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PEARLMILLET AND MUNGBEAN INTERCROPPING AS INFLUENCED BY VARIOUS ROW RATIOS UNDER CUSTARD APPLE ORCHARD OF VINDHYAN REGION

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ABSTRACT

A field experiment was conducted during 2010-11 to study the "Pearlmillet and Mungbean intercropping as influenced by various row ratios under custard apple orchard of vindhyan region". The highest grain wt. (14.25g)/ear head, test weight (8.56g), ear diameter (3.13cm), ear length (14.25cm) and ear wt. (31.15g) of pearlmillet and pod length (5.47cm), number of pod/plant (12.57) and number of grain/pod (8.03), test weight (44.33g) of mungbean were recorded under pearlmillet + mungbean (2:2) in intercropping row ratio. Whereas grain yield (1568.40 kg/ha), straw yield (5192.23 kg/ha), biological yield (6760.63 kg/ha) and mean pearlmillet grain equivalent yield (4817.03 kg/ha) of pearlmillet and grain yield (696.14 kg/ha), straw yield (1853.29 kg/ha), biological yield (2549.43 kg/ha) of mungbean were highest under pearlmillet sole and mungbean sole as compared to intercropping row ratio. Similarly, nitrogen in grain and phosphorus in grain, straw and total nitrogen and phosphorus uptake were maximum in pearlmillet sole and mungbean sole as compared to other treatments. The maximum nitrogen uptake in straw (23.44 kg/ha), protein content in pearlmillet (11.94%) and mungbean grain (23.82%), land equivalent ratio (1.04) and relative crowding coefficient of pearlmillet (1.74) and mungbean (2303.23) were observed in pearlmillet + mungbean (2:2) in intercropping row ratio. The highest aggressivity (7.58) was recorded in treatment pearlmillet + mungbean (2:1) in intercropping row ratio as compared to other treatments.

INTRODUCTION

Inspite of very substantial gains in agriculture production over the past few decades, the task of meeting the food grains, feed, fodder and fuel needs of increasing human and livestock population remains a formidable challenge before scientific community. In the present situation, increasing agricultural production through extensive agriculture has limited scope due to limited availability of cultivable area. An area of 143.8 million ha out of 329 million of geographical area is at present under cultivation and further expansion of cultivable area is extremely difficult. Under these circumstances, to meet the requirement of food grains for ever increasing population, the only option open is through time and space utilization in agriculture (Sankaran and Rangaswamy, 1990). Rainfed horticulture along with arable crops/fodders is ideal for controlling land degradation. In rainfed areas, the competition between trees and crops for water is a major problem. In agri-horti system, short duration arable crops raised in the interspaces of fruit trees provide seasonal revenue. Intercropping has been recognized as a potentially beneficial system of crop production and evidences indicate that intercropping can provide substantial yield advantage compared with pure cropping (willey, 1979). Intercropping plays an important role in the food-production system of developing countries where small farms and labour-intensive operation predominant, greater yield stability over different seasons and increasing yield or monetary returns and improved yields for subsequent crops are common advantages of intercropping. Intercropping has been recognized as a potetional beneficial system of crop production in arid regions. Intercropping is also considered advantageous in the context of increasing demand of household and better and regular employment opportunity to family labour.

