COMBINATION OF NITROGEN FERTILIZER AND RHIZOBIUM TO IMPROVE YIELD AND QUALITY OF MUNG BEAN AND ADZUKI BEAN IN MONTANA

C. Chen*, W. Franck, M. Etesami, F. Etemadi, T. Gross, C. Kowatch-Carlson, S. Franck
Eastern Agricultural Research Center, Montana State University, Sidney, MT
cchen@montana.edu; (406) 433-2208

ABSTRACT

Mung bean and adzuki bean are alternative grain legumes that may provide benefits to Montana's cropping systems by improving long-term diversification and productivity. The objective of this study was to investigate mung bean and adzuki bean responses to nitrogen fertilizer and rhizobium inoculation combinations. Two adzuki bean (Organic and O.R) and two mung bean (Organic and L.N) cultivars were grown under five nitrogen and rhizobium combinations, including (A) 22N-22P-22K, (B) 74N-22P-22K, (C) 74N-22P-22K + Rhizobia, (D) 22N-22P-22K + Rhizobia, and (E) Rhizobia only during 2019 and 2020 in Sidney, Montana. Results showed that seed yield was greatly affected by species/cultivar and fertilizer treatments. Generally, mung beans had greater yields than adzuki beans. One mung bean cultivar (Organic) produced a greater yield than the other one (L.N.) in 2019 with no difference in 2020. Treatment C (74N-22P-22K + Rhizobia) produced the highest yields in both years. Treatments A (22N-22P-22K) and E (Rhizobia only) were the lowest yielding in both years. Fertilizer affected bean protein concentrations in 2020 but not in 2019 with treatment C (74N-22P-22K + Rhizobia) producing the highest protein concentrations in 2020. Grain yield was greater in 2019 compared to 2020, however, grain protein showed the opposite trend with higher concentrations in 2020.

INTRODUCTION

Mung bean and adzuki bean have been cultivated as traditional grain legumes in Asiatic countries for food consumption and medical benefits for decades (Alemu, 2016; Torabian et al., 2021). Due to the unique seed quality and nutritional value, mung beans and adzuki beans have become commercially attractive in some regional markets, including as sprouts (predominantly mung bean) in the United States (Alemu, 2016; Torabian et al., 2021; Nair et al., 2012; Rubatzky and Yamaguchi, 2012; Pandian et al., 2021, Kondo et al., 2004). Adzuki bean grains and sprouts contain balanced amounts of digestible protein, essential minerals, fatty acids, bioactive photo-chemicals, polyphenols and phytates, making them a great source of food with pharmaceutical functions (Campos-Vega et al., 2010, Agarwal and Chauhan., 2019).

Although mung beans and adzuki beans offer nutritional benefits in human diets and potential improvements in farm sustainability, adoption by growers is lacking due in part to the absence of production and management information and associated production risks. Evaluation of yield and agronomic traits of mung bean and adzuki bean cultivars and fertility management linked to yield improvement may prompt farmers and researchers to pursue these new alternative crops thereby providing benefits to farm sustainability and the Montana economy. The objectives of this study were: 1) to investigate the combination of N, P, K fertilizer with rhizobia inoculant effects on biomass, yield, and protein concentration of mung and adzuki beans; and 2) to provide production recommendations to farmers in Montana and surrounding regions.

MATERIALS AND METHODS

A field experiment was carried out at the Montana State University Eastern Agricultural Research Center (EARC) irrigated farm located in Sidney, MT (47°43′32″ N, 104°9′5″ W) in 2019 and 2020. Soil at this site is a deep, well-drained, nearly level (field slope of ~0.15%) Savage Clay Loam (fine, smectitic, frigid Vertic Argiustolls). The average monthly air temperatures and precipitation from March–October for 2019 and 2020 are shown in Figure 1.

