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Effect of mustard (*Brassica juncea* L.) + faba bean (*Vicia faba* L.) intercropping systems on growth, yield attributes, yield and economics of faba bean

RS Singh, Manoj Kumar, CS Chaudhary, Amalendu Kumar and IB Pandey

Abstract
An experiment was conducted during *rabi* seasons of 2015-16 to 2016-17 to study the effect of intercropping system of faba bean (*Vicia faba* L.) with Indian mustard (*Brassica juncea* L.) on growth, yield, yield attributes and monetary return of faba bean at the research farm of Tirhut College of Agriculture, Dholi under Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. There were ten treatments, *viz*. [T_1-(Sole mustard), T_2 -(Sole faba bean), T_3- (Mustard+Faba bean in 1:1), T_4- (Mustard+Faba bean in 1:2), T_5- (Mustard+Faba bean in 1:3), T_6- (Mustard+Faba bean in 1:4), T_7- (Mustard+Faba bean in 1:5), T_8- (Mustard+Faba bean in 2:4), T_9- (Mustard+Faba bean in 2:5) and T_{10}- (Mustard+Faba bean in 2:6)] under replacement series in different row combinations. Intercropping system in different row combinations resulted in significant effect on growth, yield, yield attributes and monetary return with the highest number of branches per plant (5.0), number of pods per plant (30.9), number of grains per pod (2.21), grain yield per plant (33.67 g), 100-grain weight (28.94 g) of faba bean, faba bean equivalent yield (3802 kg /ha) and net return (Rs.92470/ha) of intercropping system recorded under T_9 (faba bean intercropped with Indian mustard in 2: 5 row ratio) which was significantly superior to sole faba bean, sole mustard, intercropping systems of faba bean with mustard in 1: 1, 1: 2 and 1: 3 row ratios with respect to faba bean equivalent yield and monetary returns. Significantly lowest value of branches per plant (3.8), number of pods per plant (22.4), number of grains per pod (2.16), grain yield per plant (23.49 g), 100-grain weight (27.89 g) of faba bean, faba bean equivalent yield (3257 kg/ha) and lowest net return (Rs.76419/ha) was associated with 1: 1 row ratio of mustard with faba bean. Intercropping systems of mustard + faba bean in 2:4, 2:5 or 2:6 row combinations with paired rows of mustard established better performance than intercropping system of Mustard + faba bean in 1:1, 1:2, 1:3 or 1:4 row ratios.

Keywords: Intercropping, faba bean, Indian mustard, growth, yield, net return

Introduction
Intercropping is an agroecological land management practice where at least two crop species are grown on the same field at the same time (Wezel *et al*., 2014) [6]. In the changing climatic condition all over the world and prevailing cereal-cereal cropping system in India, diversification of crops in a planned way has become imperative to get different food crops especially cereals, oilseeds and pulses to ensure food and nutrition security, to enhance crop productivity with respect to land and time, to reduce the risk of crop failure, to enhance the income of the farmers, to increase the use efficiencies of costly resources, to minimize environmental pollution by chemicals, to reduce diseases, pests and weed problems, to generate employment and its uniform distribution over time and several other direct and indirect benefits in an eco-friendly and sustainable manner. It is one of the most important leguminous crops of the world only next to soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) (Mihailovic *et al*., 2005). Its green and tender pods are mainly consumed as vegetables and its dry cotyledons/grains are excellent source of lysine rich protein (Bond, 1976; Hawtin and Hebblethpiait, 1983; Abde L, 2008) [2, 4, 1].

Keeping these facts in views, an experiment involving faba bean intercropped with Indian mustard in different row combinations was conducted at the Agricultural Research Farm of Tirhut College of Agriculture, Dholi under Dr. Rajendra Prasad Central Agrcultural University, Pusa, Bihar to study the effect of intercropping system of faba bean (*Vicia faba* L.) with Indian mustard (*Brassica juncea* L.) on growth, yield, yield attributes and monetary return of faba bean.

