United States Department of Agriculture

February/2019

FINAL STUDY REPORT
Aberdeen Plant Materials Center
Aberdeen, Idaho

Cover Crop Variety Trial, 2016-17

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ABSTRACT

Cover crop varieties available today are numerous, however information on which varieties of each species are best adapted to specific regions is largely unavailable. The Natural Resources Conservation Service Plant Materials Program conducted a multi-year trial using readily available varieties of eight different common cover crop species including: balansa clover, cereal rye, crimson clover, hairy vetch, oat, pea, radish and red clover. Evaluations conducted were: 1) germination/field emergence, 2) beginning of spring regrowth, 3) bloom and flowering period, 4) plant height, 5) disease and insect resistance, and 6) winter hardiness. Lana hairy vetch was the only hairy vetch variety to winter kill in our trial. All other varieties of hairy vetch performed similarly in the other evaluated traits. Survivor 15 was the only pea variety to survive in all 4 plots, and thus the only one to have all the data recorded for 2016 and 2017. Fixation balansa clover out-performed Frontier in all analyzed categories minus date of bloom in which Frontier bloomed 1 week earlier than Fixation. Both varieties survived lower temperatures than commonly accepted. AU Sunup and Contea had the lowest germination scores of the crimson clover varieties, while Kentucky pride bloomed the latest. Red clover was the only perennial species in the trial and looked to have the least variability among the varieties evaluated. Cyclone II red clover showed the very best germination while Mammoth was the only variety that had not flowered by termination in mid-June. Two species of oat were evaluated; Cosaque winter oat and Soil Saver black oat. Both varieties appeared vigorous enough to provide weed control though this was not directly measured. Soil Saver oat winter killed, while Cosaque survived, though survival was sporadic and plot dependent. All cereal rye varieties planted came up well and provided visible weed control. Rye varieties FL 401 and Merced had 100% winter kill, and Wrens Abruzzi largely winter killed with only a few surviving plants. Radish varieties all winter killed in 2016-17 but had good establishment which provided noticeable weed control. One exception was Graza radish, which received an average of 0.00 on the 0-3 scale for germination, indicating fewer than 25% of the Graza seeds germinated. The information gained from this trial can serve as a resource to help make an educated variety selection, reducing the risks associated with incorporating cover crops into a management plan.

Pickett, T. and D. Tilley. 2019. Cover crop variety trial, 2016-2017.

Figure 1. Taken August 25, 2016 planting 2016-17 cover crop trial.

INTRODUCTION

Incorporating cover crops into a cropping system improves soil health, conserves energy, and builds resilience and manages climate risk (Lal, 2004; Reicosky and Forcella, 1998; Hargrove, 1986; Reeves, 1994). Cover crops can be leguminous or non-leguminous. Leguminous cover crop species provide a nitrogen source for subsequent commodity crops (Singh et al., 2004; Smith et al., 1987), while non-leguminous cover crops, such as small grains, are effective at reducing nitrate leaching and for soil erosion (Meisinger et al., 1991). Utilizing a mix of leguminous and non-leguminous cover crop species can provide multiple benefits. Cover crops can bring soil available nutrients into their physical makeup over their life cycle, nutrients will then be released as the plant breaks down to work as a slow release fertilizer for the following crop. While cover crops provide numerous agronomic and environmental benefits, these benefits are not fully achieved unless cover crop varieties/cultivars are planted that meet the objective of the cover crop planting and the producer's expectations.

There has been a substantial amount of information discovered through trials from growers and research institutions regarding different species of cover crops. This trial however was specifically designed to identify varieties of those species that are best suited for use in irrigated farming systems in the geographic coverage area of the Aberdeen Idaho Plant Materials Center.

