Small-Seeded Fava Bean as Cash Crop and Within Cover Crop Mixture

Susan Tallman, CCA – USDA-NRCS Bozeman Area Agronomist

ABSTRACT

Fava bean (*Vicia faba* L.) is a cool-season legume with a high N-fixing ability, but due to its large seed size, fava bean cannot flow consistently through conventional grain drills; thus, limiting its value as a cover crop in Montana. A recent selection of a small-seeded fava bean makes it possible to establish this line with conventional grain drills and evaluate it as a potential cover crop for row crop agriculture in Montana. This line of fava bean, developed by Montana State University, was grown for cover crop assessment and seed production in 2016 on two separate seeding dates, April 4 under dryland conditions and August 17 under irrigation, at the USDA Natural Resources Conservation Service Plant Materials Center, Bridger, Montana. Cover crop treatments were grown both as a single-species cover crop and as a cover crop mixture to evaluate plant biomass and seed production in comparison with 'Arvika' forage pea (*Pisum sativum* L.), a common legume cover crop in Montana. Means from the 2016 data were separated using the Tukey-Kramer Honest Significant Difference (HSD) procedure and differences were considered significant at either $p \leq 0.05$ or $p \leq 0.1$. Differences in cover crop biomass were detected in the spring dryland planting, with mixed-cover crop treatments producing more biomass than single-species cover crop treatments due to a late harvest date ($p < 0.01$). However, there were no differences in biomass between single-species fava bean and pea biomass treatments and between mixed-species fava bean and mixed-species pea treatments. In contrast, fava bean produced more seeds by dry weight (1110 lb/ac, with 1742 seeds/lb) than forage pea (418 lb/ac, with 3294 seeds/lb) when harvested for grain under spring-seeded dryland conditions ($p < 0.05$). There were no differences in cover crop biomass between all cover crop treatments in the late-summer irrigated planting ($p = 0.15$). Results indicate fava bean produces comparable biomass to forage pea when grown as a single-species or mixed-species cover crop in both dryland and irrigated conditions in southern Montana.

INTRODUCTION

Pulse crops are commonly grown in Montana for grain and as cover crops, including pea, lentil, and chickpea (NASS, 2012). Fava bean (*Vicia faba* L.) is not grown across Montana. However, producers in Canada are finding success with the crop for grain production and as a green-manure cover crop (Douglas et al., 2013). Fava bean has the potential to fix more N than other species of cool season annual legumes (Lupwayi and Soon, 2015; Strydhorst et al., 2008; Walley et al., 2007; Amanuel et al., 2000; Brockwell et al., 1980). However, the seed is often too large to fit through the openings of most grain drills used by farmers. Dr. Perry Miller at Montana State University has isolated and increased a small-seeded accession of fava bean (261 mg/seed) that can fit through modern grain drills. In addition, the seeds are quite dark due to high tannin content, the tannin making them less susceptible to fungal disease and precluding the need for seed treatment with fungicide. This study investigates fava bean as a viable alternative cool-season legume for farmers in the Montana. The specific objectives of this study were to 1) determine the plant biomass and seed production of this small-seeded accession of fava bean when grown under dryland and irrigated conditions in Montana, 2) determine the competitive ability of fava bean when grown in a four-species cover crop mix, and 3) determine how fava bean biomass and seed production compares with forage pea, a more common cool-season legume species for Montana.

MATERIALS AND METHODS

The study site was located at the USDA Natural Resources Conservation Service Bridger Plant Materials Center in Bridger, MT (45.26638°, -108.88805°). The soil was a Heldt silty clay loam, a fine, montmorillonitic Borollic Camborthid, with 0 to 2% slopes. Soils at this location have incurred extensive tillage and are not representative of a long-term no-till system.

Four accessions of fava bean seed were obtained from the Plant Introduction Station in Pullman, Washington by Dr. Perry Miller and increased in the field and greenhouse in 2015. This study used only one accession (PI222216) with an average seed weight of 261 mg per seed. All other seeds were purchased from local or regional vendors and included forage pea (*Pisum sativum* L. var. Arvika) (138 mg per seed), spring triticale (*Triticosecale rimpaui* C. Yen & J.L. Yang [*Secale cereale* × *Triticum aestivum*] var. Trical 141), forage kale (*Brassica napus* L. VNS), and safflower (*Carthamus tinctorius* L. var. MonDak).