Materials and Methods

The experiment was conducted at the Agricultural Research Farm (25.98º N latitude, 85.60º E longitude and 52.10 MSL altitude) of Tirhut College of Agriculture, Dholi under Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar) during *rabi* seasons of 2015-16 and 2016-17. Representative soil samples were taken from the experimental field and were subjected to various mechanical, physical and chemical analysis to assess the physical and chemical properties of soil. The soil of the experimental site was calcareous alluvium in nature and alkaline in reaction. The soil of the experimental plot was sandy loam in texture. Experimental site was situated almost in the middle of the Indo-Gangetic Alluvial Plain having deep, flat and well drained alluvial soils, moderately fertile being low in organic carbon (0.39%), available nitrogen (218.6 kg/ha), phosphorus (16.42 kg/ha), and potassium (137.3 kg/ha. The pH value of the soil was 8.2. Treatments consisted of eight different row combinations of mustard with faba bean intercroppings including two sole crops of mustard and faba bean i.e., [T_1-(Sole mustard), T_2 - (Sole faba bean), T_3- (Mustard+Faba bean in 1:1), T_4- (Mustard+Faba bean in 1:2), T_5- (Mustard+Faba bean in 1:3), T_6- (Mustard+Faba bean in 1:4), T_7- (Mustard+Faba bean in 1:5), T_8- (Mustard+Faba bean in 2:4), T_9- (Mustard+Faba bean in 2:5) and T_{10}- (Mustard+Faba bean in 2:6)]. Test varieties taken of Indian mustard and faba bean were - Rajendra Sufalam and Local, respectively. Recommended package of practices were adopted for raising the crops.

Results and Discussion

Crop growth parameters

Plant growth parameters *viz*. plant height (cm), number of branches per plant were significantly influenced by different row combinations of mustard + faba bean. Under the influence of competition for various growth factors and the effect of one plant on another, growth parameters of bakla like - plant height and number of branches/plant varied markedly (Table-1 and Fig. 1). All these factors have direct or indirect effect on leaf and leaf area that receives the solar energy for dry matter production.

Plant height recorded under sole crop of faba bean was comparable with all other treatments except row combination of mustard + faba bean in 1: 1 row ratio which might be due to severe competition for growth factors specially above ground factors particularly sunlight and in response faba bean plants might have tried to compensate by increasing its height. Unlike plant height, number of branches per plant under sole faba bean was significantly higher than all other row combinations except T6, T7, T8, T9 and T10 which were found at par among themselves which may be due to lesser competition offered by mustard plants in which four or more rows of faba bean were adjusted after single row of mustard or between paired row planting of mustard. Significantly least value of branches per plant was observed under T3 in which 1: 1 row ratio of Indian mustard and faba bean might have felt maximum competition for growth factors and mustard plant might have suppressing and shading effect more on faba bean plants. Number of pods/plant was also significantly influenced by different row combinations of mustard + faba bean intercropping systems and it follows the similar trend as was for number of branches/plant may due the reasons of competition for growth resources like-light, moisture, nutrients and space between mustard and faba bean plants.

Table 1: Plant height, number of branches/plant, number of pods/plant and number of grains/pod of faba bean as affected by mustard + faba bean intercropping system.

Treatments	Plant height (cm)	No. of branches/plant	No. of Pods/plant	No. of Grains/pods	Plant population (%)	
					Mustard	Faba bean
T1(Sole mustard)					100	-
T2 (Sole faba bean)	73.4	5.3	33.7	2.24	-	100
T3 (M+B in 1:1)	80.6	3.8	22.4	2.16	50	50
T4 (M+B in 1:2)	79.2	4.6	26.8	2.17	33.3	66.7
T5 (M+B in 1:3)	76.6	4.7	30.0	2.18	25	75
T6 (M+B in 1:4)	74.4	4.8	30.4	2.20	20	80
T7 ((M+B in 1:5)	74.1	5.0	30.5	2.21	16.7	83.3
T8 (M+B in 2:4)	75.3	4.9	30.2	2.21	33.3	66.7
T9 (M+B in 2:5)	74.5	5.0	30.9	2.20	28.6	71.4
T10 (M+B in 2:6)	74.3	5.0	31.1	2.22	25	75
S.Em (±)	2.1	0.07	1.1	0.02	---	---
CD (p=0.05)	6.3	0.20	3.3	0.07	---	---