MATERIALS AND METHODS

The 2016-17 cover crop variety trial was planted using a Randomized Complete Block Design with 4 replications. Species included hairy vetch, pea, balansa clover, crimson clover, red clover, oat, cereal rye and radish (Table 1). Soil is a Declo silt loam; a soil test was taken, and a granular fertilizer was broadcast before seeding on August 19th at a recommended rate of 80-50-30-50 units and incorporated with irrigation. Plots were planted on August 25th using a modified Tye Pasture pleaser drill (The Tye Company, Lockney, TX) with 7 planters spaced at 10 in centers in a 20-foot-long plot. This date would be a typical planting window for a common row crop rotation in the Aberdeen area. Soil temperatures at the time of the planting were in the 70-90° F range. Plots were irrigated as needed receiving a total of 10 in of supplemental irrigation. Plots received 2 in of irrigation water on August 26 th, August 29 th, September 6 th, September 9 th, and September 13th. Legume seeds were inoculated with species unique rhizobium (Figure 2). Seeds were wetted using sweet and condensed milk diluted in water, rhizobium was added to the wetted seed in a small can, agitated and spread on paper to dry. Seeding rates are shown in (Table 2).

Table 1. Species and varieties tested in 2016-2017 cover crop trial.

Species	Varieties
Hairy vetch	CCS Groff, Lana, Purple Bounty, Purple Prosperity, TNT, Valana
Pea	Arvica 4010†, Dunn†, Frost Master, Lynx, Maxum†, Survivor 15, Whistler, Windham
Balansa clover	Fixation, Frontier
Crimson clover	AU Robin, AU Sunrise, AU Sunup, Contea, Dixie, Kentucky Pride
Red clover	Cinnamon Plus, Cyclone II, Dynamite, Freedom, Kenland, Mammoth, Starfire II, Wildcat
Oat	Cosaque black hulled oat (*Avena sativa*), Soil Saver black oat (*Avena strigosa*)
Cereal rye	Aroostook, Bates, Brasetto, Elbon, FL 401, Guardian, Hazlet, Maton, Maton II, Merced, Oklon, Prima, Rymin, Wheeler, Wintergrazer, Wrens Abruzzi
Radish	Big Dog, Concord††, Control††, Defender††, Driller, Ecotill, Graza, Groundhog, Lunch, Nitro, Sodbuster, Tillage

†Spring pea varieties (winter varieties not marked).
††Known to be effective as a trap crop to control nematode species of both Columbia root knot and sugar beet cyst nematode.

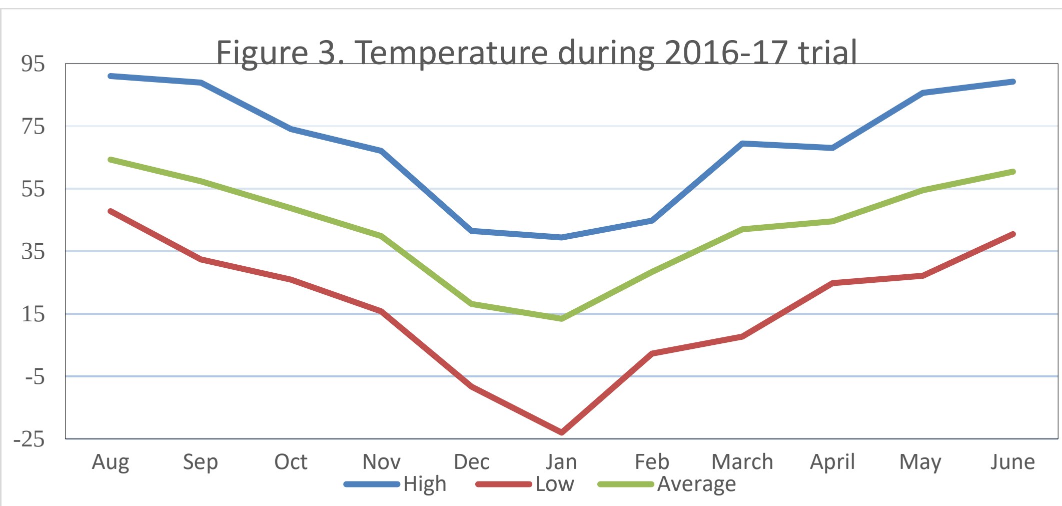
The plots were evaluated for six growth characteristics: 1) germination/field emergence, 2) beginning of spring regrowth, 3) bloom and flowering period, 4) plant height, 5) disease and insect resistance, and 6) winter hardiness. Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination). Beginning of regrowth was recorded when the cover crop began active growth in the spring for each variety of cover crop and calculated to DAP. Winter hardiness was measured by counting the number of live seedlings in a marked 1 m section of row at 28 DAP in 2016 and again at 2 to 3 weeks after spring regrowth in 2017. To determine the 50% bloom/anthesis date, the cover crop was observed as the flowering period progressed. The estimate of 50% bloom or anthesis was determined as halfway between start of bloom and peak bloom. Measurements were made when the cover crops reached 50% bloom/anthesis. Plant height was measured by taking three random measurements at the top of the foliage from within each replicated plot. Blooms or inflorescences were not included when making height measurements. Disease and insect resistance were visual estimations of the resistance of the cover crop to foliar diseases and insect damage. Two evaluations were taken: 1) within 2-3 weeks of the recorded date for the beginning of regrowth, and 2) at recorded date for 50% bloom/anthesis. Disease and insect resistance were rated on an ordinal scale from 0 to 5: 0 = no damage, 1= slight, 3= moderate, and 5 = severe damage. Data were analyzed with a one-way analysis of variance with an alpha of 0.05 to determine significance. Means were then separated using a LSD (least significant difference) test. All statistical analyses were performed using Statistix 10 Analytical Software (Analytical Software, Tallahassee, Florida). In cases where some, but not all, varieties of a species winter killed completely, those varieties were omitted from statistical analysis for the spring-summer growing season.

