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Original Research Paper

Interaction Effect of Maize and Mashbean Intercropping on Sustainable Production System in Subtropical Zone of India

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ABSTRACT

It is imperative that the world farmlands turn out to be the frontline for the battle to feed the projected 9 billion population globally. The deleterious effects of climate change on food security can be counteracting by broad-based agriculture development particularly enhanced crop diversification to mitigate farmer risk about complete destruction of crop that will overcome the impacts of climate change. It will also lead to benefits like improved food security besides improving soil nutrients. Therefore, a field trial was conducted. The experimental results revealed that application of 100% NPK with PSB and Zn in paired planted mashbean accumulated significantly more dry matter than rest of the treatment combinations, whereas normal planted mashbean intercropped with maize recorded maximum total uptake (8.15%) than 100% NPK alone. Likewise in maize similar trends were observed in dry matter and protein content. Moreover, application of 100% NPK alone with PSB and Zn on normal planted sole maize was brought significant improvement in organic carbon and potassium. However, nitrogen recorded higher under paired planted maize+mashbean. Though, normal (50 cm) planted maize+mashbean resulted significantly higher B:C ratio (2.73) at same fertility level.

INTRODUCTION

Intercropping systems more efficiently used the growth factors because they capture more radiation and make better use of the available water and nutrients, reduce pests, diseases incidence and suppress weeds and favour soil-physical conditions, particularly intercropping cereal and legume crops which also maintain and improve soil fertility (Sanginga & Woomer 2009). In small farms, the farmers raise crops as a risk minimizing measures against total crop failures and to get different produces to take of his family food, income, etc. In intercropping system involving legume and non legume, legume may provide nitrogen benefiting non-legume component, which improve nitrogen uptake and fertility status (Dwivedi et al. 2015). Intercropping corn with legumes was far more effective than corn sole to produce higher dry matter yield and roughage for silage with better quality (Geren et al. 2008). Also, intercropping common bean with corn in 2 row-replacements improved silage yield and protein content of forage compared with sole crops (Lithourgidis et al. 2007).

Growth yield attributes in maize and mashbean and protein contents in mashbean only superior in intercropping with paired planting geometry than their sole cropping with other geometries (Dwivedi et al. 2015). Intercropping of maize with urdbean resulted in 9.7 to 11.5 per cent higher grain yield than sole maize grown with normal and paired spacing, respectively. Moreover, N uptakes by blackgram were higher in the sole planting as against (2:1) maize + blackgram intercropping system (Dwivedi et al. 2012). According to Seran & Brintha (2010) the intercropping system gave higher cash return to smallholder farmers than growing as the monocrops. Therefore, the present study was carried out to investigate interaction effect of maize+mashbean intercropping: Experiences, challenges and opportunities in India.

MATERIALS AND METHODS

Site description: A field experiment was conducted during *kharif* season 2012 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), located at a latitude of 29°40' North and longitude of 77° 42' East with an elevation of 237 metres above mean sea level. The mean annual rainfall in the region is about 650 mm and the area lies in the heart of western Uttar Pradesh. The experimental field was well drained, sandy loam in texture (46.2% sand, 18.4% silt and 17.4% clay) and slightly alkaline in reaction (pH 7.8). It was medium in organic carbon (0.570%), available nitrogen (222.6 kg/ha) and available phosphorus (16.6 kg/ha) but high in available potassium (249.0 kg/ha) with an electrical conductivity (1:2, soil: water suspension) and bulk density of 1.6 dS/m and 1.42 Mg/m^3, respectively. The treatments comprised of 2 cropping systems (maize+mashbean and maize alone), 2 planting geometries (normal and paired planting) and 3 fertility levels (control, 100% NPK and 100% NPK + Zn + PSB), replicated thrice in a factorial randomized block design. Varieties PAC 712 (Maize) and PU 19 (Mashbean) with the spacing (rows) of 50 cm (Normal) and 30/70 cm (Paired) were grown with recommended agronomic package of practices. The seeds were placed manually in the furrows at a plant to plant distance of 20 and 10 cm with a seed rate of 20 and 15 kg/ha for maize and mashbean, respectively and sown on 30 July 2012. The 100 per cent NPK (for maize) is characterized by 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ ha and Zn is applied @ 0.5% $ZnSO_4$ as spray whereas, PSB is used as seed treatment @ 20 g/kg of seed. Irrigation was provided as per need of crop. Crops were kept weed free by regular hand weeding.

