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Performance of *kharif* pulses and sesame as influenced by intercropping systems and integrated nutrient management

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Abstract
A field experiment comprising twenty treatment combinations replicated three times, was conducted in Randomized Block Design with five intercropping systems [sole mungbean, sole mothbean, sole sesame, mungbean + sesame in 2:1 paired row ratio and mothbean + sesame in 2:1 paired row ratio] and four treatments of integrated nutrient management (100 % RDF through fertilizer, 75% RDF through fertilizer + 25% RDF through vermicompost, 50% RDF through fertilizer + 50% RDF through vermicompost and 100% RDF through vermicompost) during *kharif*, 2015 at Jobner (Rajasthan). Results indicated that sole mungbean and mothbean recorded significantly higher yield attributes *i.e.* pods/ plant and seeds/ pod as compared to different row ratios. Significantly higher seed (1161 kg/ha and 888 kg/ha) and straw (2403 kg/ha and 1800 kg ha^{-1}) yields were observed in sole mungbean and mothbean respectively which was 20.8 and 23.2 percent and 25.3 and 25.4 per cent higher as compared to intercropping in 2:1 PR row ratios. The planting of sesame in 2:1 PR ratio gave significantly more capsules/ plant and seeds/ capsule over sole sesame. The sole sesame recorded significantly highest seed (720 kg/ha) and stick yields (2450 kg/ha) as compared to different row ratios. The increase in seed yield of sole sesame was 99.4, and 89.5 per cent as compared to mungbean + sesame (2:1) PR and mothbean + sesame (2:1) PR ratios, respectively. Application of 50% RDF through fertilizer + 50% RDF through vermicompost recorded significant improvement in yield attributes *i.e.* pods/ plant, seeds/ pod, seed and straw yields of mungbean and mothbean and capsules/ plant, seeds/ capsule, seed and stick yields of sesame. Application of 50% RDF through fertilizer + 50% RDF through vermicompost increased seed yield of mungbean by 10.0 and 14.3 per cent and moth bean by 10.4 and 14.1 percent and sesame by 10.1 and 16.7 per cent, respectively compared to 100% RDF through fertilizer and 100% RDF through vermicompost and remained at par with application of 75% RDF through fertilizer + 25% RDF through vermicompost. Intercropping in mungbean + sesame (2:1) PR ratio, gave significantly highest mungbean equivalent yield (1316 kg/ha) and net returns (□ 78656/ha) as compared to other intercropping systems.

Keywords: Intercropping, Integrated nutrient management, Mothbean, Mungbean, Planting pattern, Sesame

Introduction
Pulses are the main source of protein particularly for vegetarians and occupy a unique position in every known system of farming as main, cover, green manure, intercrop and their inclusion in crop rotation keep the soil alive, productive and improve physical properties of soil by virtue of their biological nitrogen fixation, deep root system and leaf fall. Oilseeds also occupy important place in Indian economy. Greengram [*Vigna radiate* (L.) Wilczek], Mothbean (*Vigna aconitifolia* (Jacq.) Marechal) and sesame (*Sesamum indicum* L.) are the most important pulse and oilseed crops grown in rainfed areas of Rajasthan where the probability of crop failure is higher due to frequent occurrence of aberrant weather conditions. The scope for increasing the area under irrigation in the Rajasthan state is limited and in dry farming regions, only one season is available for taking crops. In such areas, increasing the cropping intensity is only the practice which may contribute to production and productivity by way of better and efficient utilization of available resources. Intercropping is one of the most important technique which embodies growing of crop under different plant geometry. To avoid the risk of sole crop, adoption of intercropping is more safe and profitable cropping system for increasing the total production and net profit per unit area. Intercropping offers to farmers the opportunity to engage nature's principles of diversity at his farm (Ghosh, 2004) [2].

Legumes offer excellent compatible combination for mixing with oilseeds to minimize the competition and to confer a symbiotic association to achieve the prime aim of maximum use of available resources. The integration of chemical fertilizers with organic manures have been found to be quite promising not only in maintaining higher productivity but also providing greater stability in crop production (Nambiar and Abrol, 1992) [6]. Vermicompost has been advocated as a good source of organic manure for use in integrated management practices for field crops. A judicious combination of organic and inorganic fertilizers can maintain long term fertility and sustain higher productivity of crops. Therefore, the study aimed to determine the compatibility of sesame for intercropping with *kharif* pulses under varying level of fertilizer and vermicompost under rainfed conditions.