Table 2. Target seeding rate for each species.

Species	PLS Seeds/ft
Hairy vetch	7
Pea	5
Balansa clover	57
Crimson clover	62
Red clover	56
Oat	42
Cereal rye	37
Radish	5

Figure 2. Legume innoculation.

Temperatures during the trial approached the 90s in late August at planting and again in June of the second growing season. The lowest temperature recorded during the trial was -23°F in January (Figure 3). The first frost occurred on October 7th . Growing degree days for 2016 were 687 measured from planting until December 1st.



Weather data taken from the, United States Bureau of Reclamation, Pacific Northwest Region, AgriMet website. https://www.usbr.gov/pn/agrimet/webarcread.html

RESULTS AND DISCUSSION

Legumes

Table 3. Mean separation for 28 day germination score, winter survival, height and 50% bloom date for six hairy vetch varieties. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1]	Survival	HT	50% bloom
	(28 DAP)	(%)	(CM)	(Date)
Groff	1.75	81	100	6/8/17
Lana	2.50	WK[2]	WK	WK
Purple Bounty	1.75	94	100	6/7/17
Purple Prosperity	1.75	89	98	6/8/17
TNT	1.50	91	97	6/8/17
Valana	2.00	91	95	6/8/17
Mean	1.88	89	98	N/A
LSD $_{(0.05)}$[3]	NS[4]	NS	NS	N/A

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Winter kill.
[3]Least significant difference.
[4] Not significant.

Figure 3. hairy vetch inflorescence at full bloom.

No significant differences were detected among hairy vetch accessions for germination or height (Table 3). Lana winter killed in 2016 but all other varieties survived. When Lana was removed from the analysis, there were no significant differences detected among the remaining accessions for % survival. It should be noted that Lana vetch belongs to the woolypod hairy vetch subspecies *varia*, while the remaining varieties are true hairy vetch of the subspecies *villosa*, which may account for the lack of winter hardiness. Germination was fair in all accessions, ranging from 1.5 to 2.5 on the 0 to 3 scale. Hairy vetch seedlings began spindly and inconspicuous but improved quickly under the favorable conditions at Aberdeen. Plant height of hairy vetch was difficult to measure due to high weed pressure which supported the upward growth of hairy vetch causing it to measure higher than it would have without support. This weed support caused the average to be around 98 cm in height. Hairy vetch did not show signs of disease or insect damage on any variety (data not shown).

Figure 4. A 2017 photo showing tansy mustard in hairy vetch plots.