Plant sampling and analysis: The plants measured for dry weight at 50 DAS and at maturity were used for analysing the total N uptake. The grain and straw samples were dried at 70 °C in a hot air oven. The dried samples were ground in a stainless steel Thomas Model 4 Wiley ® Mill. The N content in grains and straw was determined by digesting the samples in sulphuric acid (H_2SO_4), followed by analysis of total N by the Kjeldahl method (Page 1982) using a Kjeltec™ 8000 auto analyzer (FOSS Company, Denmark) and then multiply with 5.73 for protein content in maize (AOAC 1960). The uptake of the nutrients was calculated by multiplying the nutrient content (%) by respective yield (kg ha^1) and was divided by 100 to get the uptake values in kg ha^1.

Soil sampling and analysis: Soil samples were collected at the start of the experiment from 0 to 15 cm soil depth using an auger of 5-cm diameter. Each sample was a composite from three locations within a plot. The freshly collected soil samples were mixed thoroughly, air-dried, crushed to pass through a 2-mm sieve and stored in sealed plastic jars before analysis. Organic carbon (rapid titration method) available N (alkaline permanganate method) and NH_4OAc-extractable K were analysed using the methods described by Page (1982).

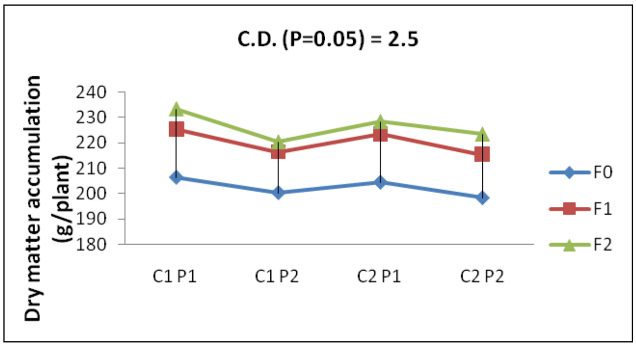
Economic study: Benefit: cost ratio in terms of net return per rupee investment was calculated by using the following formula:

$$B:C = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Statistical analysis: The data on growth, yield, total nutrient uptake, soil nutrients status and economic analysis was recorded as per the standard procedure. The data obtained were subjected to statistical analysis as outlined by Gomez & Gomez (1984). The treatment differences were tested by using "F" test and critical differences (at 5 per cent probability).

RESULTS AND DISCUSSION

Maize: Normal planted maize+mashbean with recommended 100% NPK+PSB+Zn accumulate significantly maximum dry matter (45.76 g m^{-2}) as compared to rest of the treatment combinations. Whereas, significantly minimum dry weight was noticed under paired sole maize without use of nutrients and it had also remained on par with paired planting sole maize alone in control plot (Fig. 1). The increased values of growth parameters were probably due to the fact that intercrop legume will fix nitrogen from the atmosphere which can be utilized by maize coupled with better resource utilization by border crop rows. Similar findings were also reported by Shadashiv (2004).



*C_1 = maize sole, C_2 = maize+mashbean, P_1 = normal planting, P_2 = paired planting, F_0 = control, F_1 = 100% NPK, F_2 = 100% NPK+PSB+Zn

Fig. 1: Dry matter accumulation at maturity of maize as influenced by various levels.