The study consisted of two different planting dates and moisture regimes. The first planting on April 4, 2016 consisted of six treatments arranged in a randomized complete block design with four replications. Treatments were planted with a double-disk drill under dryland conditions. Each treatment measured 4.6 feet wide and 20 feet long and contained four rows on 14-inch spacings. Treatments included 1) single-species fava bean for biomass harvest, 2) single-species fava bean for seed harvest, 3) single-species forage pea for biomass harvest, 4) single-species pea for seed harvest, 5) four-way cover crop mix of fava bean, triticale, safflower, and forage kale for biomass harvest, and 6) four-way cover crop mix of forage pea, triticale, safflower, and forage kale for biomass harvest. No fertilizer was applied, and all treatments received rhizobium inoculant (N-Charge®, Verdesian Life Sciences, *Rhizobium leguminosarum* bv. *viciae*). All treatments were seeded at a rate of 11 pure live seed (PLS)/ft^2. Each plant species in the four-species cover crop mix comprised 25% of the total PLS to normalize the inter-species competition. Planting of the first two lengths of the study site was compromised by shallow seeding depth of the planter, leaving exposed seeds (Fig. 1). Exposed seeds were covered and tamped by hand and seeding depth was increased to 0.75 inch in the subsequent four seeding passes. However, seedling emergence and plant vigor was noticeably less in the first two seeding passes (Fig. 2). In late May, plots were hand-weeded. At this same time, some weevil damage was noticeable on both fava and pea leaves (Fig. 3), however no insecticide was applied. All moisture received was from precipitation and no irrigation was applied to the treatments. Biomass was harvested later than preferred on June 24, 2016 at early pod stage of fava bean development (Fig. 4, 5, and 7). Ideal biomass harvest would be at early to mid-bloom to conserve soil moisture. All biomass treatments were sprayed with glyphosate after biomass harvest to terminate further growth. Several weeks later, it was noted that the fava plants were re-growing in spite of the glyphosate application (Fig. 6). Seed harvest from the two seed production treatments occurred on July 27, 2016. The study received 2.7 inches of precipitation from planting to biomass harvest and 3 inches from planting to seed harvest. The study site received 1984 growing degree days (GDD) (base 32°F) from planting to biomass harvest and 3269 GDD (base 32°F) from planting to seed harvest (after Bauer et al., 1984).

The second planting on August 17, 2016 consisted of four treatments in four replicated blocks and was planted with a double-disk drill under irrigated conditions. This scenario was intended to mimic a shoulder season planting following small grain harvest with possible late-fall grazing. Treatments included 1) single-species fava bean for biomass harvest, 2) single-species forage pea for biomass harvest, 3) four-way cover crop mix of fava bean, triticale, safflower, and forage kale for biomass harvest, and 4) four-way cover crop mix of forage pea, triticale, safflower, and forage kale for biomass harvest. Plot size, row spacing, plant population, and seeding depth were the same as the spring planting. Irrigation was from an overhead sprinkler irrigation system. The site was watered prior to seeding with 2.9 inches of water and received 5.8 inches of water over two irrigation sets via impact sprinkler, along with 2.5 inches of additional precipitation for a total of 8.3 total inches over the growing season. The site received 2012 GDD (base 32 °F) from the time of planting to biomass harvest. Biomass harvest occurred on November 9, 2016 (Fig. 8).

Fig. 1. Fava beans not seeded to accurate depth in first two seedling passes, April 4, 2016.

Fig. 2. Fava bean vigor less than expected in first two seeding passes in left of photo, May 31, 2016.

Fig. 3. Fava bean did show some weevil damage on leaves, May 31, 2016.

Fig. 4. Fava bean cover crop mixture at biomass harvest, June 24, 2016. Note triticale heads.