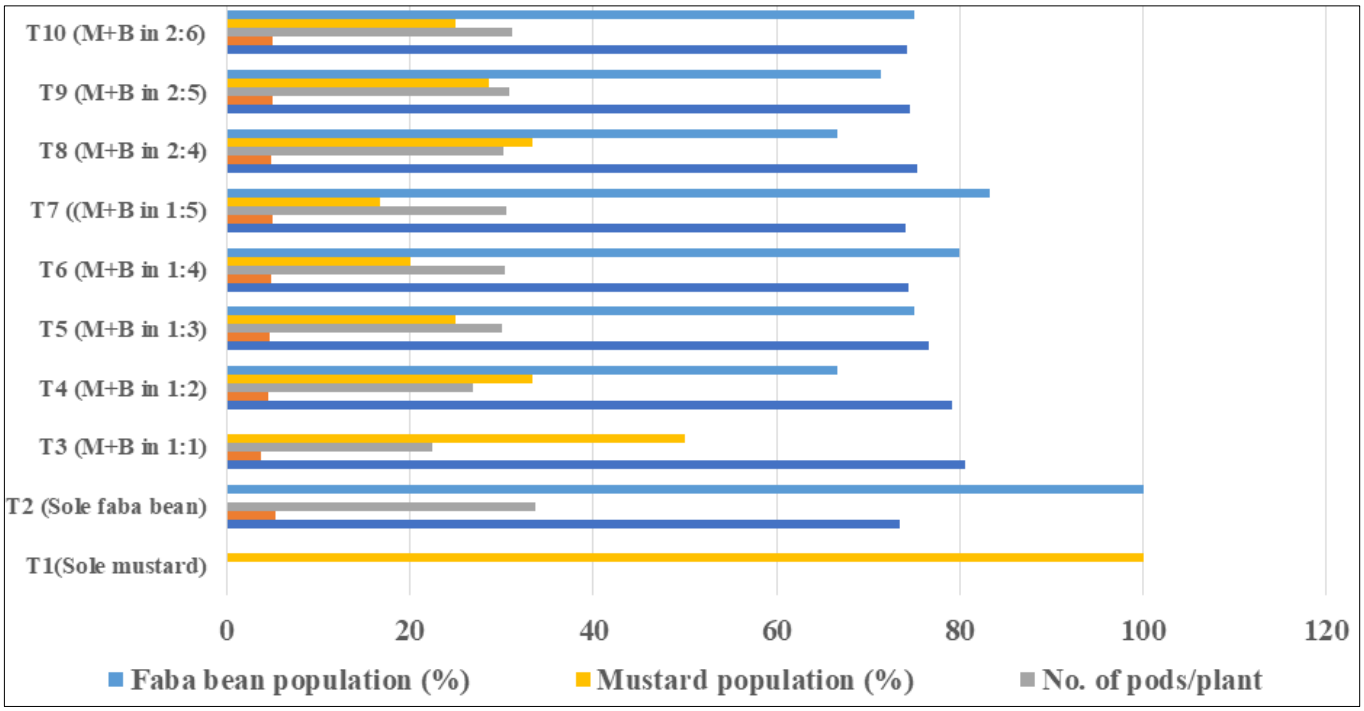

Fig 1: Plant height, number of branches/plant and, number of pods/plant, of faba bean as affected by plant population or mustard + faba bean intercropping system

Yield and yield attributes

Yield attributing characters are mainly dependent on the foundation laid down by different growth characters which mainly contribute in increasing the leaf area of plants that receives solar energy for dry matter production affecting different yield attributing characters. The cumulative effect of different yield attributes is ultimately reflected in the yield of a crop. Yield attributing characters *viz*.- number of pods/plant, number of grains/pod and 100-grain weight and yield were significantly influenced by different row combinations of Indian mustard and faba bean (Table-2 and fig.2). Number of pods and number of grains per plant were significantly affected by different row combinations of mustard + faba bean intercropping systems.