Pearl millet is the world's hardiest warm season coarse cereal crop. It can survive even on the poorest soils in the driest regions, on highly saline soils and in the hottest climates. In India, it is fourth most important cereal crop after rice, wheat and sorghum. The food value of pearlmillet is high. Trials in India have shown that pearlmillet is nutritionally superior from human growth when compared to maize and rice. The protein content of pearlmillet is higher than maize and has a relatively high vitamin A content. It is a dual purpose crop, its grain is used for human consumption and its fodder as cattle feed. Among the major crops compatible with Pearlmillet as intercrops, Mungbean [*Vigna radiata* (L.)] is one of them. It is an annual legume of dry and warm habitat and characterized as one of the most drought hardy annual legumes in arid regions. Mungbean with deep fast penetrating root system in commitment with drought avoidance capabilities can survive and thrive upto long period in open fields exhibiting fast depletion of soil moisture coupled with very high atmospheric temperature values. The multi adaptive and adjusting nature of this crop has enabled it to become a crucial part of all type of cropping and farming system of the arid semiarid regions. Mungbean being a leguminous crop has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixation. Being a short duration crop it suits well in various multiple and intercropping systems (Pearlmillet + mungbean intercropping system).Though intercropping of Pearlmillet [*Pennisetum glaucum* (L.)] and Mungbean [*Vigna radiata* (L.)] are the most dominant rainy season (*kharif*) crops of Vindhyan region. Therefore, the present study was undertaken to find out the effect of intercropping treatments with different row ratios on yield, quality, nutrient uptake and efficiency of pearlmillet and mungbean.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season 2010-2011 at the research farm Rajiv Gandhi South Campus, (Banaras Hindu University) Barkachha, Mirzapur and Uttar Pradesh. Mirzapur falls in a belt of semi-arid to sub-humid climate. The climate of this area is predominantly dry (subtropical to dry), winter season is short (December to February) but summer is long (March to November). The temperature rises up to 40^0C or more during summer and drops to 4^0C-7^0C during December to January. The average annual rainfall of Mirzapur is 1059 mm, of which 90% is received by south west monsoon in the third to fourth week of June, which lasts up to end of September. The soil of experimental site was typical red lateritic, slightly acidic with moderate to low level of fertility falling under the textural class of sandy loam. The soil had 5.9 pH, 0.30 dS/m EC, 0.23% organic C, 175.0, 10.5 and 8.10.0 kg/ha available N, P and S content. The experiment was laid out in randomized block design (RBD) with 6 treatments allocation in each replication and was replicated thrice. The experimental treatments comprised T_1= Pearlmillet Sole, T_2= Mungbean sole, T_3 =Pearlmillet + mungbean (1:1), T_4= Pearlmillet + mungbean (2:1), T_5 =Pearlmillet + mungbean (2:2) and T_6 =Pearlmillet + mungbean (Mixed)). Gross plot size was 5.0 m × 4.0 m. The seed of crops were sown @ 5 kg/ha of pearlmillet and 20 kg ha^{-1} of mungbean in lines spaced as per treatments in sole cropping. In intercropping treatments row to row distance maintained was 45 and 10 cm and sowing was done by "*kera*" method in open furrow. The crops were sown on 12 Aug 2010 with the onset of monsoon rains using 'ICMV-155' sorghum and 'HUM-2'mungbean. The recommended fertilizer does for 80 kg N/ha nitrogen was applied through urea and DAP, 40 kg P_2O_5/ha phosphorus through DAP and 40 kg K_2O/ha. Potassium through MOP prior to sowing was applied only in pure crops. In intercropping combinations seed rate and fertilizers were adjusted according to the number of row arrangement. The other agronomic practices were followed as per recommendation.

Experimental design, data collection and analysis

Regarding agronomic characters, five competitive plants were randomly selected from each plot and observations were recorded for growth attributes, yield attributes and yield The data were analyzed as per standard statistical procedure (RBD) suggested by Gomez and Gomez (1984).

Protein content (%)

Protein content (%) in grain was worked out by multiplying the nitrogen content in grain by the factor 6.25 (A.O.A.C.,

Table 1: Effect of different intercropping system on yields and yield contributing characters pearmillet and mungbean