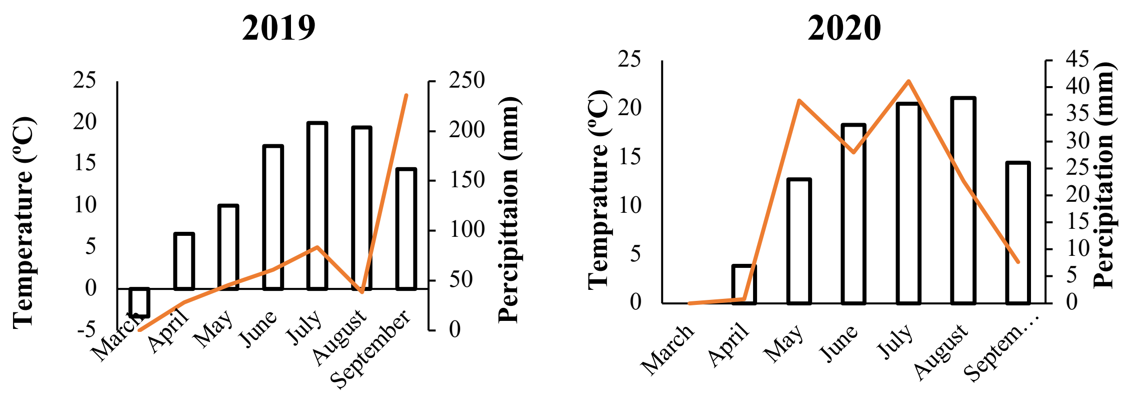

Figure 1. Growing season monthly average temperature and precipitation.

The experiment was conducted as a randomized complete block design with 3 replicates, where mung and adzuki bean cultivars and fertilizer treatments were randomly assigned to plots within each block. There were two mung bean (cv. Organic and L.N) and two adzuki bean (cv. Organic and O.R) cultivars and five nitrogen and rhizobium combinations, including (A) 22N-22P-22K, (B) 74N-22P-22K, (C) 74N-22P-22K + Rhizobia, (D) 22N-22P-22K + Rhizobia, and (E) Rhizobia only. In treatments A through D, a starter fertilizer was applied in the same furrow with seeds at planting at a rate of 22 kg ha^{-1} N, 22 kg ha^{-1} P_2O_5, and 22 kg ha^{-1} K_2O. In addition, treatments B and C received a top-dress of urea at the 8-leaf stage at a rate of 52 kg ha^{-1} N. A commercial rhizobia inoculant was mixed with seed at planting in those treatments containing rhizobia.

Planting dates were May 14, 2019 and May 8, 2020, and trials followed sugar beets in both years. Seeding rates were 129 pure live seed per m^{-2}. The plot size was 1.5 m wide x 4.6 m long. Prior to planting seeds were treated with Cruiser Maxx insecticide and Apron Maxx fungicide. Outlook herbicide (720 g l^{-1} Dimethenamid-P) was applied pre-emergence at the rate of 1.0 l ha^{-1}. Hand weeding was performed as needed during the growing season. Plots were harvested in late September when seeds were completely matured using a plot combine harvester. The grain yield was calculated and adjusted to 6% moisture content. A sub-sample of grain was ground to test nitrogen concentration by Dumas combustion using a Perkin Elmer Series Ⅱ Nitrogen Analyzer and then converted to protein content by multiplying a factor of 6.25.

RESULTS AND DISCUSSION

Biomass and Grain Yields

The analysis of variance for biomass is presented in Table 1. Cultivar effects (*P*<0.001) and cultivar x year interactions (*P*<0.01) were significant for biomass. Mung beans produced more biomass than adzuki beans in both years (Figure 2). There were no differences in biomass between the two mung bean cultivars nor between the two adzuki bean cultivars. The biomass yields were higher in 2020 than in 2019 for adzuki beans but not mung beans. The magnitude of difference between mung beans and adzuki beans was less in 2020 relative to 2019 giving rise to the cultivar x year interaction.

Fertility treatments have moderate (*P*=0.059) effects on mung and adzuki bean biomass yields. Treatment C (74N-22P-22K) produced the highest biomass yields in both years (Figure 3).

Table1. Analysis of variance table for cultivar, year and treatment effects on biomass yield, grain yield and grain protein.

Source of Variation	**df**	**Biomass Yield**	**Grain Yield**	**Grain Protein**
		P>F	*P>F*	*P>F*
Cultivar	3	<0.001	<0.001	<0.001
Treatment	4	0.059	<0.001	0.023
Year	1	0.262	<0.001	<0.001
Cultivar*Treatment	12	0.813	0.009	0.880
Cultivar*Year	3	0.008	0.049	0.305
Treatment*Year	4	0.275	<0.001	0.016
Cultivar*Treatment*Year	12	0.216	0.318	0.960