Fig. 5. Fava bean plant at biomass harvest, June 24, 2016. Note early pods and desiccated flowers.

Fig. 6. Fava bean after herbicide termination. Note upright growth habit and regrowth of plant, August 25, 2016.

Biomass and seed harvest sampling was conducted by hand, with two, 3-foot sample lengths in each treatment. Samples were taken only from inside rows to avoid edge effects. All aboveground biomass was collected, air-dried, and then oven-dried at 150°F for 48 hours prior to weighing. For seed production data, all seed pods were kept on the plant at harvest, then threshed, cleaned, and weighed in the laboratory.

Statistical analysis was performed with R statistical software (The R Foundation for Statistical Computing, Vienna, Austria, 2016). Linear models were constructed with treatment and replicate as independent variables and analyzed with ANOVA. Specific treatment comparisons were reported using Tukey-Kramer Honest Significant Difference (HSD) procedure with differences considered significant at $p \leq 0.05$ or $p \leq 0.1$, using the *agricolae* package (de Mendiburu, 2016) in R.

RESULTS AND DISCUSSION

For the spring-planted (dryland) portion of the study, biomass was not significantly different between the single-species fava bean and single-species pea treatments (Table 1). Likewise, biomass production was not significantly different between the mixed-species fava bean and the mixed-species pea treatments. However, biomass production of both mixed-species treatments was significantly greater than that of both single-species treatments. It is assumed this is mainly due to seed head and pod production in the triticale, fava bean, and pea, due to a late harvest. The Honest Significant Difference ($HSD_{0.05}$) was 2676 lb/ac, over half the total maximum production of 5085 lb/ac, indicating a high amount of variation between replicates. Even though both fava bean and pea produced considerable biomass as single-species treatments, they were the least competitive species in the mixed-species treatments, with only 3 and 9% of the total biomass, respectively. This corresponds with field observations and clippings across south-central Montana in which legumes often did not compete well in an annual, mixed-species cover crop (USDA-NRCS, 2016). In contrast, seed production by weight (Table 2) was greater for fava bean than pea, indicating greater potential feed production of fava bean than forage pea under similar growing conditions. (The potential toxicity of fava bean seed as feed is unknown to this author and should not be fed to livestock without further information.)

For the late-summer planted (irrigated) portion of the study, biomass did not significantly differ among all four treatments (Table 3) regardless of plant species number ($HSD_{0.1}$). Biomass was harvested when all plants were in a vegetative stage with few to no flowers observed on the legumes and no triticale seed heads (Fig. 6). Fava bean and pea represented more of the mixed-species biomass than in the spring-planted treatments, at 18 and 13% of the total biomass, respectively. Forage kale produced 36 to 42% of the total biomass, while safflower biomass was very low at only 3 to 5%, likely due to cooler fall temperatures. The $HSD_{0.1}$ was 1606 lb/ac, indicating less variability among treatments than those planted in the spring.

Fig. 7. Biomass harvest of dryland treatments, June 24, 2016.

Fig. 8. Biomass harvest of irrigated treatments, November 9, 2016.

Table 1. Dryland cover crop biomass by treatment 81 d after April 4 seeding, June 24, 2016, Bridger, MT.

		Total	Fava	Pea	Triticale	Kale	Safflower
		--- lb/ac ---	------------------------------ Species ratio ----------------------				
Fava, single-species	c†	1338	1.0	-	-	-	-
Pea, single-species	bc	1695	-	1.0	-	-	-
Fava, mixed-species	ab	4372	0.03	-	0.55	0.24	0.18
Pea, mixed-species	a	5085	-	0.09	0.54	0.17	0.20
		p-value					
Treatment		<0.01					
$HSD_{0.05}$		2676					
SE		1249					

†Means in column followed by the same letters are not significantly different at $p \leq 0.05$.

Table 2. Dryland seed production of fava bean and forage pea 115 d after April 4 seeding, July 27, 2016, Bridger, MT.

