfa has high B demand among crops and is sensitive to low B availability, we conducted this study to determine how much B maintenance fertilization is needed to grow alfalfa in northwest Montana.

Alfalfa is also known for its high water use demand. Water regimes were added to this experiment as the main plot factor – 1) rain-fed check, 2) fully irrigated (100% evapotranspiration, ET), and 3) partial irrigation (50ET, scheduled on the same date of application as 100ET but only half of its amount). The B rates (subplot factor) are shown in Table 1, which were randomly assigned to plots within each of the water regimes. See Figure 1 for the amount of irrigation applied and precipitation received in 2016.

Table 1: Boron (B) treatments, amounts, and timing of application.

Treatment	Total B (lb/acre)	Application time
B_0	Untreated check	None
B_1	0.5	Split: 0.25 lb applied at 3-inch spring growth + 0.25 lb at 3-inch regrowth after first cutting
B_2	1.0	Split: 0.50 lb applied at 3-inch spring growth + 0.50 lb at 3-inch regrowth after first cutting
B_3	2.0	Split: 1.0 lb applied at 3-inch spring growth + 1.0 lb at 3-inch regrowth after first cutting
B_4	2.0	2.0 lb applied at 3-inch spring growth

Table 2. Management information

Soil type: Sandy loam	Variety: HybriForce-3400
Seed rate: 20 lb/acre, broadcast	Seeding date: 24th May, 2016
Previous crop: Spring wheat	Soil test (2016): 121-21-144
Boron: 10% Agri B solution™	Fertilization (2016): 44-104-240-20S

Results found that irrigation increased hay production. Compared with the rain-fed check, yield increased by 45% with 50 ET irrigation treatment (i.e. 3 inches of irrigation plus 4.9 inches rainfall). However, no yield differences were detected between 50 ET and 100 ET. Boron application did not influence yield.

Forage quality of alfalfa decreased with irrigation. Crude protein dropped by 10% and relative feed value by 17%. However, all the forage, regardless of irrigation and B treatments, were mostly found to be of premium to supreme quality.

Figure 1: Rainfall and irrigation events, 2016

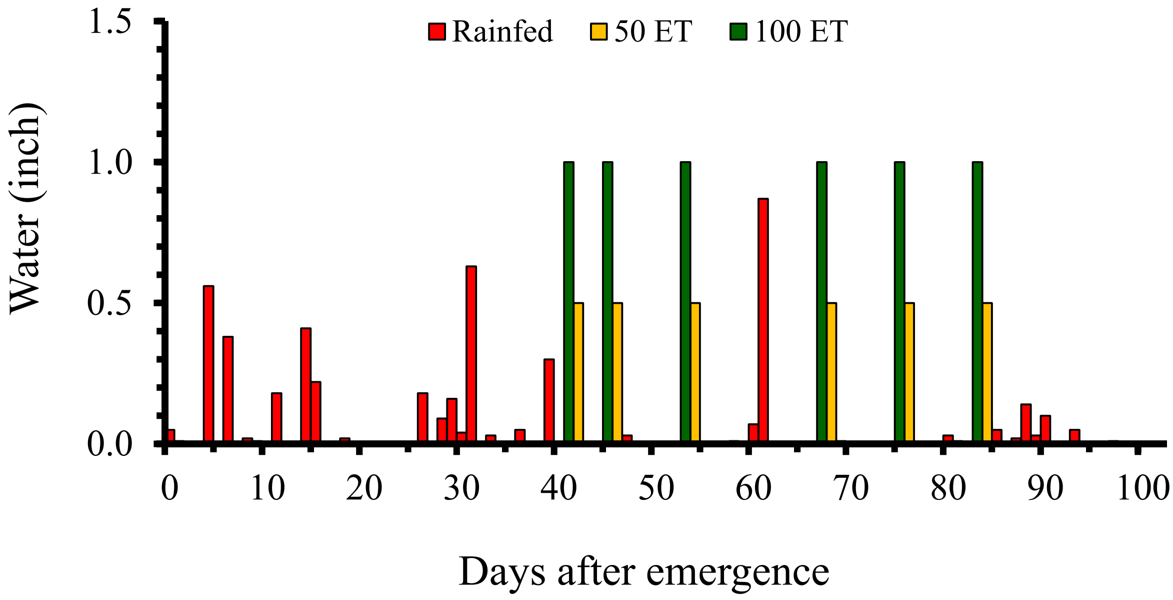
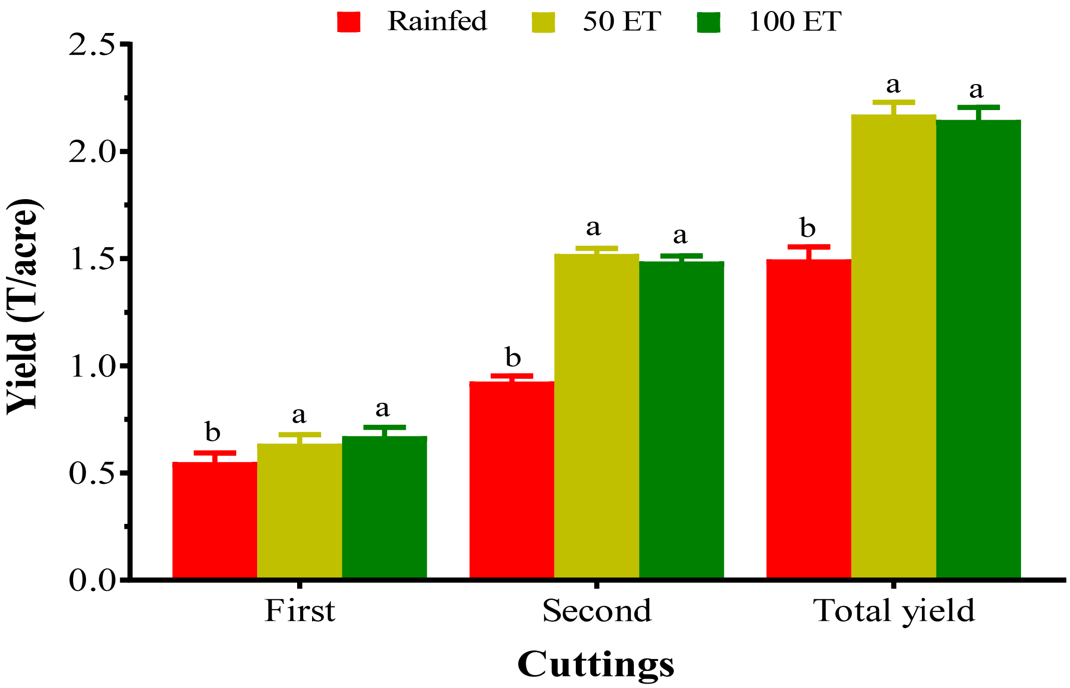


