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Effect of two different forage collards in the same cover crop mix and seeding rate on stand establishment and biomass production for weed suppression and forage quantity and quality

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ABSTRACT

Two cool season cover crop mixtures and three different seeding rates were studied for weed suppression, and forage quantity and quality at the USDA Natural Resource Conservation Service Plant Materials Center in Bridger, Montana from 2022 to 2023. Testing of various cover crops was requested by Montana and Wyoming USDA NRCS field staff via the Montana Plant Materials Program Needs Assessment. Treatments were two cover crop mixes including ‘Impact forage’ collard or ‘Bayou’ kale (*Brassica oleracea* L.) and ‘Lavina’ barley (*Hordeum vulgare* L.), ‘4010’ pea (*Pisum sativum* L.), ‘Baldy’ safflower (*Carthamus tinctorius* L.), ‘Surge’ triticale (x

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Triticosecale W.), and 'Purple Top' turnip (*Brassica juncea* L.) and three different seeding rates: 100%, 80%, and 60%. Impact forage collard was the control and Bayou kale was the cover crop tested. Dryland plantings were seeded in a randomized complete block design with four replications in Spring 2022 and Spring 2023. Data collection occurred when triticale reached the boot stage. Plant density (plants per linear foot) was recorded and categorized into three groups: 1) Collard or kale, 2) the remaining species in the mix, and 3) weeds. Categorized plants were clipped at ground level, dried and weighed for aboveground biomass measurements (lbs/acre). Data was analyzed using an ANOVA model. Years were analyzed separately. In addition, each mix with each seeding rate and every single species was planted alongside the study plots for forage analysis. This study found Bayou kale can replace Impact forage collard for the mix and achieve the same density and biomass measurements. All seeding rates produced the same density and biomass measurements. For weed suppression, 80% or 60% seeding rates are recommended due to statistically significant differences in weed biomass using 100% seeding rate in 2022, but there was no statistical difference in 2023. Forage quality was good for the mixes and single species.

INTRODUCTION

Cover crop mixes are intended to diversify and prolong monoculture cover crop benefits by keeping soil covered, suppressing weeds, retaining moisture, providing supplemental forage for livestock, and extending soil nutrients for the cash crop (Franco et al., 2021; Coblentz et al., 2018; Osipitan et al., 2018; Wortman et al., 2012; Brennan et al., 2009). Designing mixes by incorporating various functional groups, i.e. grasses, legumes, broadleaves, and specific plant families, is one effective way to achieve diversity (Miller et al., 2023; Florence et al., 2019; Khan and McVay, 2019). One functional group that is often pursued is the Brassicaceae family due to its allelochemicals that contribute to weed suppression (Mennan et al., 2020; Haramoto & Gallandt, 2005).

Early spring is a critical time for weed control in the Intermountain West. Winter snowmelt, early spring rains, and air and soil temperatures beginning to rise lead to cool season species seed germination. Without desired species' seed in the seedbank, these environmental conditions lead to weed seed germination, establishment, and the need for weed control early in the growing season in agricultural systems (Osipitan et al., 2018). Utilizing early, cool season cover crops is one weed suppression strategy (Douglas et al., 2023; Brennan & Smith, 2005). Choosing cool season cover crops with high nutritional value not only reduces early season weed establishment, but can also provide quality feed for livestock (Obour et al., 2022; Osipitan et al., 2018; Rao & Horn, 1986).

Cover crop seeding rate studies compare rates to biomass production or test species mix proportion with production and competition (Bybee-Finley et al., 2022; Scianna et al., 2022; Baraibar et al., 2018). In some studies, cover crop biomass production was the same at 100%, 75% and 50% seeding rates, depending on crop, variety, and location (Douglas et al., 2023; Scianna et al., 2022). This has led to reduced cover crop seeding rates in conservation applications while achieving the desired results (Scianna et al., 2022; Young-Mathews, 2017). The objective of this study is to determine the effect of two different Brassicaceae family species on the same cover crop mix and to examine seeding rate effects on stand establishment and biomass production for weed suppression and forage quantity and quality.