Paired planted sole maize recorded significantly maximum protein content (7.0 %) 50 cm planted maize+ mashbean (6.95%) with the use of 100% NPK+PSB+Zn in both (Fig. 2). Moreover, normal planted maize alone recorded significantly lowered protein content (6.70 %). The increase in protein content of maize grains under paired cm planted mashbean (4.6 g m^{-2}) in untreated plot. This might be due to more penetration of light and better utilization of resources (Dwivedi et al. 2015). Normal planted mashbean in maize under 100 % planting has also been reported by Dahmardeh

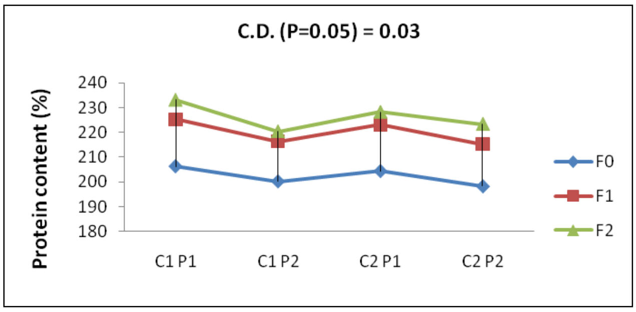


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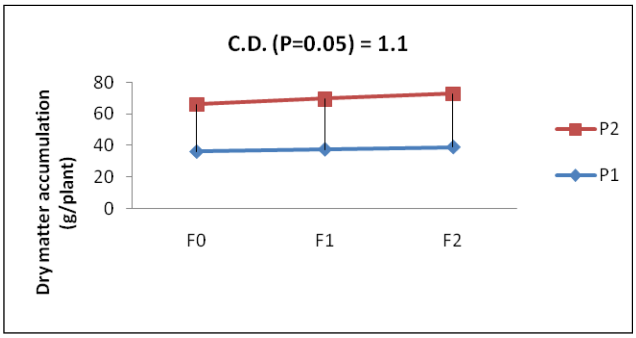
Fig. 2: Protein content of maize as influenced by various levels.



*P_1 = normal planting, P_2 = paired planting, F_0 = control, F_1 = 100% NPK, F_2 = 100% NPK+PSB+Zn

Fig. 3: Drymatter accumulation of mashbean at 50 DAS as influenced by various levels.

et al. (2011). Higher protein content in grains might be due to the more nitrogen content in grains and higher grain yield which in turn improved the protein yield.

Yields: The data presented in Table 1 revealed that significantly higher grain (40.46 q/ha) and stover (71.6 q/ha) yield were recorded under intercropping system than sole cropping. Significantly higher stover (1.6 %) per hectare was obtained under paired planting than normal planting, but the differences were non-significant in grain yield. Grain and stover yield per hectare varied significantly due to each increment in fertility levels, however grain yield remained on par between 100% NPK and 100% NPK+Zn+PSB treatments. The increase in grain and stover yield might be due to increase in yield attributes which were also influenced due to more dry matter accumulation. Our results were also supported by Jeyakumaran & Seran (2007).

Mashbean: Application of 100% NPK with PSB and Zn in paired planted mashbean accumulated significantly more dry matter than rest of the treatment combinations (Fig. 3). The next in the order was paired planted mashbean fertilized with 100% NPK alone. However, significantly lower dry weight

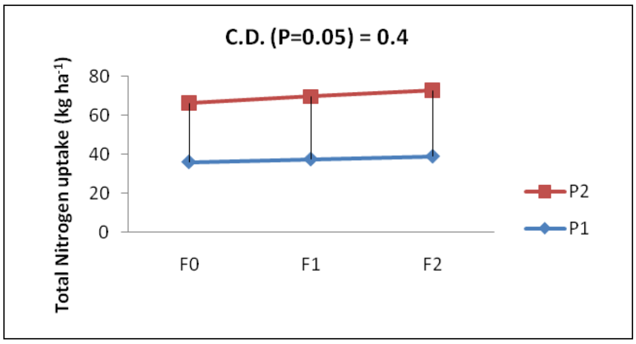


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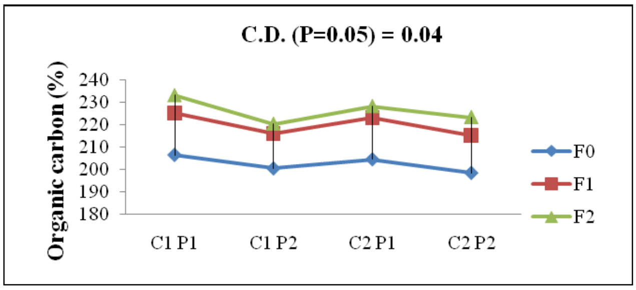
Fig. 4: Total nitrogen uptake of mashbean as influenced by various levels.