Significantly highest value of number of pods/plant (33.7) was recorded in sole/pure faba bean than T3, T4, T5 and T8 but was found at par with T6, T7, T9 and T10. Lowest value of number of pods/plant (22.4) was found in T3 which was significantly lower than all other treatments. Number of grains/plant didn't varied significantly among different treatments except T3 which might be due to severe competition for growth factors and shading and suppressing effect of mustard on faba bean.

Grain yield/plant and of faba bean was also affected significantly due to different row combinations with mustard. Grain yield realized under sole faba bean was significantly superior than all other treatments of row combinations except T7, T9 and T10 which may be due to lesser competition for growth factors between faba bean and mustard as compared to other treatments that might have led to better growth and yield characters which resulted in higher grain yield/plant. The minimum grain yield/plant of faba bean was recorded in T3 Faba bean equivalent yield recorded in T9 where mustard and faba bean was sown in 2: 5 row ratio was significantly superior than all other treatments of different row ratios and sole cropping of mustard and soybean except T7, T8 and T10 may be due to better performance of growth as well as yield attributing characters of both crops that reflected into ultimate realization of equivalent yield of faba bean. Yield advantage of intercropping in terms of faba bean equivalent yield was up to 16.6 per cent in T9 as compared to sole cropping of faba bean. Similar findings were also reported by Hunady and Hochman (2014) [5]. Significantly lowest faba bean equivalent yield was calculated in T3 might be due to poor performance of growth and yield attributing characters of both crops especially of faba bean that resulted into lowest equivalent yield. In fact, the reason of high equivalent yield of crop in intercropping systems is the efficient utilization of environmental resources such as light, water, nutrients, space and nitrogen fixation by faba bean and its partial utilization by the intercrops than in sole cropping. Similar results were also reported by Esmaeil *et al*.,(2010) [3] from Maize + Faba bean intercropping system.

Table 2: Grain yield/plant, 100-grain weight, yield of mustard, yield of faba bean, faba bean equivalent yield (FBEY), net return and B:C ratio of the system as affected by mustard + faba bean intercropping system.

Treatments	Grain yield/plant (g)	100-grain wt.(g)	Yield (kg/ha)			Net return (Rs./ha)	B: C ratio
			Mustard	Faba bean	FBEY		
T1(Sole mustard)	6.54	0.47	1964	---	3367	83219	2.40
T2 (Sole fababean	37.11	29.01	---	3162	3162	78803	2.47
T3 (M+B in 1:1)	23.49	27.89	1086	1395	3257	76419	2.03
T4 (M+B in 1:2)	27.61	28.12	743	2022	3296	78304	2.11
T5 (M+B in 1:3)	30.97	28.41	587	2366	3372	81242	2.21

T6 (M+B in 1:4)	32.88	28.44	496	2583	3433	83533	2.28
T7 ((M+B in 1:5)	34.26	28.53	443	2734	3493	85741	2.35
T8 (M+B in 2:4)	32.23	28.47	803	2316	3693	92194	2.49
T9 (M+B in 2:5)	33.67	28.54	713	2474	3696	92470	2.51
T10 (M+B in 2:6)	34.23	28.62	599	2644	3671	91692	2.49
S.Em (±)	1.4	---	---	---	69	1891	0.07
CD (p=0.05)	4.1	NS	---	---	208	5673	0.21