MATERIALS AND METHODS

This dryland study was conducted in 2022 and 2023 at the USDA Natural Resources Conservation Service, Plant Materials Center in Bridger, Montana (45º17'12.7", 108º53'9.7") in a Heldt silty clay loam soil (USDA, NRCS, 2023) and Major Land Resources Area 58A. It was seeded in different fields each year to avoid seed contamination from the previous year. Sites were fallow prior to study seeding and were visually inspected for weeds. No weed control was employed before or during the study.

Baseline soil samples were collected in 2022 and 2023 prior to seeding. Composite samples were collected at 0-6" and 6-24" depths and analyzed for Nitrate (N), Phosphorous (P), and Potassium (K) by Agvise Laboratories in North Dakota. In both years, N was 132-134 lbs/acre, P was 12-15 ppm, and K was 246-252 ppm, which was interpreted as high by the laboratory. Fertilizer was not applied during the study.

The experimental design was a randomized complete block design with four replications. Each block consisted of six plots that were 25 feet by 9 feet. Treatments were two cover crop mixes including 'Impact forage' collard or 'Bayou' kale and 'Lavina' barley, '4010' pea, 'Baldy' safflower, 'Surge' triticale, and 'Purple Top' turnip and three different seeding rates: 100%, 80%, and 60% (Table 1). 'Impact forage' collard was the control and 'Bayou' kale was the crop tested.

Table 1. Crop species, variety, percent of full stand rate for mix composition, and percent of full seeding rate: 100%, 80%, and 60% seeding rates (PLS lbs/acre), 2022 and 2023.

Crop species	Variety	Percent of Full Stand Rate (%)	Seeding Rate (PLS lbs/ac)		
			100%	80%	60%
Collard	Impact forage	13	0.75	0.6	0.45
Kale	Bayou	13	0.75	0.6	0.45
Barley	Lavina	2	1	0.8	0.6
Pea	4010	25	38	30.4	22.8
Safflower	Baldy	25	7.5	6	4.5
Triticale	Surge	23	14	11.2	8.4
Turnip	Purple Top	13	0.75	0.6	0.45

Seeding occurred on March 31, 2022 and April 12, 2023 using a four-row, precision cone-seeder (Kincaid Equipment Manufacturing®, Haven, KS) equipped with double disk furrow openers, 3/4" depth bands, and double packer wheels. Eight rows were seeded per plot with 14-inch between-row spacing.

Adjacent to the study plots in both years, monocultures of each species were planted with the cone-seeder to use for forage quality analysis. Four rows were seeded per species with 14-inch between-row spacing and 25 feet length (i.e. 5 x 25 ft plots). Monoculture seeding depths varied and are reflected in Table 2. Biomass collection for forage analysis occurred when grasses (barley and triticale) were at the boot stage (when seedhead swells in flag leaf sheath), broadleaves (pea and safflower) were at 50% bloom, and brassicas (collard, kale, and turnip) were approximately 12 inches high (Table 2). Collected biomass was sent to Midwest Laboratories in Omaha, Nebraska for forage analysis.

Table 2. The 2022 and 2023 seeding depth of single species and biomass collection date for forage quality analysis.

Crop species	Variety	Seeding depth (inches)	Forage quality biomass collection date (2022)	Forage quality biomass collection date (2023)
Collard	Impact forage	0.5	6/16	6/15
Kale	Bayou	0.5	6/9	6/15
Barley	Lavina	1.5	6/16	6/15
Pea	4010	2.0	6/23	6/15
Safflower	Baldy	1.25	7/21	7/24
Triticale	Surge	1.5	6/23	6/21
Turnip	Purple Top	0.5	6/16	6/15

Total annual precipitation in 2022 was approximately 12 inches. During the study period, from March 31 to June 23 in 2022, there was nearly 7 inches of precipitation. Annual 2023 precipitation was approximately 14 inches, with 6 inches falling during the study period, from April 12 to June 28 (NOAA, 2023).