Materials and methods

A field experiment comprising twenty treatment combinations replicated three times, was conducted in Randomized Block Design with five intercropping systems [sole mungbean, sole mothbean, sole sesame, mungbean + sesame in 2:1 paired row ratio and mothbean + sesame in 2:1 paired row ratio] and four treatments of integrated nutrient management (100 % RDF through fertilizer, 75% RDF through fertilizer + 25% RDF through vermicompost, 50% RDF through fertilizer + 50% RDF through vermicompost and 100% RDF through vermicompost) during *kharif*, 2015 at S. K. N. College of Agriculture, Jobner (Rajasthan). The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), low in organic carbon (0.14%), available nitrogen (130 kg/ha), available phosphorus (16.52 kg P_2O_5/ha) and medium in potassium (151.8 kg K_2O/ha) content. The crops were sown on 5th July 2015 in lines 30 cm apart for sole crops. In intercropping situation, after pairing two rows of mothbean at 20 cm leaving the space of 40 cm in between pairs, one row of sesame was sown in 2:1 paired row intercropping system. The mugbean 'RMG-492' mothbean 'RMO-257' and sesame 'RT-46' were raised with recommended package of practices. Integrated nutrient management through fertilizer (DAP and Urea) and vermicompost was applied in the soil before sowing in plots as per treatments. Yield of *kharif* pulses and sesame were computed from the plants of net plot in each treatment. The economics and mothbean equivalent yield (MEY) were computed at prevailing market rates of different commodities during 2015.

Results and discussion

Intercropping

Results (Table 1) indicated that sole planting of mungbean and mothbean gave significantly higher pods/ plant and seeds/ pod as compared to 2:1 PR ratios. The sole mungbean and mothbean produced 18.0 and 11.5 per cent and 17.7 and 24.5 per cent more pods/ plant and seeds/ pod compared to 2:1 PR ratio, respectively. Reduction in yield attributes under intercropping might be due to competition between the component crops for nutrients, light and water as compared to sole mothbean. Significantly 20.8 and 23.2 per cent and 25.3 and 25.4 per cent higher seed (1161 kg/ha and 888 kg/ha) and straw (2403 kg/ha and 1800 kg/ha) yields of mungbean and mothbean were observed under sole mungbean and mothbean over the intercropping system of 2:1 PR ratio respectviely. A significant reduction in seed and straw yields of mungbean and mothbean were recorded due to intercropping with sesame over sole crop. The reduction in seed and straw yields of *kharif* pulses in all intercropping systems over sole mungbean and mothbean was primarily due to low plant population of *kharif* pulses in intercropping treatments. The seed and straw yields being the function of growth and yield attributes, reduced with the reduction in these parameters under influence of intercropping. These results are in close conformity with those of Goud and Andhalkar (2012) [3] who reported significant reduction in yield of pigeon pea when intercropped with soybean. Prajapat *et al.* (2011) [7] also reported reduction in seed yield of mungbean when intercropped with sesame as compared to their sole stand.

Sesame as an intercrop gave significantly higher capsules/ plant and seeds/ capsule as compared to sole sesame (Table 1). The planting of sesame with mothbean 2:1 PR ratio and at par with mungbean with 2:1 row ratio, produced significantly 18.6 and 13.5 per cent higher capsules/ plant and seeds/ capsule, respectively as compared to sole sesame. It might be due to conducive environment created by main crop (*kharif* pulses) as it fixed atmospheric nitrogen and increased its availability in soil which might have also been utilized partly by sesame plants for better growth and development and ultimately increased the growth and yield attributes. Prajapat *et al.* (2012) [8] also reported increase in yield attributes of sesame when intercropped with mungbean as compared to sole cropping. However, planting of sole sesame gave significantly highest seed yield (720 kg/ha) and stick yield (2450 kg/ha) as compared to different row ratios. The increase in seed yield of sole sesame was 99.4 and 89.5 per cent over mungbean + sesame (2:1) PR and mothbean + sesame (2:1) PR ratios, respectively.

Integrated nutrient management

Application of 50 % RDF through fertilizer + 50% RDF through vermicompost recorded significantly higher pods/plant, seeds/ pod, seed and straw yields of *kharif* pulses (Table 1) over rest of the treatments and remained at par with 75 % RDF through fertilizer + 25% RDF through vermicompost. Application of 50 % RDF through fertilizer + 50% RDF through vermicompost increased seed and straw yield of mungbean by 10.0 and 14.3 per cent and mothbean by 10.4 and 14.1 percent, respectively over 100% RDF through fertilizer and 100% RDF through vermicompost and remained at par with application of 75% RDF through fertilizer + 25% RDF through vermicompost. Whereas, Application of 75% RDF through fertilizer + 25% RDF through vermicompost also produced significantly higher seed and straw yield which was 11.8 and 10.1 per cent and 11.3 and 10.3 per cent higher over 100% RDF through vermicompost. Application of 50 % RDF through fertilizer + 50% RDF through vermicompost recorded significant improvement in capsules/ plant, seeds/ capsule, seed and stick yields of sesame. Application of 50 % RDF through fertilizer + 50% RDF through vermicompost increased seed yield of sesame by 10.1 and 16.7 per cent and stick yield by 9.4 and 12.4 per cent, respectively 100% RDF through fertilizer and 100% RDF through vermicompost and remained at par with application of 75% RDF through fertilizer + 25% RDF through vermicompost. Application of 75% RDF through fertilizer + 25% RDF through vermicompost also produced significantly higher seed and stick yield which was 12.1 and 10.8 per cent per cent higher over 100% RDF through vermicompost. The efficacy of inorganic fertilizer is much pronounced when it is combined with organic manure. The increased vegetative growth and the balanced C:N ratio might have increased the synthesis of carbohydrates, which ultimately promoted yield. The important factors considered

