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RELATIVE ADVANTAGES AND ECONOMICS OF BAJRA BASED INTERCROPPING SYSTEMS UNDER RAINFED CONDITION

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SUMMARY

A field experiment was conducted during two consecutive *kharif* seasons (2019 and 2020) at Agricultural Research Station, Navgaon (Alwar), S.K.N. Agriculture University, Jobner, Jaipur (Rajasthan), India, to study the effect of different intercrops in pearl millet (bajra). The experiment was laid out in a randomized block design with ten treatments and replicated thrice. The crop was sown as per the package of practices recommended for zone III-B of Rajasthan. Treatments included Bajra + mung bean (2:1), Bajra + mung bean (4:2), Bajra + black gram (2:1), Bajra + black gram (4:2), Bajra + Cluster bean (2:1), Bajra + Cluster bean (4:2) including sole bajra, mung bean, black gram and cluster bean. Among the different intercropping treatments, Bajra + mung bean (4:2) recorded significantly higher pearlmillet equivalent yield (15.69 q/ha in 2019 and 15.79 qt/ha in 2020) with higher economic efficiency. The intercropping of pearl millet + mung bean (4:2) recorded significantly higher net monetary return (Rs.15184 ha^{-1}) than all other intercropping systems. The mean maximum benefit-cost ratio (1.87) was also recorded by pearl millet + mung bean (4:2).

Keywords : Bajra, mung bean, cluster bean, black gram, intercropping, BC ratio, LER

Pearl millet (*Pennisetum glaucum*) is mostly spread in Rajasthan, Gujarat, Maharashtra, Utter pradesh, Haryana and Karnataka. As its cultivation is mostly confined to rainfed lands poor and impoverished soils, growing of pearl millet as a sole crop under this situation is rather risky and uneconomical. Intercropping can increase the production and productivity by better utilization of available resources and thereby helps to minimize the risks and brings stability under rainfed conditions. Intercropping provides stability and ensures adequate yields of one of the component crops (Rao and Willey, 1983; Subba Reddy and Havangi, 1986) under aberrant weather situations. It's intercropping with grain legumes such as mung bean, cluster bean, black gram, cowpea and moth bean is a common recommended practice. Plant population and spatial arrangement in intercropping have important effects on the balance of competition between component crop and on their productivity. Inclusion of legumes as intercrop, not only provides nitrogen to the base crop but also increases the amount of humus in the soil due to decaying crop remains (Kheroar *et al.,* 2013).

Intercropping is an age old practice being followed by subsistence farmers to achieve their domestic needs. The main advantage of the intercropping is that the component crops are able to use the growth resources differently and make better overall use of growth resources than grown separately (Willey, 1979). Intercropping system is primarily used to change the bio-diversity of pests and beneficial on the main crop. The intercropping leads to a change in crop canopies and bring about a resultant change in the climate at the micro level (Devendra Prasad and Binay Kumar, 2002). Further, taller intercrops have been observed to check the dispersal of flying insect pests of shorter crops, thus preventing migration towards the main crop (Leon *et al.* 1997). The higher cluster bean equivalent yield (0.92 t/ha), net returns (₹ 7,440/ha), benefit: cost ratio (1.80) and sustainable yield index (0.74) were recorded with cluster bean + sesame (2:1) intercropping system over the sole crop of cluster bean (0.71 t/ha, ₹ 5,945/ha 1.68 and 0.71, respectively) in Rajasthan (Meena *et al.,* 2009). Haque *et al.* (1986) also reported that protein yield per hectare is increased by intercropping cereals and forage legumes. Protein yield of cereal crops such as sorghum was higher when intercropped with fodder cowpea than with grain legumes grown to maturity. (Yadav *et al.*, 2009), suggesting legume intercropping and green manuring are important measures to sustain fertility and enhance productivity of soil. Intercropping can be used as an effective weed control strategy. Growing of different plant types together which enhances weed control by capturing a great share of available resources (Shah *et al.,* 2011) and probability by increasing shade and crop competition with weeds in tighter crop spacing (Praveen and Bhanu, 2005). Besides, intercropping also reduces weeding cost and realizes higher total productivity of the system and monetary returns (Bhullar *et al.,* 2006). Evidence of better weed suppression was reasonably clear where intercropping provides a more competitive effect against weeds either in light, time or space than monocropping (Dwivedi *et al*., 2012). Sugarcane + greengram intercropping recorded lower weed dry weight and the highest cane yield over sole sugarcane, sugarcane + blackgram and sugarcane + okra (Bhullar *et al.,* 2006). Intercropping provides an insurance against calamities and helps in the maximization of productivity and profit by efficient utilization of natural resources (Thakur *et al.,* 2000). Presence of legumes in the mixtures benefits the associated non-legumes as the legumes provide a portion of biologically fixed nitrogen to non-legume components (Tanwar *et al.,* 2011) as legumes increase the soil nitrogen content and help to maintain soil fertility. The information available on the suitability of intercropping systems in millets with legumes. Therefore, keeping these facts of intercropping in mind, the present investigation was undertaken to study the effect of different intercrops in bajra. To find out the suitable ratio of mung bean, cluster bean, black gram intercrops with bajra and performance of bajra based intercropping system; the present experiment was planned and conducted under rainfed condition.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* season in the year 2019 and 2020 at Agricultural Research Station, Navgaon (Alwar), S.K.N Agriculture University, Jobner, Jaipur (Rajasthan), India, to study the effect of different intercrops in pearl millet**.** The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, and medium in phosphorus and potassium with alkaline in pH. The experiment was laid out in a randomized block design with ten treatments including Bajra+ mung bean (2:1), Bajra+ mung bean (4:2), Bajra+ black gram (2:1), Bajra+ black gram (4:2), Bajra+ Cluster bean (2:1), Bajra+ Cluster bean (4:2) including sole bajra, mung bean, black gram and cluster bean with three replications. The recommended cultivars like MPMH-17 of pearl millet, Samrat of mung bean, RGC-1038 of cluster bean and Pant Urd-31 of black gram were used in the experiment. The sole pearl millet mung bean, black gram and cluster bean the recommended plant spacing *i.e.* 30 cm × 10 cm was adopted and in intercropping systems were followed plant spacing 30 cm × 15 cm. The crops were sown in first week of July in both seasons of experimentation.