Table 4. Mean separation for 28 day germination score and winter survival, for eight pea varieties. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1] (28 DAP)	Survival (%)
Arvica 4010	2.50a[2]	WK[3]
Dunn	2.00ab	WK
Frost Master	0.25c	31ab
Lynx	0.25c	27b
Maxum	1.75b	WK
Survivor 15	2.50a	66a
Whistler	1.75b	13b
Windham	1.75b	10b
Mean	1.60	29
LSD $_{(0.05)}$[4]	0.75	37

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Means in columns followed by the same letters are not significantly different at *P*<0.05.
[3]Winter kill.
[4]Least significant difference.

Figure 5. Survivor 15 winter pea taken June 19, 2017.

Significant differences were detected among pea accessions for germination and percent survival. Frost Master and Lynx (both winter pea varieties) received the lowest germination scores averaging only 0.25 on the 0 to 3 scale. Spring pea varieties Arvica 4010, Dunn and Maxum received scores of 2.50, 2.00 and 1.75 respectively on the 0 to 3 scale. The spring varieties grew tall and appeared to produce more biomass than the winter type before they winter killed, though biomass was not measured. The plots experienced high weed pressure through both growing seasons. Survivor 15 winter pea was the only variety to survive through final evaluation in all four plots, therefore it was the only variety to be evaluated for height and bloom time. Survivor 15 had a mean height of 66 cm and bloom date at 50% bloom of June 15, 2017. A small amount of fungal disease was observed on all the pea varieties in the fall of 2016, but it looked to be affecting each variety minimally (data not shown).

Figure 6. Taken October 6, 2016 showing the difference in the taller spring varieties compared to the more compact winter varieties of pea.

Table 5. Mean separation for 28 day germination score, winter survival, height and 50% bloom date for two balansa clover varieties. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1] (28 DAP)	Survival (%)	HT (CM)	50% bloom (Date)
Fixation	2.75	83	44a[2]	6/7/17
Frontier	1.75	52	8b	5/30/17
Mean	2.25	68	26	N/A
LSD $_{(0.05)}$[3]	NS[4]	NS	11	N/A

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Means in columns followed by the same letters are not significantly different at P<0.05.
[3]Least significant difference.
[4]Not significant.

No significant differences were detected among balansa clover accessions for germination and survival. Germination was fair in both accessions averaging 2.75 and 1.75 on the 0 to 3 scale. Frontier balansa clover bloomed 8 days earlier than Fixation. Where these two varieties differed greatly was in the height of the plants at 50% bloom. Fixation averaged 44 cm while Frontier plants only averaged 8 cm in height. Neither variety of balansa clover showed signs of disease or insect damage (data not shown).

Figure 7. Balansa clover, Fixation left and Frontier right.

Table 6. Mean separation for 28 day germination score, winter survival, height and 50% bloom date for six crimson clover varieties. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1] (28 DAP)	Survival (%)	HT (CM)	50% bloom (Date)
AU Robin	2.50ab[2]	56b	32cd	5/30/17
AU Sunrise	3.00a	75ab	39a-c	5/30/17
AU Sunup	1.75c	42b	27d	5/30/17
Contea	1.75c	43b	33b-d	5/30/17
Dixie	3.00a	73ab	43a	5/30/17
Kentucky Pride	2.25bc	98a	41ab	6/1/17
Mean	2.38	65	36	N/A
LSD $_{(0.05)}$[3]	0.65	37	8	N/A

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Means in columns followed by the same letters are not significantly different at $P<0.05$.
[3]Least significant difference.

Significant differences were detected among crimson clover accessions for germination, percent survival and height. AU sunup and Contea received the lowest scores for all measurable traits with an average germination rating of 1.75 and % survival ratings of 42 and 43 respectively. Kentucky Pride had the highest average winter survival (98%) and differed significantly from AU Robin, AU Sunup and Contea which had survival averages of 56, 42 and 43% respectively. Heights ranged from 27 cm (AU Sunup) to 43 cm (Dixie). Dates to 50% bloom were uniform. Crimson clover did not show signs of disease or insect damage on any variety (data not shown).

Figure 8. Crimson clover where melted snow caused pooling, suspected to kill clover.