Figure 2: Effects of irrigation on yield of alfalfa, 2016



Variety Options for Peas, Lentils, and Faba Beans

Montana is the leading grower of pulse crops in the United States. Pulses are excellent rotational crops in wheat-based cropping system as they serve as 'break' crops which improve soil and plant health. They fix atmospheric nitrogen (N) for growth and yield (**Table 1**). Most pulse crops provide a nitrogen credit of 10 to 20 lb/A. They are also reported to be good scavangers of P and other nutrients. Improved rooting environment (physical and microbial) is another rotational benefit.

Table 1. Nitrogen (N) fixed estimates
Source: Dr. Schoenau, U of Saskatchewan

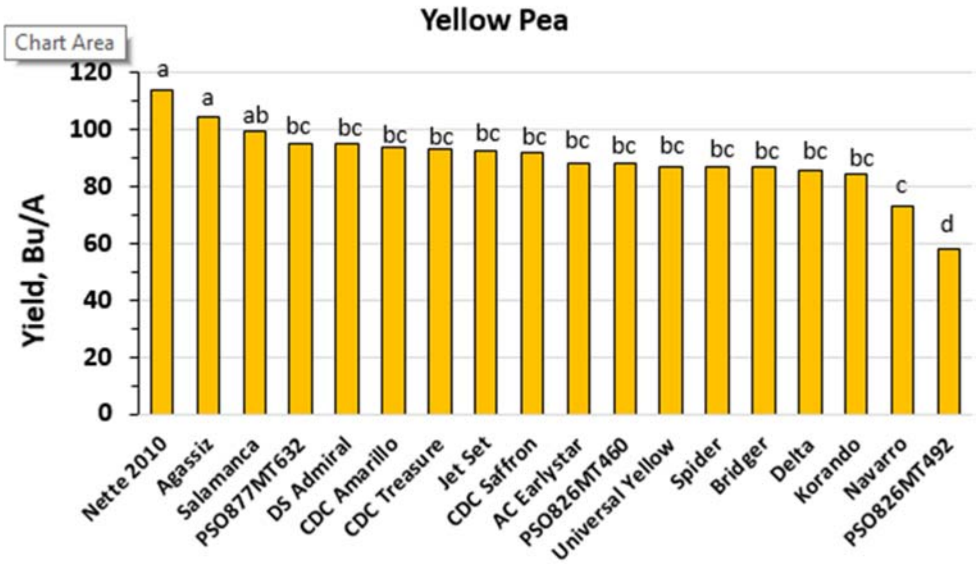
Crop	**Fixed N, lbs/acre**
Pea	50-150
Lentil	30-120
Faba bean	80-160