Treatments	Pearlmillet								Mungbean						
	Grain wt. (g)/ ear head	Test wt. (g)	Ear diameter cm	Ear length cm	Ear wt. (g)	Grain yield kg/ha	Straw yield kg/ha	Biological yield kg/ ha	Pod length (cm)	Pods/ plant	grain /pod	Test weight	Grain yield kg/ha	Straw yield kg/ha	Biological yield kg/ha
Pearlmillet Sole	13.28	8.17	2.62	13.65	26.45	1568.40	5192.23	6760.63	-	-	-	-	-	-	-
Mungbean sole	-	-	-	-	-	-	-	-	4.95	9.83	7.10	42.75	696.14	1853.29	2549.43
Pearlmillet + mungbean (1:1)	13.67	8.29	2.75	13.02	26.95	804.31	2658.99	3463.29	5.02	10.70	7.29	43.02	316.43	896.16	1212.58
Pearlmillet + mungbean (2:1)	14.05	8.43	2.88	14.11	27.80	1129.25	3625.80	4755.04	5.27	11.59	7.68	43.89	210.95	472.30	683.25
Pearlmillet + mungbean (2:2)	14.25	8.56	3.13	14.25	31.15	1003.77	3033.06	4036.84	5.47	12.52	8.03	44.33	278.45	667.85	946.31
Pearlmillet + mungbean (Mixed)	12.93	8.05	2.49	12.83	26.01	784.20	2628.80	3413.00	4.64	9.34	6.85	42.19	302.67	946.91	1249.57
SEm ±	0.28	0.42	0.04	0.30	1.04	1.71	12.49	10.95	0.12	0.71	0.29	1.23	0.59	48.95	49.00
C.D.(P=0.05)	0.82	1.23	0.10	0.88	3.03	5.01	36.54	32.05	0.35	2.07	0.84	NS	1.71	143.24	143.38

Table 2: Effect of different intercropping system on nutrient uptake in pearmillet and mungbean

Treatments	Nitrogen uptake (kg/ha)						Phosphorus uptake (kg/ha)					
	Pearlmillet			Mungbean			Pearlmillet			Mungbean		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Pearlmillet Sole	29.67	22.73	52.40	-	-	-	3.70	6.94	10.64	-	-	-
Mungbean sole	-	-	-	17.17	17.30	34.47	-	-	-	1.77	2.53	4.30
Pearlmillet + mungbean (1:1)	13.88	18.52	32.39	11.26	6.89	18.14	2.13	3.81	5.94	0.99	1.36	2.36
Pearlmillet + mungbean (2:1)	24.50	23.78	48.28	6.27	3.98	10.26	3.07	6.11	9.19	0.71	0.74	1.45
Pearlmillet + mungbean (2:2)	15.43	23.84	39.26	9.33	5.26	14.58	3.04	4.77	7.81	1.01	0.86	1.88
Pearlmillet + mungbean (Mixed)	14.24	13.63	27.87	8.94	7.56	16.49	2.14	3.81	5.95	0.83	1.49	2.32
SEm ±	1.53	2.47	2.41	0.80	0.42	0.99	0.14	0.30	0.31	0.06	0.10	0.13
C.D.(P=0.05)	4.49	7.22	7.05	2.35	1.24	2.88	0.40	0.89	0.91	0.19	0.28	0.39

Table 3: Effect of different intercropping system on protein content, competitive function and economics of pearmillet and mungbean

Treatments	Protein content		PGER	LER	AGGRESIVITY	RCC		Net Return	B:C
	Pearlmillet	Mungbean				Pearlmillet	Mungbean	(Rs ha^{-1})	ratio
Pearlmillet Sole	11.06	-	4817.03	1.00	0	-	4817.00	19638	2.07
mungbean Sole	-	20.57	-	1.00	0	-	-	27318	2.31
Pearlmillet + mungbean (1:1)	11.35	21.87	2280.96	0.97	0.58	1.05	2280.96	24344	2.36
Pearlmillet + mungbean (2:1)	11.46	22.24	2113.68	1.02	7.58	1.29	2113.68	23678	2.37
Pearlmillet + mungbean (2:2)	11.94	23.82	2303.23	1.04	2.40	1.78	2303.23	25097	2.46
Pearlmillet + mungbean (Mixed)	11.24	21.73	2196.65	0.94	0.65	1.00	2196.65	23662	2.32
SEm ±	0.02	0.20	2.27	1.73	-	-	2.27	-	-
C.D.(P=0.05)	0.07	0.58	6.65	5.45	-	-	6.65	-	-

1970).