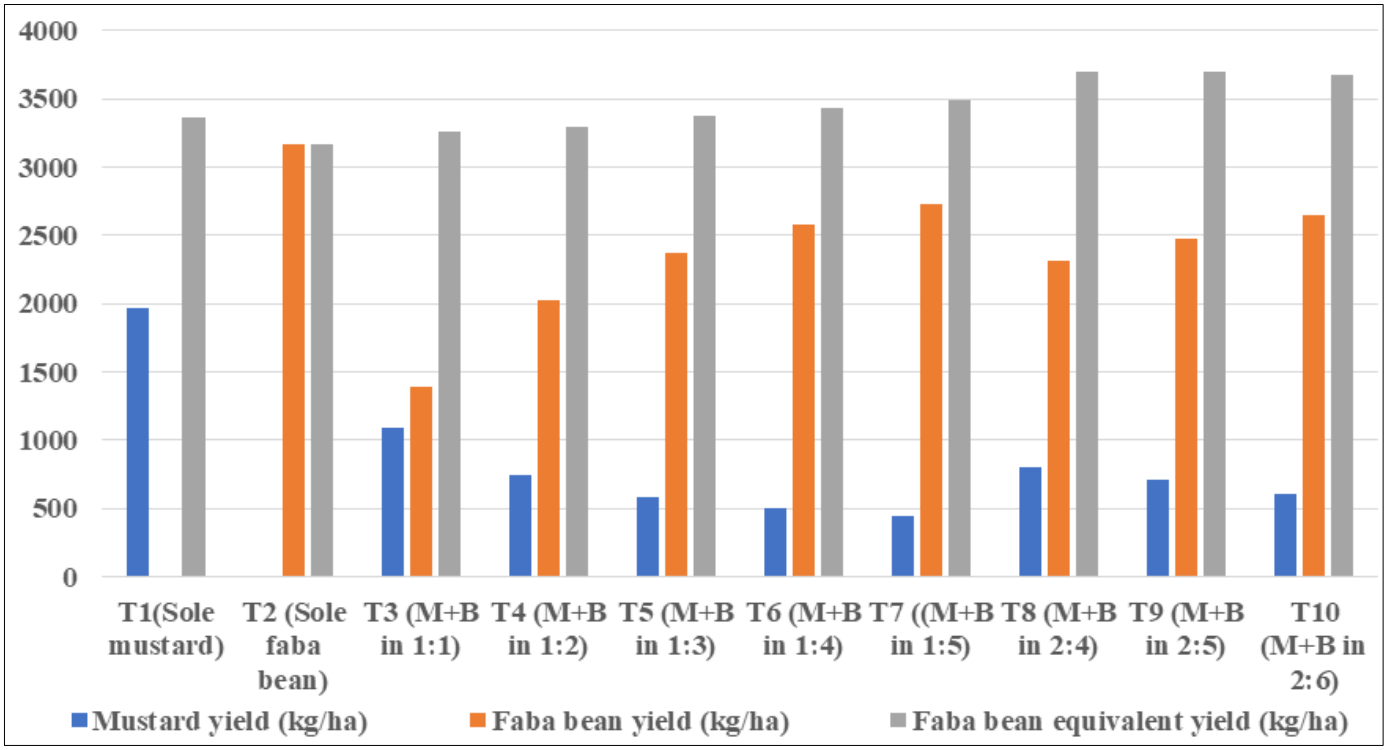

Fig 2: Yield of mustard, yield of faba bean and faba bean equivalent yield (FBEY) of the system as affected by mustard + faba bean intercropping system

Economics

Net return followed the similar trend to that of faba bean equivalent yield which was affected significantly due to treatments of different row ratio combinations including sole cropping of mustard and soybean. Highest net return (Rs.92470/ha) was obtained in T9 which was significantly higher than rest of the treatments but was found at par and closely followed by T6, T7, T8 and T10 obviously may be due to highest faba bean equivalent yield and gross return. Economic advantage of intercropping in terms of net return was up to 21.0 per cent in T9 as compared to sole cropping of faba bean. Lowest net return (Rs.76419/ha) was recorded in T3 which was significantly lower than all other treatments but was found comparable with T2, T4 and T5. B:C ratio of different treatments followed almost similar trend to that of net return may be due to proportionately similar values of net return and cost of cultivation.

Conclusion

Based on two years data of performance of growth and yield attributes and economic indices like - net return and B:C ratio, it can be concluded that faba bean can be taken as an intercrop with mustard in row ratio of 1:5, 2:5 or 2:6 for higher productivity and net return per unit area and time, efficient nitrogen enrichment of soil with the minimum risk of crop failure.

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