*C_1 = maize sole, C_2 = maize+mashbean, P_1 = normal planting, P_2 = paired planting, F_0 = control, F_1 = 100% NPK, F_2 = 100% NPK+PSB+Zn

Fig. 5: Organic carbon of maize+mashbean intercropping as influenced by various levels.

was observed in normal planted control, remained on par with paired planted control.

Normal planted mashbean intercropped with maize at 100% NPK+PSB+Zn noticed significantly higher (8.15%) uptake of N than normal planting with 100% NPK alone (Fig. 4). Whereas, significantly minimal N uptake was observed under paired planted control plot. The highest uptake was directly related to root growth in terms of number and dry weight of root nodules per plant and increased biomass coupled with more N content in the produce. Similar results were also reported by Tripathi et al. (2008).

Yields: Significantly higher grain and straw yields per hectare was noticed under normal planting than paired planting and the improvement was to the tune of 20.0 % and 5.4 % respectively (Table 1). Grains and straw per hectare was increased by increasing levels of fertility up to 100 % NPK + Zn + PSB. The higher grain and straw yield was mainly due to higher dry matter accumulation and also more translocation of photosynthates toward sink. Similar findings were also reported by Pathak & Singh (2008).

Soil available nutrients: Application of 100% NPK alone

Table 1: Crop yields as influenced by various treatments.

Treatment	Maize yield (t ha^{-1})		Mashbean yield (t ha^{-1})	
	Grain	Stover	Grain	Straw
A) Cropping systems				
Sole maize	3.89	6.99	-	-
Maize+Mashbean	4.10	7.16	-	-
S.Em.±	0.02	0.03	-	-
C.D. (P=0.05)	0.06	0.08	-	-
B) Planting geometries				
Normal (50 cm)	3.95	7.02	0.54	1.55
Paired (30/70 cm)	3.99	7.13	0.45	1.47
S.Em.±	0.19	0.03	0.01	0.01
C.D. (P=0.05)	NS	0.08	0.03	0.03
C) Fertility levels				
Control	3.20	6.10	0.48	1.49
100% NPK	4.32	7.47	0.50	1.51
100% NPK+Zn+PSB	4.38	7.66	0.53	1.54
S.Em.±	0.02	0.03	0.01	0.01
C.D. (P=0.05)	0.07	0.10	0.03	0.03

with PSB and Zn on normal planted sole maize was brought significant improvement in organic carbon (0.61%) and also remained statistically on par with normal planted maize+mashbean (0.60%), 100% NPK alone in same level (0.59) and paired/normal planted sole maize/maize+mashbean, while lowered organic carbon under unfertilized paired planted sole maize (0.53%) (Fig. 5). The more organic carbon was probably due to the higher root biomass, nodulation and leaf shedding ability by legume component in maize+legume intercropping. Similar findings were also reported by Rubapathi et al. (2004).

Significantly highest available N (204.0 kg ha^{-1}) was recorded in 100% NPK+PSB+Zn in paired planted sole maize followed by 100% NPK alone (200.1 kg ha^{-1}) in same level (Fig. 6). Though, significantly minimum N (170.47 kg ha^{-1}) was recorded in unfertilized plot of 50 cm away planted maize+mashbean. This might be due to the full dose of NPK which maintained available soil nitrogen status, besides PSB and Zn which are capable of increasing the uptake of nitrogen and also activating the several nutrients. Similar findings were also reported by Kumar & Thakur (2009).

Normal planted sole maize grown under 100% NPK+PSB+Zn was noticed significantly maximum available K (233.3 kg ha^{-1}) than rest of the treatments (Fig. 7). Whereas, minimum was recorded under control plot of paired planted maize+mashbean (198.3 kg ha^{-1}). This might be due to the fact that total uptake of potassium was higher under paired planting, which was mainly due to better growth parameters and yield. These findings were also supported by Thavaprakash and Velayudham (2005).