Pearl millet equivalent yield was calculated by converting grain yield of intercrop into pearl millet on the basis of prevailing market rates of the crop produce. Net monetary returns and benefit-cost ratio were

TABLE 1

Effect of various treatments on grain yield of different crops and pearlmillet equivalent yield (PEY)

Symbol	Treatments	Grain yield (q/ha)						PEY (q/ha)		
		Main crop			Inter crop			2019	2020	Pooled
		2019	2020	Pooled	2019	2020	Pooled			
T1	Bajra (sole)	10.91	10.73	10.82	-	-	-	10.91	10.73	10.82
T2	Cluster bean (sole)	5.99	5.68	5.83	-	-	-	11.97	10.65	10.94
T3	Mung bean (sole)	5.52	4.03	4.06	-	-	-	14.40	14.52	14.61
T4	Black gram (sole)	5.09	3.94	3.97	-	-	-	11.39	11.81	11.90
T5	Bajra+ mung bean (2:1)	9.17	8.97	9.07	1.56	1.54	1.55	14.66	14.50	14.64
T6	Bajra+ mung bean (4:2)	10.25	10.08	10.17	1.57	1.56	1.56	15.77	15.69	15.79
T7	Bajra+ black gram (2:1)	8.21	8.16	8.19	1.02	0.98	1.00	11.12	11.11	11.20
T8	Bajra+ black gram (4:2)	10.90	10.82	10.86	1.25	1.21	1.23	14.47	14.44	14.55
T9	Bajra+ Cluster bean (2:1)	9.15	8.97	9.06	1.07	1.03	1.05	11.29	10.90	11.03
T10	Bajra+ Cluster bean (4:2)	10.08	9.69	9.89	1.24	1.25	1.32	12.89	12.03	12.37
	SEm ±	0.68	0.55	0.58	-	-	-	0.93	0.68	0.74
	CD at 5%	2.05	1.61	1.70	-	-	-	2.79	2.00	2.18

computed by using the prevailing rates of inputs and produce. Land equivalent ratio of the different intercropping system was calculated by the following formula given by Willey (1979):

$$\text{LER} = \sum_{i}^{m} \frac{Y_i}{Y_{ij}}$$

Y_i = Individual crop yield under intercropping system
Y_{ij} = Individual crop yield under sole cropping system

Relative yield of different crops in terms of pearl millet equivalent was calculated and reported as q/ha. Pearlmillet equivalent yield of different crops (PEY) was calculated by the following formula:

$$\text{PEY (q/ha)} = \frac{\text{Yield of different crops (q/ha)} \times \text{Price of different crops (₹/q)}}{\text{Price of pearl millet (₹/q)}}$$

Cultivation cost of different crops under different copping system was calculated on the basis of prevailing local charges for different inputs *i.e.* labors, equipment, seed, fertilizers, chemicals and others. Gross return of each treatment was calculated by pearlmillet equivalent yield of different treatments were converted into gross return (Rs. /ha) on the basis of minimum support price of these crops. Net return of each treatment was calculated by deducting the cost of cultivation from the gross returns. Benefit-cost ratio was calculated by using following formula as given by Bhandari (1993) follows:

$$\text{Benefit : cost} = \frac{\text{Gross return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Crop profitability was calculated by the following formula:

$$\text{CP (Rs./ha/day)} = \frac{\text{Net return}}{\text{Actual crop growing days}}$$