Table 7. Mean separation for 28 day germination score, winter survival, height and 50% bloom date for eight red clover varieties. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1] (28 DAP)	Survival (%)	HT (CM)	50% bloom (Date)
Cinnamon Plus	2.00bc[2]	98ab	47	6/15/17
Cyclone II	2.75a	98ab	37	6/15/17
Dynamite	2.50ab	99ab	38	6/15/17
Freedom	2.25ab	100a	37	6/15/17
Kenland	1.50cd	100a	41	6/15/17
Mammoth	1.00d	94b	34	NB[3]
Starfire II	1.50cd	98ab	41	6/15/17
Wildcat	2.50ab	99ab	41	6/15/17
Mean	2.00	98	40	N/A
LSD $_{(0.05)}$[4]	0.69	5	NS[5]	N/A

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Means in columns followed by the same letters are not significantly different at $P<0.05$
[3]No bloom by termination.
[4]Least significant difference.
[5] Not significant.

Red clover was the only short-lived perennial in the trial. As with balansa clover and crimson clover, all varieties survived the winter, which was an expected outcome based on literature recommendations. Significant differences were detected among red clover accessions for germination and percent survival. Cyclone II, Dynamite, Wildcat and Freedom had the best germination with scores of 2.75, 2.50, 2.50 and 2.25 respectively; however, survival percentages through the winter were high in all varieties ranging from a low of 94% to a high of 100%. Mammoth received the lowest scores in all evaluations and had not bloomed by termination mid-June. Red clover did not show signs of disease or insect damage (data not shown).

Figure 9. Honey bee visiting a red clover flower.

Annual Grasses

A single variety of two species of oat was evaluated, Cosaque black hulled oat (*Avena sativa*) and Soil Saver black oat (*Avena strigosa*). Oat is the least winter hardy of the four common small grain species, and black oat is especially known for low tolerance to cold temperatures. Germination was good for both oat varieties in our trial. Cosaque scored 2.75 while Soil Saver scored 2.00 on the scale of 0 to 3, these scores showed no significant difference at 28 DAP. Soil Saver did winter kill while Cosaque showed 50% survival. Cosaque had a mean height of 55 cm and bloom date at 50% bloom of June 12, 2017. Neither oat varieties showed signs of disease or insect damage (data not shown).

Figure 10. Taken March 23, 2017 Cosaque oat beginning regrowth compared to Soil saver which winter killed.

Table 8. Mean separation for 28 day germination score, winter survival, height and 50% bloom date for sixteen cereal rye varieties. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1]	Survival	HT	50% bloom
	(28 DAP)	(%)	(CM)	(Date)
Aroostook	3.00a[2]	52ef	99ef	6/5/17
Bates	3.00a	20gh	112cde	6/5/17
Brasetto	2.25c	92ab	107cde	6/5/17
Elbon	3.00a	72cd	88f	6/5/17
FL 401	2.25c	WK[3]	WK	WK
Guardian	1.00d	81a-d	136a	6/3/17
Hazlet	NSA[4]	90a-c	117b-d	6/4/17
Maton	3.00a	70de	98ef	6/5/17
Maton II	2.25c	52ef	107c-e	6/3/17
Merced	2.75ab	WK	WK	WK
Oklon	3.00a	74b-d	107c-e	6/3/17
Prima	2.50bc	95a	118bc	6/3/17
Rymin	NSA	NSA	NSA	6/3/17
Wheeler	2.25c	81a-d	132ab	6/7/17
Wintergrazer	3.00a	37fg	107c-e	6/5/17
Wrens Abruzzi	3.00a	5h	102d-f	6/5/17
Mean	2.59	63	110	N/A
LSD $_{(0.05)}$[5]	0.47	18	17	N/A

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Means in columns followed by the same letters are not significantly different at P<0.05.
[3]Winter kill.
[4]No seed available at time of original planting. Hazlet was planted one week later so fall data was taken on week later than the other varieties. Due to the late planting date (9/25/16) of Rymin only bloom date was recorded.
[5]Least significant difference.

Significant differences were detected among cereal rye accessions for germination, percent survival and height. Guardian received the lowest evaluated germination score of 1.00 while there were seven varieties with scores of 3.00 on our 0 to 3 scale. Wrens Abruzzi, Wintergrazer, and Bates suffered greater than 50% winter losses. Heights varied significantly ranging from 88 cm (Elbon) to 136 cm (Guardian). 50% bloom dates were uniform and only varied by 1 or 2 days. Cereal rye varieties did not show signs of disease or insect damage (data not shown).