Data collection occurred in the study plots from June 22 to June 23, 2022, and June 22 to June 27, 2024 when triticale reached boot stage. Data was collected from three randomly chosen drill rows per plot, excluding border rows. Three-foot sections along drill rows were randomly selected for sampling. Along the three-foot drill row, number of plants (density) were counted and recorded in three groups: 1) Collard or kale, 2) the remaining species in the mix, and 3) weeds. Then plants were clipped at ground level, divided in the three groups, stored separately, then dried at 50°C for 5 days in a forced air oven (VWR Scientific Products 1390 FM), and weighed (kg).

Statistical analysis was performed with Statistix software (Statistix 10, Tallahasee, FL) using an analysis of variance (ANOVA) for means separation. All pairwise comparisons were conducted using Tukey's Honestly Significant Difference (HSD), with $P \leq 0.05$. Years were analyzed separately.

RESULTS AND DISCUSSION

In 2022, collard and kale mixes without weeds and at all three seeding rates had no statistical difference in density (plants/linear foot) or biomass (lbs/acre) (Table 3). Although it was not significant, collard had more plants per linear foot than kale with the 100% seeding rate, but not with the 80% or 60% seeding rates. Collard density was almost identical with the 80% (6.5 plants/linear foot) and 60% (6.6 plants/linear foot) seeding rates. Kale mix density for the 80% and 60% seeding rates followed a similar trend and were alike with 7.9 and 7.7 plants/linear foot, respectively. Kale mix biomass trended higher than the collard mix among all seeding rates.

Similarly in 2023, there was no statistical difference in density or biomass between the collard mix and kale mix among seeding rates (Table 4). The collard mix trended higher in density than the kale mix among each seeding rate. Collard mix density was similar in the 100% (9.7 plants/linear foot) and 80% (9.8 plants/linear foot) seeding rates. The kale mix veered higher in biomass than collard in the 100% and 60% seeding rates, but not with the 80% seeding rate.

Table 3. Collard and kale mix density (plants/linear foot) and biomass (lbs/acre), by seeding rate used (100%, 80%, or 60%) for 2022.

	Seeding Rate		
Measurement	100%	80%	60%
Density (plants/linear foot)			
Collard	10.8 A[1]	6.5 A	6.6 A
Kale	9.0 A	7.9 A	7.7 A
Biomass (lbs/acre)			
Collard	2067 A	1866 A	1523 A
Kale	2084 A	2022 A	2004 A

[1]Means in table followed by different letters in each column are significantly different according to Tukey's HSD at $P<0.05$.

Table 4. Collard and kale mix density (plants/linear foot) and biomass (lbs/acre), by seeding rate used (100%, 80%, or 60%) for 2023.

	Seeding Rate		
Measurement	100%	80%	60%
Density (plants/linear foot)			
Collard	9.7 A[1]	9.8 A	6.6 A
Kale	7.7 A	6.7 A	6.2 A
Biomass (lbs/acre)			
Collard	2180 A	2039 A	1648 A
Kale	2246 A	1666 A	1961 A

[1]Means in table followed by different letters in each column are significantly different according to Tukey's HSD at $P<0.05$.

Since statistically significant differences were not detected between collard and kale densities or biomass production, these cover crops can likely be used interchangeably in the tested mix. Similarly, since reduced seeding rates produced similar densities and biomass as the full rate, a producer opting for a reduced seeding rate could expect to get similar results as if using 100% seeding rate for these mixes.

