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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 for many years. The total number of acres in the wheat-fallow system 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 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 and needed composition of mixed species cover crops to perform the functions of improved plant diversity, reduce C-N ratios of residue returned, improved water infiltration, amelioration of soil compaction, and addition of organic nitrogen to the soil system. The use of mixed cover crops has mostly occurred in regions of ample or at least greater 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 spring grain cropping system to allow changes to soil quality to approach an equilibrium in order to quantify their impact on crop production and soil quality.

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 west block in spring wheat and the east block in cover crop treatments for 2019. It will likely take several crop cycles before quantifiable changes in soil quality can be documented. The impact of four different plant species, or 'functional groups' will be compared.

5. Methods: Mixed species cover crops and a chemical fallow were established using a randomized complete block with 4 replications in early May 2019 in field J at the Southern Agricultural Research Center. Each group was composed multiple species (see Table 2). Treatments included legume mix, brassica mix, grass mix, taproot mix, a mixture of all 4 groups, mixture of all without (w/o) legume, all w/o grass, all w/o brassica, all w/o taproot, pea only, and a chemical fallow check. Cover crops were planted May 6 to 8 using a Seedmaster no-till drill in plots 15 ft wide by 60 ft in length. On May 2, 2019, spring wheat was planted perpendicular to the cover crop strips

of 2018. This resulted in a strip-plot design using four nitrogen rates with urea placed in bands adjacent to the seed to evaluate the impact of cover crops on nitrogen response of the spring grain. Nitrogen rates were based on yield goals using MSU recommendations. Rates are 0, 0.5, 1.0 and 1.5 times the MSU recommendation for spring grain reduced by soil nitrate content in a 4 foot profile measured prior to planting. Targeted plant populations (Table 2) were adjusted by species within a group (for example in the legume group the target population for each species was reduced by a factor of 4 since there were 4 species in that group), and when mixed across groups, by a factor of the numbers of groups within a mix (either by 3 for mixtures minus one group; or by 4 for the 'All groups' mixture).

6. Results

A severe hailstorm occurred on August 12 preventing harvest of spring wheat plots. Prior to the storm spring wheat yields looked promising with greater plant height and darker green plants were evident where nitrogen fertilizer had been added. Yields of wheat for the top 2 nitrogen rates would have likely exceeded 60 bu/a, with little difference between those upper level N rates.

The cover crops had been terminated prior to the storm and the results are presented below. The most obvious difference in overall cover crop growth was how cover crop biomass accumulation increased on plot strips where the previous wheat crop had been fertilized with nitrogen. Since this difference was clearly visible in the field it was decided to sample the results from the high and low N rates for comparison. Table 4 shows that the average biomass across treatments produced nearly 750 lbs/a greater biomass following the highest previous N rate than following the lowest (Table 4). This unexpected difference will require a modification to our sampling procedures from here on to ensure that N treatments over years remain on the same plots so that potential changes in soil quality can follow this development.

It is also obvious from comparing established plant populations to targeted populations that on average only 60% of our population target is being achieved (Table 2). Yet due to normal to higher than normal precipitation received during the growing season (Table 1) biomass production of the cover crops was greater than most previous years averaging nearly 2800 lbs/a (Table 3). As in previous years the pea only cover crop was superior in biomass accumulation to all except the complete mix cover crop treatment (Table 3). This was a good year for production of the cool-season species. Within the legume group the cowpea (a warm season species) did not establish well. In the grass group the warm season grasses of millet and Indian corn also established poorly as compared to oat and triticale. The brassica group behaved similarly where mustard, the species of this group that favors warmer growing conditions established the poorest. In the taproot group there are only 2 species, but even here safflower which favors warmer conditions was outcompeted by flax, a species that excels in cool conditions. Until this point in this study safflower has been one of the best biomass producing species. The addition of flax to this group had a definite negative impact on the establishment and growth of safflower.

The relative and total biomass production of the 4 cover crop types when grown together is illustrated in Figure 1. This year no one group dominated biomass production. This may in part be attributed to the fact that we now have multiple species in each group. This design helps to ensure that each group has at least one species that will successfully establish and compete for resources to represent the group. Our planting this year favored the cool season species with a cooler than normal May which followed a wetter than normal late winter and spring which likely recharged the soil with water to allow good biomass production by these cover crops.

Table 1. Summary of climatic data by months for the 2018-2019 crop year and historical averages for the period 1911-2018 at the Southern Agricultural Research Center near Huntley, MT.

	2018				2019							Year	
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Precipitation (inches)													
Current year (2018-2019)	0.36	0.66	0.48	0.40	0.61	1.44	0.28	1.53	3.48	2.32	1.71	1.70	14.97
Avg (1911-2018)	1.31	1.10	0.63	0.61	0.55	0.47	0.80	1.38	2.22	2.32	1.13	0.97	13.49
Mean Temperature (°F)													Avg
Current year (2018-2019)	57.3	44.0	34.7	28.9	25.4	6.3	24.8	46.2	50.4	63.0	69.6	70.6	43.43
Avg (1911-2018)	58.2	46.9	33.7	23.8	21.1	25.8	34.4	45.5	55.0	63.4	70.9	68.8	45.63

Table 2. Targeted and Established plant populations for each species in cover crop study, Huntley MT 2019

Group	Species	As Sole crop	Mixture Target	Established
		--------------------------- plants / ft^2 ---		
Legume	Spring pea	9.0	2.2	2.2
	Cowpea	6.5	1.6	0.1
	Faba bean	4.0	1.0	0.9
	Chickpea	4.0	1.0	1.1
Grass	Oat	25.5	6.3	4.1
	Millet	40.0	10.0	0.9
	Triticale	19.0	4.9	2.2
	Indian corn	0.5	0.2	0.01
Brassica	Canola	9.0	2.2	1.9
	Mustard	6.0	1.5	0.4
	Radish	6.0	1.5	1.0
	Turnip	6.0	1.5	1.3
Taproot	Safflower	8.0	4.0	2.0
	Flax	40.0	20.0	13.4

Table 3. Total biomass (lbs/a) production of cover crop treatments averaged across previous crop nitrogen treatments

Treatment	Total Biomass
Pea only	3830 a
Legume mix	2570 b
Grass mix	2839 b
Brassica mix	1290 c
Taproot mix	2575 b
Complete mix	3288 ab
Mix w/o legume	2955 b
Mix w/o grass	2627 b
Mix w/o brassica	3028 b
Mix w/o taproot	2926 b

Table 4. Total biomass (lb/acre) separated by previous crop N rate averaged across cover crops.

Nitrogen Rate for 2018 wheat	Total Biomass
High	3170 a
Low	2448 b

Figure 1. Distribution of and total biomass production (lb/acre) for each cover crop mixture averaged across all previous crop nitrogen treatments, Huntley 2019.