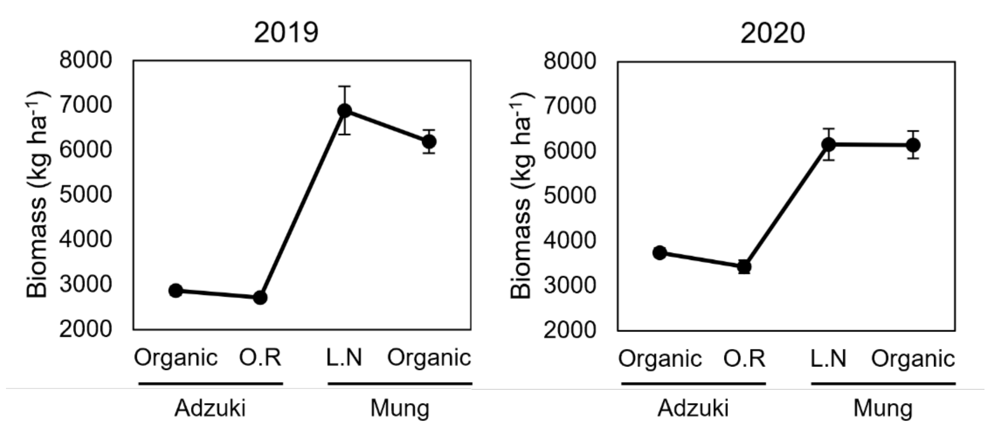

Figure 2. Biomass yield of mung and adzuki bean cultivars in 2019 and 2020. Error bars represent standard error.

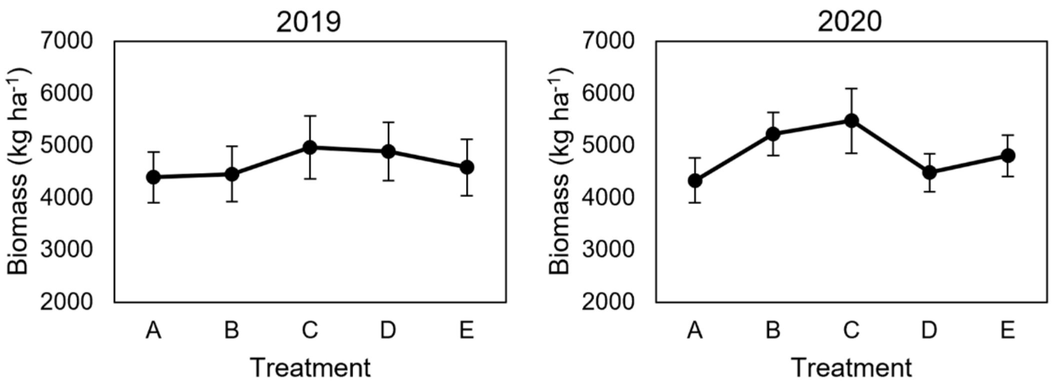

Figure 3. Biomass yield affected by treatments in 2019 and 2020. Treatments: (A) 22N-22P-22K, (B) 74N-22P-22K, (C) 74N-22P-22K + Rhizobia, (D) 22N-22P-22K + Rhizobia, and (E) Rhizobia only. Error bars represent standard error.

The analysis of variance for grain yield is presented in Table 1. Cultivar, treatment, and year effects were significant for grain yield (P<0.001). Significant interactions were observed for cultivar x treatment (P<0.01), cultivar x year (P<0.05) and treatment x year (P<0.001). Mung beans produced higher grain yields than adzuki beans, and the grain yields were higher in 2019 than 2020 (Figure 4) for both for mung bean and adzuki beans. The reduction in yield from 2019 to 2020 was greater for the two adzuki bean cultivars resulting in a cultivar x year interaction. The fertility treatment had significant effects on grain yield. Treatment C produced the highest yield and treatment E produced the lowest yield (Figure 5). The patterns of the fertility effects looked similar, but the magnitude of the effects was greater in 2019 than in 2020 (Figure 5) resulting in a significant treatment x year interaction.