On-site weed presence included cheatgrass (*Bromus tectorum* L.), common mallow (*Malva neglecta* Wallr.), common purselane (*Portulaca oleracea* L.), field bindweed (*Convolvulus arvensis* L.), kochia (*Bassia scoparia* [L.] A.J. Scott), prickly lettuce (*Lactuca serriola* L.), prostrate pigweed (*Amaranthus albus* L.), redroot pigweed (*Amaranthus retroflexus* L.), tall tumblemustard (*Sisymbrium altissimum* L.), western salsify (*Tragopogon dubius* Scop.), and witchgrass (*Panicum capillare* L.) in 2022 and 2023. There was no statistical difference in weed density in 2022 in the collard and kale mixes and among all seeding rates (Table 5). Weed density was slightly higher in the collard mix with 100% and 80% seedings rates (11.5 and 10.6 weeds per linear foot, respectively) compared to the 60% seeding rate where the kale mix had more weeds than the collard mix (11.7 weeds per linear foot).

There was a significant difference in 2022 weed biomass between the collard and kale mixes in the 100% seeding rate (Table 5). The 100% rate had almost six times the weed biomass in the collard mix (780 lbs/acre) than the kale mix (132 lbs/acre), despite weed density being statistically similar. The collard mix weed biomass was also higher than the kale mix in the 80% and 60% rates, though it was not statistically different (Table 5).

Table 5. Collard and kale mix weed density (weeds/linear foot) and biomass (lbs/acre) by seeding rate (100%, 80%, or 60%) for 2022.

	Seeding Rate		
Measurement	100%	80%	60%
Weed Density (weeds/linear foot)			
Collard weeds	11.5 A	10.6 A	8.4 A
Kale weeds	10.3 A	8.0 A	11.7 A
Biomass (lbs/acre)			
Collard weeds	780 A	479 A	621 A
Kale weeds	132 B	281 A	389 A

[1]Means in table followed by different letters in each column are significantly different according to Tukey's HSD at P<0.05.

Table 6. Collard and kale mix weed density (weeds/linear foot) and biomass (lbs/acre) by seeding rate (100%, 80%, or 60%) for 2023.

	Seeding Rate		
Measurement	100%	80%	60%
Weed Density (weeds/linear foot)			
Collard weeds	9.2 B	17.1 A	30.3 A
Kale weeds	35.1 A	20.3 A	24.6 A
Biomass (lbs/acre)			
Collard weeds	128 A	170 A	318 A
Kale weeds	133 A	311 A	566 A

[1]Means in table followed by different letters in each column are significantly different according to Tukey's HSD at P<0.05.

In 2023 there was a statistical difference in weed density at the 100% seeding rate (Table 6). The collard mix had significantly less weeds than the kale mix (9.2 and 35.1 weeds per linear foot, respectively). This difference was not reflected in weed biomass however, as both mixes had the same biomass statistically (128 and 133 lbs/acre). Within the study site, small, young kochia weeds were growing in the understory of the mature mix crops. This could have contributed to the weed density disparity in 2023. Weed biomass was statistically the same between mixes and across seeding rates though the kale mix had slightly higher biomass.

Forage analysis and quality were a component of this study. Factors affecting forage quality include the type of species: legumes or grasses, cool season or warm season species, air temperature, plant maturity stage, leaf-to-stem ratio, nitrogen fertilization, harvesting and storage effects (Ball et al., 2001). Crude protein (CP), Neutral Detergent Fiber (NDF), Relative Feed Value (RFV), Nitrates, and Total Digestible Nutrients (TDN) for each mix and seeding rate, and single species are presented in Table 7. Crude protein is the total amount of protein in biomass and determines hay quality, yet it varies among feeds (University of Idaho Extension, 2005). Higher protein is considered higher quality hay. Plant maturity stage and leafiness contribute to crude protein measurements. As a plant matures, crude protein usually decreases. In general, grasses have 4-16% crude protein while legumes have 10-25%. If feed has over 25% crude protein, nitrates could be a contributing factor and should be analyzed (University of Idaho Extension, 2005). In this study in 2022 and 2023, most of the mix and single species had over 25% crude protein (Table 7).