Nutrient uptake

Nutrient uptake in grain and straw of the crops were calculated in kg/ha in relation to yield/ha by using the following formula (Jackson, 1967)

Nutrient uptake (kg/ha) = Nutrient content (%) × yield (q/ha)

Pearlmillet equivalent yield

Seed yield of mungbean was calculated in terms of pearlmillet for all intercropping treatments. On the basis of their market price and then analyzed statistically as equivalent grain yield of pearlmillet treatment using the formula given by Welley and Rao (1980)

$$\text{Pearlmillet grain equivalent yield (kg/ha)} = \frac{\text{Yield of intercrop (kg/ha)} \times \text{Price of intercrop (Rs/kg)} + \text{Pearlmillet grain yield (kg/ha)}}{\text{Price of pearlmillet (Rs/kg)}}$$

Land equivalent ratio

It denotes the relative land area under sole crop required to produce the same yield as obtained under a mixed or an intercropping system at the same management level (Mead and Willey, 1980)

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Yab = is the yield of crop 'a' in association with crop 'b'

Yba = is the yield of crop 'b' in association with crop 'a'

Yaa = is the pure stand yield of crop 'a'

Ybb = is the pure stand yield of crop 'b'

Aggressivity

It gives a simple measure of how much the relative yield increase in crop 'a' is greater than that for crop 'b' in an intercropping system (McGilchrist, 1965).

$$Aab = \frac{Yab}{Yaa\ Zab} - \frac{Yba}{Ybb\ zba}$$

Zab = is the crop 'a' proportion with crop 'b'

Zba = is the crop 'b' proportion with crop 'a'

Relative crowding coefficient

It is a measure of the relative dominance of one component crop over the other in an intercropping system (De Wit, 1960). The coefficient (K) is determined separately for each component crop e.g. for crop 'a' in association with 'b' the coefficient is as

$$Kab = \frac{Yab \times Zba}{(Yaa - Yab) \times Zab}$$

$$Kba = \frac{Yba \times Zab}{(Ybb - Yba) \times Zba}$$

RESULTS AND DISCUSSION

Yield and yield attributes

The different intercropping system had significant influence the yields and yield attributes of pearlmillet. The highest yield attributes *viz*. grain wt. (14.25g)/ear head, test weight (8.56g), ear diameter (3.13cm), ear length (14.25cm) and ear wt. (31.15g) of pearlmillet were recorded in pearlmillet + mungbean with 2:2 row ratio followed by pearlmillet + mungbean with 2:1 row ratio. Whereas maximum grain (1568.40 kg/ha), straw (5192.23 kg/ha) and biological yields (6760.63 kg/ha) were recorded pearlmillet sole as compared to among intercropping system. It might be due to the fact that legume intercrops were competitive with pearlmillet for nutrients and environmental resources. The yield attributes of mungbean was significantly superior under intercropping system as compared to sole and mixed crop. Among the intercropping row ratio, maximum yield attributes viz. pod length (5.47cm), number of pod/plant (12.52), number of grain/pod (8.03), test weight (44.33g) were obtained under pearlmillet + mungbean with 2:2 row ratio followed by pearlmillet + mungbean with 2:1 row ratio and pearlmillet + mungbean with 1:1 row ratio. This might be due to availability of more space, less competition as compared to other intercropping system of pearlmillet + mungbean in different row ratio. Wider space in between row and more row of component legume crop provided better environment of rizhosphere lead to significantly higher yield attributes. Yadav *et al*. (2005) reported similar result on yield attributes of mungbean in intercropping system. The maximum grain (696.14 kg/ha), straw (1853.29 kg/ha) and biological yields (2549.43 kg/ha) of mungbean were recorded in sole stand. Among the intercropping row ratio, highest grain (316.43 kg/ha), straw (896.16 kg/ha) and biological yields (2549.43 kg/ha) were recorded under pearlmillet + mungbean with 1:1 row ratio followed by pearlmillet + mungbean with 2:2 row ratio and pearlmillet + mungbean with 2:1 row ratio. This might be due to low level of plant performance coupled with reduction in number of mungbean row that causes significantly decline in yield of mungbean. Singh and Joshi (1997) observed that row intercropping of pearlmillet with clusterbean (1:1) and strip cropping (4:4) with 50 per cent of the sole pearlmillet population produced 35.4 per cent lower pearlmillet yield in the moisture season and 37.4 per cent lower pearlmillet yield in the moisture stressed season. Rana *et al*., (2006) reported that maize paired row (40/80 cm) + 1 row of mungbean recorded significantly higher cobs/plant, cob length, grains/cob, grain weight/cob compared to sole maize.