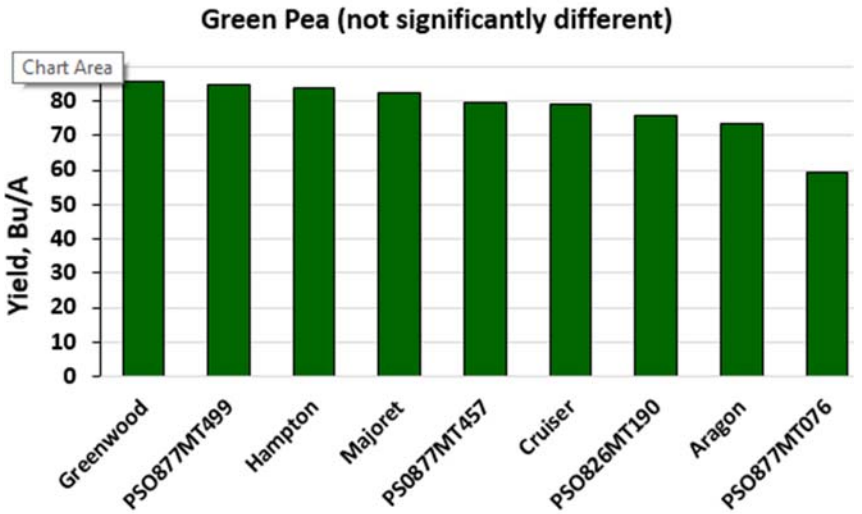
Seed inoculation is an important consideration in growing pulse crops. Seed treatment for disease and insect control is another management factor that impacts pulse production. Weed control is important for all crops, but particularly so for lentils. Unfortunately, there are few herbicide options available (Table 2). This year, pea leaf weevil was found in the area, thus, an insecticide was applied first week of June.

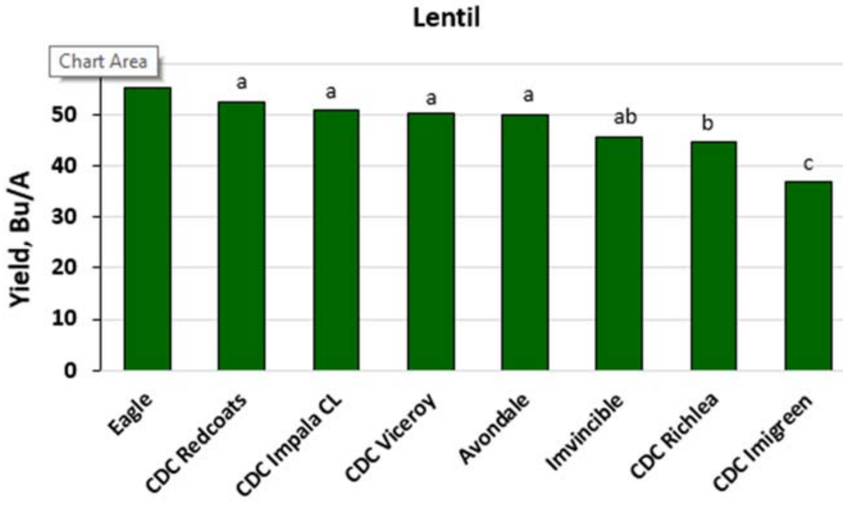
Table 2. Management information

Soil: Creston silt loam	Nutrient applied: 6-30-40
Planted: May 11, 2017	Herbicide: Triflurex (preplant incorporated)
Seed Treatment Insecticide: Cruiser 5FS Fungicide: Apron Maxx RTA	Insecticide: Warrior II (June 6)
Inoculant: N-charge	

Faba bean is a new option being considered for this area. Among pulses, it has the highest N-fixing ability (Table 1). There are quite a number of unknowns in terms of managing Faba bean, agronomically. In our experience, planting Faba bean can impose a challenge at planting. It is relatively a large-seeded crop with an irregular shape which can potentially plug the seeder openers. Planting at the slowest speed can reduce faba bean hose plugging, thus, occasional checking is recommended. In Canada, Lygus, blister beetles, grass hoppers, and aphids can be a problem. It is also prone to disease - Chocolate Spot. The crop may require a desiccant to help with harvest.


Yellow Pea


Green Pea (not significantly different)


Lentil