Neutral Detergent Fiber is a measurement of feed quality and plant maturity. As a plant matures, NDF increases (USDA-NRCS, 2018). Higher quality forages typically have lower amounts of NDF, though it varies by functional group. Alfalfa is usually 30%, mature straws and grasses are 78%, and legumes are lower than grasses (USDA-NRCS 2018, University of Idaho Extension, 2005). In this study, NDF varied from 32-69% in 2022 and 25-69% in 2023. Barley and triticale were in the 50% range in both years. Pea NDF was below barley and triticale with 32% in 2022 and 39% in 2023.

Relative Feed Value is an index combining feed digestibility and intake estimates into one number. A RFV of 100 is equivalent to full bloom alfalfa. The higher the value, the better the forage quality (University of Idaho Extension, 2005). In both years, RFV varied from 101 to 262.

Nitrates are not toxic to animals, but at elevated levels, they can cause nitrate poisoning. Nitrates build up in the lower portion of the plant stem when plant roots accumulate nitrate faster than the plant can convert it to protein during photosynthesis. Stressful growing conditions cause nitrate build-up, such as drought, frost, prolonged cool temperatures, hail, shade, disease, insects, high levels of soil nitrate, soil mineral deficiencies, and herbicide damage (Goosey et al., 2022). Nitrate levels less than 1,500 ppm are safe for all conditions of livestock; 1,500-5,000 ppm is generally safe for nonpregnant livestock (Goosey et al., 2022). Both cover crop mixes at all tested seeding rates and each species had less than 1,500 ppm nitrates except for barley in 2022 and turnip in 2023. Those crops had less than 5,000 ppm nitrates and are considered safe for non-pregnant livestock (Goosey et al., 2022). While crude protein was over 25% with some mixes and single species, nitrates did not influence the percentages.

Total Digestible Nutrients is a digestible forage estimate which estimates feed energy. It is a value that is calculated, not measured (University of Idaho Extension, 2005). Higher values equate to higher feed quality. In 2022, TDN ranged from 63-72%, and was higher in 2023 with a range of 63-78%.

Table 7. Forage quality data of mixes among all seeding rates and single species mixes in 2022 and 2023.

Mix or Species	Crude Protein (%)		Neutral Detergent Fiber (%)		Relative Feed Value		Nitrates (ppm)		Total Digestible Nutrients (%)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
C100 Mix[1]	29	23	38	69	166	158	200	20	72	69
K100 Mix	24	22	42	28	137	232	200	130	63	75
C80 Mix	29	29	34	33	179	183	200	40	68	69
K80 Mix	28	25	37	29	164	219	130	810	69	72
C60 Mix	25	27	43	35	137	179	140	790	66	70
K60 Mix	31	20	35	38	178	160	300	20	69	68
Collard	28	33	44	25	131	262	700	1040	64	76
Turnip	28	29	56	28	106	236	1100	2240	65	78
Kale	34	30	40	28	143	230	1050	910	64	74
Barley	27	29	54	54	108	111	1500	1240	64	66
Triticale	22	18	55	57	109	101	90	1030	66	63
Pea	34	28	32	39	199	152	20	30	71	66
Safflower	14	16	39	63	149	166	120	30	65	63

[1]C = collard mix at 100%, 80%, and 60% seeding rate. K= kale mix at the three rates.

CONCLUSION

Kale and collard brassicas can be used interchangeably in the tested cover crop mix without significant differences in density or biomass production. The 100%, 80% and 60% seeding rates tested produced statistically similar densities and biomass. When weed suppression is the goal, using either mix at 80% or 60% of the full seeding rate produced differences in weed density and biomass production in 2022 and 2023. The laboratory analysis of cover crop mixes and the single species indicate forage quality is safe for livestock and could be used for feed.

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