Brassicas

Table 9. Mean separation for 28 day germination score. USDA-NRCS, Aberdeen, ID, 2016-17.

	Germ[1] (28 DAP)
Big Dog	2.50ab[2]
Concord	2.50ab
Control	1.75bc
Defender	2.50ab
Driller	2.50ab
Ecotill	2.25a-c
Graza	0.00d
Groundhog	2.25a-c
Lunch	1.75bc
Nitro	2.50ab
Sodbuster	1.50c
Tilliage	2.75a
Mean	2.06
LSD $_{(0.05)}$[3]	0.76

[1]Germination/field emergence was evaluated at 7, 14, 21 and 28 days after planting (DAP) on a scale based on visual determination: 0 = poor (<25% germination), 1 = moderate (30-60% germination), 2 = good (65-85% germination), 3 = excellent (90-100% germination).
[2]Means in columns followed by the same letters are not significantly different at *P*<0.05.
[3]Least significant difference.

Photo taken in October 2016.

Photo taken in March 2017.

Figure 11. Weed control of radish, middle plot in this photo is Graza.

The first frost of the trial occurred on October 7, however the radishes kept growing until late November. For radish, height, winter survival and 50% bloom date were not recorded due to uniform winter kill leaving no live plants the following season. Significant differences were detected among radish accessions for percent germination. Radish varieties ranged in germination from 0.00 (Graza) to 2.75 (Tillage) on the 0-3 scale. Except for Graza, all of the radish varieties appeared to provide strong weed control of winter annuals from the large amount of above-ground biomass produced. Weeds were controlled even in the areas where areas of radish were removed for biomass measurements in mid-November after radish quit growth (Figure 11).

CONCLUSIONS

Conducting this trial revealed notable differences within varieties of each species. Some differences contribute more relevance in making decisions on which varieties to select than others. The objective of the decision maker will determine which differences are desirable to their goals.

Hairy vetch seedlings are inconspicuous and seemed slow to start in our trial, but seedlings that did over winter were hardy, appearing to have grown even during winter. This lack of complete dormancy allowed the seedlings to begin growing quickly in the spring. As noted previously, Lana hairy vetch is of a different subspecies than the other varieties tested. Lana was released for its early maturation and intended for use in the warmer climates of central California. It is also known for its high percentage of hard seed, which has led to it becoming a weed issue where it has escaped cultivation.

It was soon clear that the pea varieties were of two types, winter and spring. Winter varieties grew shorter with a lot of tendrils while spring varieties were taller and less tendrilled. Spring pea varieties all winter killed leaving a mulch, which appeared to suppress a few winter annual weeds in the fall, but this was short lived as weeds were able to grow well in early spring. Survivor 15 winter pea was the only variety of pea that survived in all four plots, and therefore the only one to have a complete data set recorded for 2016-17. Based on these results Survivor 15 appears best adapted for use in the Aberdeen PMC service area.

Visually the two balansa clover varieties looked to be very different throughout the trail. Statistically the two varieties did not show significant differences for the traits of germination and winter survival, likely due to significant variations recorded within each variety for the same trait. Germination scores for Fixation and Frontier were 2.75 and 1.75 respectfully, and winter survival scores for Fixation and Frontier were 83% and 52% respectfully. Fixation was significantly taller than Frontier at maturity and produced visibly more biomass. However, Frontier bloomed earlier than Fixation did. Both varieties surprisingly survived the 2016-17 winter where temperatures dipped down to -23°F in January, while anecdotal evidence previously indicated survival down to 5° F. It is possible that snow cover provided enough insulation to allow the plants to persist at lower temperatures than anticipated. Greater height at maturity (and more biomass) would likely be beneficial traits in the high-density environment of cover crop mixes where maximum production is desired.