Economics: Normal (50 cm) planted maize+mashbean

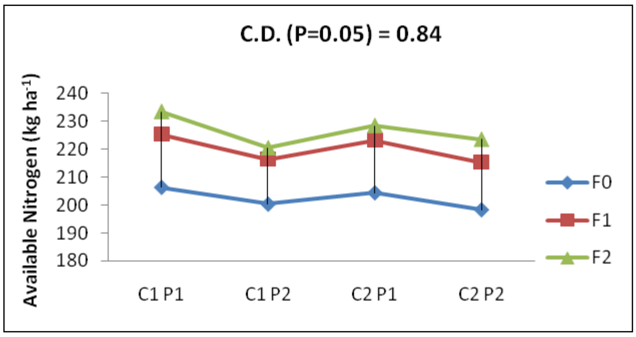


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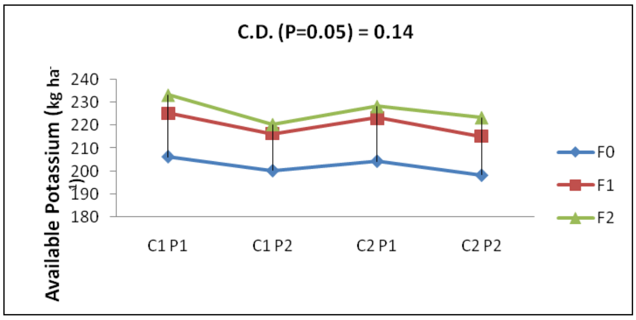
Fig. 6: Available nitrogen of maize+mashbean intercropping as influenced by various levels.



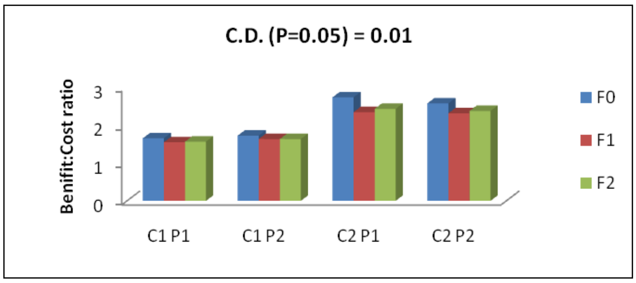
*C_1 = maize sole, C_2 = maize+mashbean, P_1 = normal planting, P_2 = paired planting, F_0 = control, F_1 = 100% NPK, F_2 = 100% NPK+PSB+Zn

Fig. 7: Available potassium of maize+mashbean intercropping as influenced by various levels.

resulted significantly higher B:C ratio (2.73) followed by 30/70 cm away planted maize+mashbean (2.57) under no fertilization than rest of treatments (Fig. 8). Moreover, application of 100% NPK with and without PSB and Zn showed marginal differences among themselves. However, it was statistically lower down where 50 cm apart maize grown alone with 100% NPK (1.54). The probable reason was that lower cost involved in control and substantial amount of nitrogen was fixed by mashbean from atmosphere and release of organic carbon into the soil by mashbean. Similar findings were also reported by Dwivedi et al. (2012).

CONCLUSION

Based on above findings it can be concluded that maize+mashbean intercropping under paired/normal planting proved not to be better when fertilized with 100% NPK+Zn+PSB for dry matter accumulation at maturity as well as protein content in maize and dry matter accumulation at 50 DAS and total nitrogen uptake in mashbean. Besides, they also not interacted well to maintain organic carbon, nitrogen and potassium.



*C_1 = maize sole, C_2 = maize+mashbean, P_1 = normal planting, P_2 = paired planting, F_0 = control, F_1 = 100% NPK, F_2 = 100% NPK+PSB+Zn

Fig. 8: Benifit: cost ratio of maize+mashbean intercropping as influenced by various levels.

The interaction "Cropping system × Planting geometry × Fertility Level" was not significant for yield; consequently, it was possible to identify planting geometry and fertility level suitable to maize+mashbean intercropping. Consequently, further studies, for a longer period, with more diversified crops are needed to select planting geometry and fertility level adapted to conservation agriculture.

