RESULTS OF CROPPING SYSTEMS RESEARCH CONDUCTED IN SOUTH CENTRAL MONTANA-2020
Southern Agricultural Research Center, Huntley, MT

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1. Project Title: Spring grain performance following various cover crop mixes in southcentral Montana
2. Investigators:
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3. Justification: Crop production in the rainfed areas of Montana has been dominated by wheat/fallow for many years. The total number of acres in fallow has steadily declined over the past 20 years but 3 million acres continue to be fallowed in Montana as of 2016. Fallow farming has been successful at reducing the risk of crop failure in winter wheat production, but is considered largely responsible for a decline in soil quality. Cover crops have been suggested as a means to stabilize and rebuild soil quality replacing fallow in the traditional wheat—fallow crop rotation. A lot of information exists on the impact of single species cover crops as they were a common practice early in the previous century prior to the availability and use of modern fertilizers. There is less information on the impact of cover crop species composition and the impact they may have on soil properties such as water infiltration, amelioration of soil compaction, and addition of organic nitrogen to the soil system. Different specie C:N ratios, rooting structures and effective rooting depths may influence soil properties. The use of mixed cover crops has mostly occurred in regions of temperate or continental climate under greater annual precipitation than what is received in the semiarid region of the northern Great Plains. This study was initiated to provide a location where mixed cover crops are included in a small grain cropping system. Soil quality measures are to be assessed over time to determine the impact of adding various species of cover crops in place of fallow. Changes in soil properties are slow to occur, so it is important to continue this study for several years.

4. Objectives: A two-year rotation of cover crops/small grain crop was established in 2015 at the Southern Agricultural Research Center near Huntley, MT to provide a means for evaluating changes in soil quality and comparison of small grain yield and quality as impacted by cover crop mixtures. There are 2 blocks in Field J dedicated to this study, with the east block in spring wheat and the west block in cover crop treatments for 2020. The impact of four different plant specie type, or ‘functional groups’ are compared.

5. Methods: On Apr 22, 2020, spring wheat was planted perpendicular to the cover crop strips of 2019. This strip-plot design used four nitrogen rates with fertilizer placed in bands separated but adjacent to the seed to evaluate the impact of cover crops on nitrogen response of the spring grain. Nitrogen rates for spring wheat were 0, 25, 50, and 75 lb N/a using urea as the N source. Mixed species cover crops and a chemical fallow were established using a randomized complete block with 4 replications in early May 5, 2020 in field J at the Southern Agricultural Research Center. Each group was composed of multiple species (see Table 1). Treatments included

legume (L) mix, brassica (B) mix, grass (G) mix, taproot (T) mix, a mixture of all 4 groups as B-G-L-T, and then mixtures of 3 of 4 groups, G-L-T, B-L-T, B-G-T, and B-G-L. A cover crop of pea only, and a chemical fallow check were also included. Cover crops were planted using a Seedmaster no-till drill in plots 15 ft wide by 60 ft in length. Targeted plant populations for mixes (Table 1) were adjusted by dividing the target population of each species by 4 since there were 4 species in each group. Then when mixed across groups, the targeted population for each species mix was divided by a factor of the numbers of groups within a mix.

6. Results: Cover crop establishment was as expected except for Brassicas where very few of that group established (Tables 2 and 3). The poor establishment of brassicas resulted in reduced average stands across all treatments that included brassicas. Nitrogen fertilization of the previous wheat crop continued to influence cover crop biomass production in the following year (Table 4). In nitrogen starved environments (treatments where no fertilizer N has been added since 2015) biomass production averaged 37% less as compared to following wheat where N fertilizer was applied (Table 4). The difference is even greater where no legume is included in the cover crop mix. At Low N where pea was the only species as a cover crop, biomass production was the highest of all treatments, although no significant differences were found across all cover crop treatments. At the highest N rate the biomass production was greatest with B-G-L mix, although still no significant differences in biomass could be shown.

   Spring wheat yield ranged from 45 to nearly 50 bu/a where the previous crop treatment was fallow, legume mix, or pea (Table 5). The highest yielding of all treatments for the entire study has been following fallow, but the difference in wheat yield following pea and legume mix is not significantly different from following fallow in 2020. Spring wheat responded positively to fertilizer N applications in terms of grain yield, grain protein, and plant height (Table 6). This response is expected for a grass crop such as wheat. Grain test weight declined slightly as N rates increased.