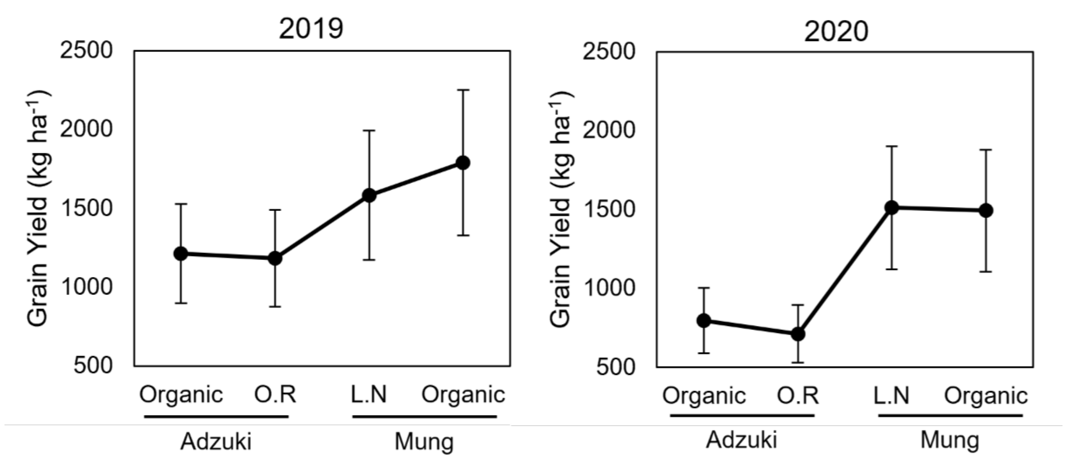

Figure 4. Grain yield of mung and adzuki bean cultivars in 2019 and 2020. Error bars represent standard error.

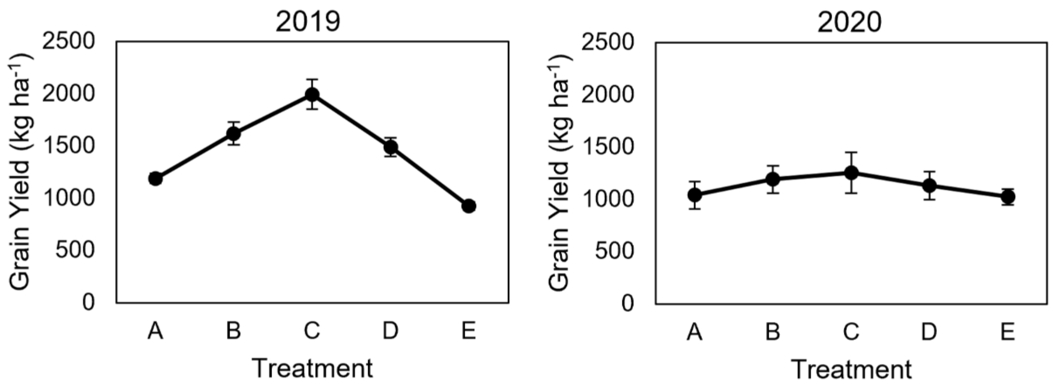

Figure 5. Grain yield affected by treatments in 2019 and 2020. Treatments: (A) 22N-22P-22K, (B) 74N-22P-22K, (C) 74N-22P-22K + Rhizobia, (D) 22N-22P-22K + Rhizobia, and (E) Rhizobia only. Error bars represent standard error.

Grain Protein

Table 1 includes analysis of variance for grain protein. Cultivar (P<0.001), treatment (P<0.05), and year (P<0.001) effects are all significant for grain protein. Grain protein concentrations were higher in 2020 than in 2019. Mung beans had higher grain protein concentrations than adzuki beans, but the protein concentration did not differ between the mung bean cultivars nor between the adzuki bean cultivars (Figure 6).

Grain Treatment effects on grain protein concentration differed between 2019 and 2020 (Figure 6) producing a significant treatment x year interaction (P<0.05). In 2020, treatment B and C had the highest protein concentrations and treatment A and E had the lowest protein concentrations, while there was little difference among the treatments in 2019.