to reaping better production were mainly due to supply of nutrients in balanced form and in adequate amount. The increase in yield attributes and yields (seed and stick) under combination of organic and inorganic fertilizer is obvious from the fact that application of improved overall nutritional environment of the rhizosphere as well as in the plant system, which in turn enhanced the plant metabolism and photosynthesis activity resulting into better growth and development of plants and ultimately the yields. The present trend of increase in yield is in close conformity with the findings of Jaishankar and Wahab (2005) [4], and Choudhary *et al*. (2011) [1] and Shivran *et al*. (2015) [9].

Mungbean equivalent yield and economic returns

The intercropping system productivity measured as mungbean equivalent yield (MEY) was significantly higher in mungbean + sesame 2:1 PR ratio ((1316 kg/ha)) which was 13.3, 43.0, 88.0 and 94.1 per cent higher as compared to mungbean sole, mothbean + sesame (2:1) PR ratio, sole sesame and mothbean, respectively (Table 1). Similarly, The sole mungbean also increased mungbean equivalent yield significantly by 29.2, 65.9 and 71.2 per cent when compared to mothbean + sesame (2:1) PR ratio, sole sesame and mothbean, respectively. The mothbean + sesame (2:1) PR ratio also gave significantly higher mungbean equivalent yield which was 31.4 and 35.7 per cent higher over sole sesame and mothbean, respectively.

Intercropping in mungbean + sesame 2:1 PR ratio also recorded 15.2, 64.5, 153.2 and 159.5 per cent higher net returns (□ 78656/ha) as compared to mungbean sole, mothbean + sesame (2:1) PR ratio, sesame sole and mothbean sole, respectively. The mungbean sole also increased net returns significantly by 42.8, 119.8 and 125.4 per cent as compared to mothbean + sesame (2:1) PR ratio, sesame sole and mothbean sole, respectively. This was due to higher production per unit area in intercropping and higher price of produce compared to sole cropping (Prajapat *et al*., 2012) [8].

Application of 50% RDF through fertilizer + 50% RDF through vermicompost fetched significantly maximum mungbean equivalent yield (1018 kg/ha) and net returns (□ 55803/ha). These findings are in accordance with the results reported by Choudhary *et al*. (2011) [7], Kumar *et al*. (2013) [5] and Shivran *et al.* (2015) [9].

It was concluded that intercropping of that mungbean-sesame (2:1) paired row ratio produced maximum mungbean equivalent yield (1316 kg/ha and net returns (□ 78656/ha). Application of 50% RDF through fertilizer + 50% RDF through vermicompost fetched significantly maximum mungbean equivalent yield (1018 kg/ha) and net returns (□ 55803/ha).

Table 1: Performance of *kharif* pulses and Sesame as Influenced by Intercropping Systems and Integrated Nutrient management

Treatments	Mungbean				Mothbean				Sesame				MEY (kg ha-1)	Net returns (Rs ha-1)
	Pods/ plant	Seeds / pod	Seed yield (kg ha-1)	Straw yield (kg ha-1)	Pods/ plant	Seeds / pod	Seed yield (kg ha-1)	Straw yield (kg ha-1)	Capsules/ plant	Seeds/ Capsules	Seed yield (kg ha-1)	Stick yield (kg ha-1)		
Cropping systems														
Mungbean sole	17.00	11.30	1161	2403	-	-	-	-	-	-	-	-	1161	68300
Mothbean sole	-	-	-	-	34.25	5.46	888	1800	-	-	720.5	2598.2	678	30306
Sesame sole	-	-	-	-	-	-	-	-	26.71	42.63	720	2450	700	31066
Mungbean + Sesame (2:1)	14.40	9.60	965	1919	-	-	-	-	30.31	45.37	361	1274	1316	78656
Mothbean + Sesame (2:1)	-	-	-	-	30.72	4.80	721	1435	31.70	46.26	380	1343	920	47829
CD (P=0.05)	1.12	0.69	56	90	1.72	0.20	45	105	1.90	2.53	36	101	55	2635
B. Integrated nutrient management														
100% RDF (fertilizer)	15.00	10.20	1030	2105	31.55	4.99	779	1567	28.85	43.23	475	1650	927	51692
75% RDF (fertilizer) + 25% RDF (VC)	16.40	10.60	1098	2229	33.47	5.29	827	1654	30.30	46.12	502	1737	988	54938
50% RDF (fertilizer) + 50% RDF (VC)	17.40	11.40	1133	2307	34.39	5.48	860	1749	32.28	48.12	523	1783	1018	55803
100% RDF (VC)	14.00	9.60	991	2003	30.52	4.76	751	1500	26.87	41.53	448	1586	887	42492
CD (P=0.05)	1.58	0.98	80	128	2.43	0.28	64	149	2.19	2.92	42	117	49	2357

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