   There was a significant interaction in grain protein between N application and cover crop. Figure 1 shows that at the lowest two N rates there was little difference in grain protein. But at the higher two N rates grain protein was enhanced following fallow, pea, and legume mix. This response is likely due to the fixation of nitrogen from the legume species and due to mineralization during the fallow period for the fallow treatment. Fallow practices typically lead to an accumulation of both water and N in the profile where soils are deep enough to retain them for a following crop. Even though legumes are a portion of the B-G-L-T, B-L-T, and G-L-T mixes, the percent contribution of the legume fraction to biomass in these treatments is relatively low.

7. Future plans: This study will continue in 2021. As part of our long-term plan for this study we will begin collecting measures of physical soil properties in 2021. Plans are to measure water infiltration and aggregate stability on the cover crop phase of the study for both the N0 and N100 treatments for all cover crop treatments.

Table 1. Target plant populations for each species in cover crop study, Huntley MT 2020.

Group	Species	As Sole crop plants/ft^2	Mixture Target plants/ft^2
Legume	Chickpea	4.0	1.0
-	Cowpea	6.5	1.6
-	Faba bean	4.0	1.0
-	Spring pea	9.0	2.2
Grass	Corn	0.5	0.2
-	Millet	40.0	10.0
-	Oat	25.5	6.3
-	Triticale	19.0	4.9
Brassica	Canola	9.0	2.2
-	Mustard	6.0	1.5
-	Radish	6.0	1.5
-	Turnip	6.0	1.5
Taproot	Buckwheat	15.0	3.8
-	Flax	40.0	10.0
-	Safflower	8.0	2.0
-	Sunflower	0.7	0.2

Table 2. Percent of target stand of cover crop treatments measured just prior to biomass harvest, Huntley, MT 2020.

Mixture	N Applied	Brassica	Grass	Legume	Taproot	Total of target
		%	%	%	%	%
B-G-L-T	Low	6.5	92.9	99.2	106.0	76.1
-	High	19.9	121.1	103.9	99.9	86.2
G-L-T	Low	-	83.8	78.0	64.2	75.3
-	High	-	74.7	70.8	100.9	82.1
B-L-T	Low	14.8	-	70.8	123.9	69.8
-	High	18.4	-	102.7	139.1	86.7
B-G-T	Low	1.0	78.7	-	70.3	50.0
-	High	5.1	112.0	-	107.0	74.7
B-G-L	Low	0	85.8	92.1	-	59.3
-	High	0	103.0	113.3	-	72.1

Species functional groups identified as B = Brassica, G = Grass, L = Legume, T = Taproot

Table 3. Total Biomass production and percent contribution from functional groups for cover crop mixes, Huntley, MT 2020.

Mixture	N Applied*	Brassica %	Grass %	Legume %	Taproot %
B-G-L-T	Low	0	56	15	29
-	High	0	63	19	18
G-L-T	Low	-	64	13	23
-	High	-	49	11	40
B-L-T	Low	1	-	19	80
-	High	0	-	25	75
B-G-T	Low	0	64	-	36
-	High	0	67	-	33
B-G-L	Low	0	78	22	-
-	High	0	74	26	-
Mean	Low	0	65	18	42
	High	0	63	20	42

*No fertilizer was applied during the cover crop phase. Values indicate the N applied to the previous crop of wheat, In 2019 Low was 0, High N Rate was 150 lb N/a.

Species functional group identified as B = Brassica, G = Grass, L = Legume, T = Taproot

There was no significant difference in biomass production due to cover crop treatments

Table 4. Total biomass (lb/a) production of cover crop treatments for each treatment following low and high N applications to the previous spring wheat crop, Huntley, MT 2020.

Mixture	Low N	High N	Average
B-G-L mix	1883	2887	2385
Pea	2089	2426	2257
G-L-T mix	1712	2425	2068
Tap Root	1505	2425	1965
Grass	1259	2331	1795
B-G-L-T mix	1413	2128	1771
B-L-T mix	1282	2227	1755
Legume	1314	2028	1671
B-G-T mix	1012	1982	1497
LSD(.05)	NS	NS	NS

Species functional groups identified as B = Brassica, G = Grass, L = Legume, T = Taproot, P = Pea

Low N = 0 lb N/a, High N = 150 lb N/a

Brassica mix cover crop treatment did not establish and was excluded from the analysis.