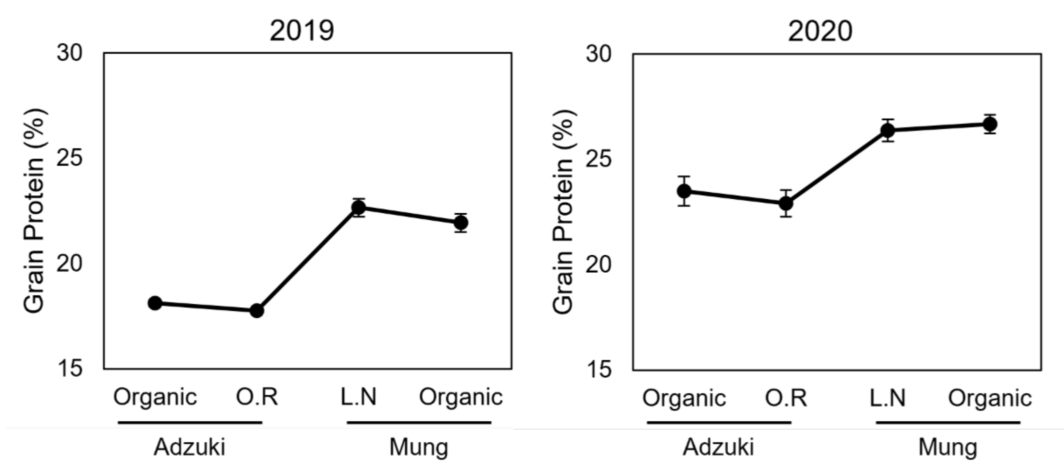

Figure 6. Grain protein of mung and adzuki beans in 2019 and 2020. Error bars represent standard error.

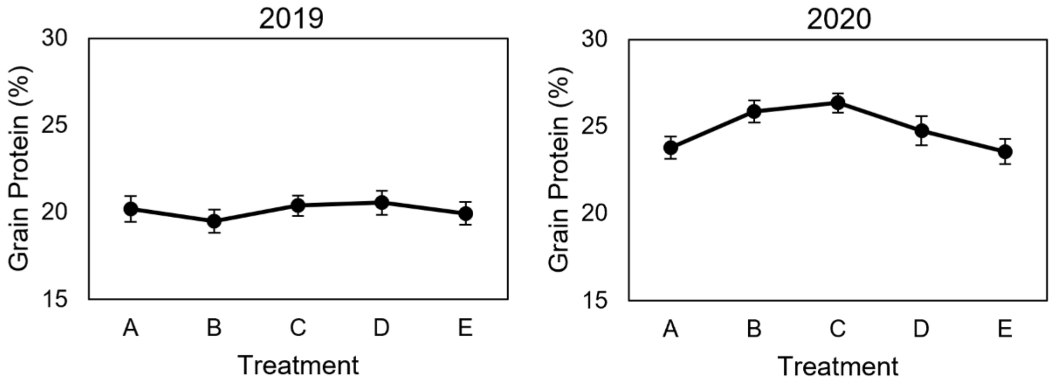

Figure 7. Grain protein affected by treatments in 2019 and 2020. Treatments: (A) 22N-22P-22K, (B) 74N-22P-22K, (C) 74N-22P-22K + Rhizobia, (D) 22N-22P-22K + Rhizobia, and (E) Rhizobia only. Error bars represent standard error.

REFERENCES

Agarwal., S. Chauhan., E. S. 2019. Adzuki beans. Physical and nutritional characteristics of beans and their health benefits. International Journal of Health Science and Research. 9(4); 304-310.

Alemu, I. D. 2016. General Characteristics and Genetic Improvement Status of Mung bean (*Vigna radiata* L.) in Ethiopia. International Journal of Agriculture Innovations and Research. 5(2): 232–237. http://www.ijair.org/index.php/issues?view=publication&task=show&id=811.

Kondo, N., Notsu, A., Naito, S., Fujita, S. Shimada, H. 2004. Distribution of Phytophthora vignae f. sp. adzukicola races in adzuki bean fields in Hokkaido, Japan. Plant disease. 88: 875–877.

Nair. R. M., Schafleitner, R., Kenyon, L. Srinivasan, R., Easdown, W., Ebert, A.W., Hanson, P. 2013.Genetic improvement of mung bean. SABRAO. Journal of Breeding and Genetics 44 (2) 177-190.

Pandian, M., Sivakumar, P., Krishnaveni, A., Sivakumar, C., Radhakrishnan, V., Vaithiyalingam, M., Tomooka, N. 2021. The beans and the peas. Adzuki Bean Chapter. Elsevier. Chapter 5: 89-103.

Rubatzky, V. E. Yamaguchi, M. 2012. World vegetables: principles, production, and nutritive values. Springer Science and Business Media.

Torabian, S. Qin, R., Wysocki, D., Liang, X. 2021. Adzuki bean: a potential rotational crop for the Colombia Basin. Oregon State University Extension Service. 6 pages.