The differences in measured characteristics for crimson clover were visually noticeable. AU Sunup and Contea appeared less vigorous when compared to the other varieties. Of the three clovers in the trial, crimson clover seemed to attract the most bees. AU Sunrise, Dixie and Kentucky Pride had similar ratings for establishment, % survival and plant height and indicated a high degree of adaptation to site conditions at Aberdeen.

All varieties of red clover grew well and survived the winter. Mammoth was the only variety that hadn’t flowered by mid-June at termination which may be a factor if a grower is looking to add pollinator benefits to the cover crop mixture, or a later blooming red clover for longer cover. Cyclone II, Dynamite, Freedom and Wildcat all had high levels of germination. Winter survival and plant height varied little among accessions.

The oat varieties were of two kinds, Soil Saver, a black oat variety and Cosaque winter oat. Cosaque is a wide leafed variety with good growth and fair winter survival while Soil Saver has narrower leaves, but it was taller than Cosaque before it winter killed. Even though Soil Saver died, and Cosaque partially survived, both varieties appeared to suppress winter annuals. The difference in winter survivability should be the main factor considered for managers to choose among these varieties.

Sixteen cereal rye varieties were evaluated. Seven of the 16 evaluated varieties had excellent germination (Aroostook, Bates, Elbon, Maton, Oklon, Wintergrazer and Wrens Abruzzi); however, these seven received among the lowest winter survival percentages. Each variety appeared to do a good job controlling winter annuals, including those varieties that winter killed. Brasetto was not tall but was very uniform in height. Guardian had the most impressive tillering ability, and even though it had a low germination score it quickly looked as dense as other plots. Wheeler and Guardian were amongst the tallest varieties with average heights of 132 and 136 cm respectively. Cereal rye varieties FL 401 and Merced both completely winter killed in our trial indicating low tolerance to cold winter conditions. Managers will need to consider management priorities carefully. Winter kill may be a beneficial trait for those concerned with rye becoming a weed issue, while those looking for greater biomass production and suppression of spring weeds might consider a more winter-hardy variety.

All radish varieties uniformly winter killed. Graza established poorly, while all other varieties of radish showed good to fair germination and quickly covered the soil and made a noticeable difference in controlling winter annuals. Varieties Concord, Control and Defender are known to be effective as a trap crop to control nematode species of both Columbia root knot and sugar beet cyst nematode. This may be the most important factor for choosing a radish variety depending on whether the cover crop is intended for use to control nematodes or for other attributes.

With these results it is possible to select either a single variety or a combination of varieties of oat, pea, radish and rye that will winter kill yet still provide noticeable weed control, an opportunity for grazing, and increased plant diversity. Based on observations following biomass clippings, radish can be harvested to the ground after the growing season but pre-winter, and still provide noticeable control of winter annuals. Although other trials have shown that clovers are slow to establish, we learned which will perform best in our environment, including later flowering varieties. There may even be a benefit to varieties that had low height measurements, such as Frontier balansa clover. A low-growing living mulch of clover to fix nitrogen but not out-compete the intended crop could be useful in certain rotations.

Winter kill, or winter hardiness, can be an important factor depending on the intended use. It may in some cases be beneficial for the cover crop to completely winter kill and facilitate early spring planting of the following crop, while in other cases it may be desirable for the cover crop to persist and produce more biomass through the spring and summer. Varieties to potentially avoid simply from a management standpoint would be those that had partial, but not complete, winter kill.

Growing cover crops costs money in the forms of seed, fuel, water, time and termination, just to name a few. One of the largest costs may not be the most obvious, education, which should be a major consideration in production economics and needs to be considered as part of the sustainability of any farming operation. Cover crops have been a major focus in the recent past for a variety of different reasons, each reason as unique as the specific resource concern being addressed. Plants are a product of their genetics and environment and it is quite impossible to mimic each growing condition that these varieties will be grown under and for what purpose. What has been discovered with all the trials conducted to understand the complex relationships between the physical and biological properties of soil is that a soil void of plants is in a state of degradation and instability. Success using cover crops earlier in the transition process has the potential to increase cover crop adoption. Actively growing plants equates to actively building soil health. Choosing the best adapted variety of each species of cover crop can augment the use of cover crops and thus accelerate soil health.

LITERATURE CITED

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