NS = non-significant

Table 5. Spring wheat performance following various cover crop treatments, Huntley, MT 2020

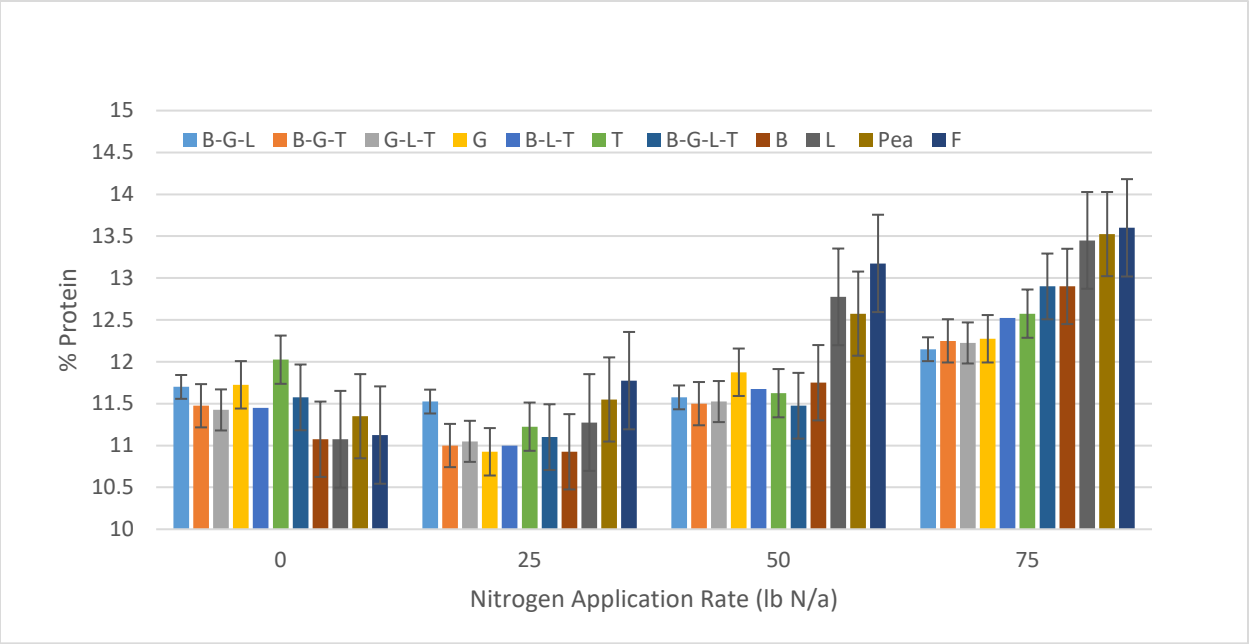
Treatment	Yield	Test wt	Protein	Height
	bu/a	lb/bu	%	in
Fallow	48.4	60.59	12.4	68.4
Legume mix (L)	47.4	60.78	12.1	69.3
Pea	47.3	60.93	12.3	70.8
Brassica_mix (B)	45.3	61.16	11.7	67.6
B-G-L mix	43.5	60.96	11.7	69.1
B-L-T mix	43.3	60.82	11.7	68.1
B-G-L-T mix	41.0	60.88	11.8	67.9
B-G-T mix	39.5	60.89	11.6	67.6
G-L-T mix	39.4	61.29	11.6	68.9
Taproot mix (T)	38.7	60.87	11.9	66.3
Grass mix (G)	36.9	61.09	11.7	66.1
LSD(.05)	3.1	NS	0.3	2.4

LSD based on Fisher's protected mean separation at the 5% probability level.
NS = non-significant
Species functional groups identified as B = Brassica, G = Grass, L = Legume, T = Taproot, P = Pea

Table 6. Spring wheat performance to fertilizer nitrogen application averaged across cover crop treatments, Huntley, MT 2020.

Treatment	Yield	Test wt	Protein	Height
lb N/acre	bu/a	lb/bu	%	in
0	28.7	61.5	11.5	63.9
25	39.5	61.5	11.2	68.2
50	49.8	60.8	12.0	70.8
75	53.2	60.0	12.8	70.1
LSD(.05)	1.9	0.4	0.2	1.4

LSD based on Fisher's protected mean separation at the 5% probability level.



Species functional groups identified as B = Brassica, G = Grass, L = Legume, T = Taproot P= Pea ; F = Fallow,

Figure 1. Spring wheat protein response to additions of fertilizer N following various cover crop treatments, Huntley, MT 2020.