		Total
		--- lb/ac ---
Fava, single-species	a†	1110
Pea, single-species	b	418
		p-value
Treatment		<0.05
$HSD_{0.05}$		588
SE		261

†Means in column followed by the same letters are not significantly different at $p \leq 0.05$.

Table 3. Irrigated cover crop biomass by treatment 85 d after August 17 seeding, November 9, 2016, Bridger, MT.

	Total	Fava	Pea	Triticale	Kale	Safflower
	--- lb/ac ---	-------------------------- Species ratio ----------------------				
Fava, single-species	2409†	1.0	-	-	-	-
Pea, single-species	2587	-	1.0	-	-	-
Fava, mixed-species	3658	0.18	-	0.42	0.36	0.05
Pea, mixed-species	3569	-	0.13	0.42	0.42	0.03
	p-value					
Treatment	0.15					
$HSD_{0.1}$	1606					
SE	803					

† Means are not significantly different at $p \leq 0.1$.

CONCLUSION

Results from this study indicate that fava bean produces comparable biomass to forage pea when grown as a single-species or mixed-species cover crop in both dryland and irrigated conditions. This may give farmers in Montana an additional cool-season legume option. Likewise, when grown at similar plant populations and harvested in the vegetative state, both fava bean and pea can produce comparable biomass quantities to mixed-species, cool-season cover crops. What is unknown is the differences in forage quality between fava bean and forage pea.

Biomass production of both fava bean and forage pea were lower than expected in a mixed-species cover crop, especially in the spring-seeded treatments. This was likely due to skewed results from late harvest that included heavy triticale heads. Plant species ratios were more evenly distributed in the late-summer planting, although the amount of safflower was negligible.

The late-summer planting is the most likely scenario for local farmers as an additional crop to fill the gap after malt barley harvest in late July. A mixed-species forage would provide additional grazing for livestock into late fall. Large field sizes and full-size drills are recommended for future study to determine on-farm feasibility.

LITERATURE CITED

Amanuel, G., R.F. Kuhne, D.G. Tanner and L.P.G. Vlek. 2000. Biological N fixation in faba bean (*Vicia faba* L.) in the Ethiopian highlands as affected by P fertilization and inoculation. Biology and Fertility of Soils 32:353-359.

Bauer, A., C. Fanning, J.W. Enz, and C.V. Eberlein. 1984. Use of growing-degree days to determine spring wheat growth stages. North Dakota Cooperative Extension Service EB-37. Fargo, ND.

Brockwell, J., R.R. Gault, D.L. Chase, F.W. Hely, M. Zorin, and E.J. Corbin. 1980. An appraisal of practical alternatives to legume seed inoculation: Field experiments on seed bed inoculation with solid and liquid inoculants. Australian Journal of Agricultural Research 31:47-60.

de Mendibiru, F. 2016. Agricolae: Statistical Procedures for Agricultural Research. R package 1.2-4.

Douglas, L., D. Laviolette_Brown, X. Ma, B. Shapka, Z. Yu. 2013. Alberta Faba bean Producers Manual 1.0. Accessed on Feb. 10, 2017 at http://www.pulse.ab.ca/images/uploads/news_publications/FABABEAN_PRODUCER_MANUAL_-Final_Copy.pdf

Lupwayi, N.Z. and Y.K. Soong. 2015. Carbon and nitrogen release from legume crop residues for three subsequent crops. Soil Science Society of America Journal 79:1650:1659.

R Core Team. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Strydhorst, S.M., J.R. King, K.J. Lopetinsky, and K.N. Harker. 2008. Weed interference, pulse species and plant density effects on rotational benefits. Weed Science 56:249-258.

Walley, F.L., G.W. Clayton, P.R. Miller, P.M. Carr, and G.P. Lafond. 2007. Nitrogen economy of pulse crop production in the northern Great Plains. Agronomy Journal 99:1710-1718.

United States Department of Agriculture, National Agricultural Statistics Service - Montana. 2012. Census of Agriculture. Specified Crops by Acres Harvested.

United States Departments of Agriculture, Natural Resource Conservation Service. 2016. Bozeman Area Soil Health Report 2015. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/soils/health/?cid=nrcseprd705211