Nutrient uptake and Protein content

The data relating to the nitrogen and phosphorus uptake of pearlmillet and mungbean grain and straw in have been presented in Table 2. The maximum nitrogen uptake in grain 29.67, straw 23.84, total 52.40 were observed under Pearlmillet sole, Pearl millet + mungbean with 2:2 row ratio and Pearlmillet sole, respectively. The maximum phosphorus uptake in grain 3.70, straw 6.94 and total 10.64 were observed under Pearlmillet sole. Whereas, mungbean, the maximum nitrogen uptake in grain 17.17, straw 17.30 and 34.47 total were observed under mungbean sole. The maximum phosphorus uptake in grain 1.77, straw 2.53 and total 4.30 were observed under mungbean sole as compared to intercropping system. It might be due to the increased uptake of N and P uptake mainly due to higher dry matter yield. Similar finding given by Ikramullah *et al*., (1996). Singh (1992) observed that nitrogen uptake by grain and straw and total uptake was maximum in pearlmillet + clusterbean intercropping as compared to pearlmillet:mungbean and pure stand of pearl millet.

The intercropping row ratio improved the grain protein content significantly as compared to sole crops. Pearl millet + mungbean with 2:2 row ratio recorded significantly higher protein content in pearlmillet grain (11.94) and mungbean grain (23.82) followed by pearlmillet + mungbean with 2:1 row ratio. Sharma, *et al*., (2009) showed that pearl millet + cowpea (2:2) recorded significantly crude protein yield (1.36 t/ha).

Competition function

Data presented in Table 3 indicated that intercropping treatments significantly influenced the mean pearlmillet grain equivalent yield. The maximum mean pearlmillet grain equivalent yield (4817.05 kg ha^{-1}) was obtained under pearlmillet sole which is significantly higher than all other treatments. The obvious reason for large yield advantage in pearlmillet sole is that the intercropping competes in their use of natural resources and utilized those more efficiently resulting in higher yields per unit area sole crops than that produced by their intercropping treatments. Mungbean being short duration crop with slow initial growth and deep root system did not pose any severe competition for natural resources with pearlmillet under different row proportions. The land equivalent ratio was significantly higher in intercropping than sole. Among the intercropping treatments, the maximum land equivalent ratio were recorded under pearlmillet + mungbean with 2:2 row ratio (1.04) followed by pearlmillet + mungbean with 2:1 row ratio (1.02). The product of relative crowding coefficient was maximum under pearlmillet + mungbean with 2:2 row ratio (1.78) followed by pearlmillet + mungbean with 2:1 row ratio (1.29) and pearlmillet + mungbean with 2:2 row ratio (1.04) followed by pearlmillet + mungbean with 1:1 row ratio (1.00) and in mungbean maximum relative crowding coefficient was observed in sole stand followed by pearlmillet + mungbean with 2:2 row ratio. Among intercropping treatmemts aggresivity was highest in pearlmillet + mungbean with 2:1 row ratio as compared to others. Rathore, *et al*. (2006) result found cluster bean was more suitable for intercropping in pearlmillet as it gave higher mean pearlmillet equivalent yield (1351 kg/ha), LER (1.01). Rao *et al*. (2009) observed that intercropping of sorghum with mungbean in 2:1 row ratio at 50 kg N/ha recorded the highest land equivalent ratio, relative crowding co-efficient (10.99).

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