REFERENCES

A.O.A.C. 1960. Methods of Analysis. Association of Official Agricultural Chemists, Washington, D.C., 9th edition. pp. 15-16.

Dahmardeh, M., Ghanbari, A., Siahsar, B. A. and Ramroudi, M. 2011. Evaluation of forage yield and protein content of maize and cowpea (*Vigna unguiculata* L.) Intercropping. Iranian J. Crop Sci., 13: (4) 658-670.

Dwivedi, A., Singh, A., Kumar, V., Naresh, R.K., Tomar S.S. and Dev, I. 2015. Population studies, phenology and quality of mashbean and maize as influenced by planting geometry and nutrient management under intercropping system, Prog. Agric., 15(1): 95-98.

Dwivedi, S. K., Shrivastava, G. K. and Shrivatava, A. 2012. Nodulation, nutrient uptake and yield of maize+blackgram intercropping system in Vertisols under rainfed condition. Current Adv. Agri. Sci., 4(2): 139-143.

Geren, H. Avcioglu, R. Soya, H. and Kir, B. 2008. Intercropping of corn with cowpea and bean: Biomass yield and silage quality, Afr. J. Biotechnol., 7: 4100-4104.

Gomez, K. A. and. Gomez, A. A. 1984. Statistical procedure for Agricultural Research, An International Rice Research Institute Book. John Willey and Sons, 2nd edition, pp. 329.

Jeyakumaran, J. and Seran, T. H. 2007. Studies on intercropping capsicum (*Capsicum annum* L.) with bushitao (*Vigna unguiculata* L.). Proceedings of the 6th Annual Research.

Kumar, A. and Thakur, K. S. 2009. Effect of intercropping *in-situ* green manures and fertility levels on productivity and soil nitrogen balance in maize (*Zea mays*)-gobhi sarson (*Brassica napus*) cropping system. Ind. J. Agric. Sci., 79(9): 758-762.

Lithourgidis, A. S. Dhima, K. V., Vasilakoglou, I. B., Dordas, C. A. and Yiakoulaki, M. D. 2007. Sustainable production of barley and wheat by intercropping common vetch. Agron. Sustain. Dev., 27: 95-99.

Page, A. L. 1982. Methods of Soil Analysis: Part 2. Chemical and Microbiological Properties. American Society of Agronomy, Soil Science Society of America, Madison, WI, USA.

Pathak, K. and Singh, N. P. 2008. Growth and yield of blackgram (*Phaseolus mungo*) varieties under intercropping system with maize (*Zea mays*) during rainy season in northern India. J. Farming Systems Res. Dev., 14(1): 29-34.

Rubapathi, K., Rangasamy, A. and Chinnusamy, C. 2004. Nutrient uptake pattern of sorghum and redgram influenced by sorghum-based intercropping system in rainfed vertisols. J. Ecobiol., 16(2): 137-141.

Sadashiv, B. N. 2004. Production potential of hybrid cotton (*Gossypium hirsutum*) based vegetable intercropping systems under irrigation. M.Sc. Thesis, University of Agricultural Sciences, Dharwad, India.

Sanginga, N. and Woomer, P. L. 2009. Integrated Soil Fertility Management in Africa: Principles, Practices and Development Process, Tropical Soil Biology and Fertility. Institute of the International Centre for Tropical Agriculture, Nairobi.

Seran, T. H. and Brintha, I. 2009. Studies on determining a suitable pattern of capsicum (*Capsicum annum* L.)-vegetable cowpea (*Vigna unguiculata* L.) intercropping. Karnataka J. Agric. Sci., 22: 1153-1154.

Thavaprakaash, N. K. and Velayudham, V. B. 2005. Effect of crop geometry, intercropping systems and integrated nutrient management practices on productivity of baby corn (*Zea mays* L.) based intercropping systems. Res. J. Agric. Biol. Sci., 1(4): 295-302.

Tripathi, A. K., Dubey, A. P., Awasthi, U. D., Tripathi, B. N. and Somendranath, 2008. Growth and dry-matter partitioning of winter maize (*Zea mays*) as influenced by intercropping. Current Adv. Agric. Sci., 4(1): 20-24.