RESULTS AND DISCUSSION

Pearl millet equivalent yield

The pearl millet equivalent yield (Table 1) was found to be influenced by different intercropping systems. The pooled mean data showed that

TABLE 2

Effect of various treatments on LER, cost of cultivation, gross return, net return, BC ratio and crop profitability

Treatments	LER			Cost of cultivation (₹/ha)			Gross returns (₹/ha)			Net returns (₹/ha)			B : C ratio			Crop profitability (₹/ha /day)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Bajra (sole)	1.00	1.00	1.00	17067	17313	17190	21813	23066	22440	4746	5753	5249	1.28	1.33	1.31	67.79	82.19	74.99
Cluster bean (sole)	1.00	1.00	1.00	17861	17242	17552	23943	22901	23422	6082	5659	5871	1.34	1.33	1.33	86.88	80.85	83.87
Mung bean (sole)	1.00	1.00	1.00	17739	17338	17538	28793	31213	30003	11055	13875	12465	1.62	1.80	1.71	157.92	198.21	178.07
Black gram (sole)	1.00	1.00	1.00	17739	17338	17538	22773	25390	24082	5034	8052	6543	1.28	1.46	1.37	71.92	115.04	93.48
Bajra+mung bean (2:1)	1.22	1.22	1.22	17512	17389	17451	29310	31181	30245	11797	13792	12795	1.67	1.79	1.73	168.53	197.03	182.78
Bajra+mung bean (4:2)	1.33	1.33	1.33	17512	17389	17451	31543	33726	32635	14031	16337	15184	1.80	1.94	1.87	200.45	233.39	216.92
Bajra+black gram (2:1)	1.01	1.02	1.01	17317	17317	17317	22246	23896	23071	4929	6578	5753	1.28	1.38	1.33	70.41	93.98	82.19
Bajra+ black gram (4:2)	1.32	1.32	1.32	17317	17317	17317	28945	31049	29997	11628	13731	12680	1.67	1.79	1.73	166.11	196.16	181.14
Bajra+Cluster bean (2:1)	1.03	1.02	1.02	17512	17389	17451	22571	23438	23004	5059	6048	5554	1.29	1.35	1.32	72.27	86.40	79.34
Bajra+ Cluster bean (4:2)	1.17	1.13	1.15	17512	17389	17451	25771	25871	25821	8259	8481	8370	1.47	1.49	1.48	117.99	121.16	119.58
SEm ±	0.07	0.06	0.06	0.02	0.02	0.02	1699.22	1467.22	1533.13	1699.22	1467.22	1533.13	0.10	0.09	0.09	24.27	20.96	21.90
CD at 5%	0.19	0.17	0.17	0.05	0.05	0.05	4983.94	4303.47	4496.79	4983.94	4303.47	4496.79	0.29	0.25	0.26	71.20	61.48	64.24

intercropping of pearl millet + mung bean (4:2) produced significantly higher pearl millet equivalent yield (15.79 q ha^{-1}) followed by pearl millet + mung bean (14.64 q ha^{-1}) in 2:1 row proportion and these treatments proved statistically superior to sole crops and pearl millet + cluster bean. This might be due to higher yield of pearl millet. This indicated complementary and non competitive effects of these intercrops due to differences in the temporal and spatial characteristics of the crops. Reddy and Willey (1981) reported that the yield stability was greater. Similar results were also reported by Gadhia *et al* (1993).

Land equivalent ratio (LER)

The LER is important indice to measure the yield advantage in intercropping systems. Different intercropping systems varied significantly in respect of Land equivalent ratio **(**LER). All the intercropping systems, recorded higher LER than sole bajra, mung bean, black gram and cluster bean. The LER values (Table 2) for intercropping systems showed that pearl millet + mung bean planted 4:2 row ratio recorded maximum LER (1.32) followed by pearl millet + blackgram 4:2 row ratio (1.31). Similarly, Singh and Joshi (1994) also found that the pearl millet-green gram strip cropping (4:4) showed the highest land equivalent ratio of 1.26 indicating 26 per cent advantage over sole cropping. (Ennin *et al.,* 2001; Adeniyan and Ayoola, 2006 and Muoneke *et al.,* 2007) Better results of land use (LER) have been observed in the intercropping system than the sole crops. Osman *et al.* (2011) reported the LERs value more than unity, representing benefits of intercropping over sole cropping of millet.

ECONOMICS

The net monetary returns were found to be influenced by different intercropping systems (Table 2). The intercropping of pearl millet + mung bean (4:2) recorded significantly higher return (Rs.15184 ha^{-1}) than all other intercropping systems. The mean maximum benefit-cost ratio was also recorded by pearl millet + mung bean (1.87). The advantage of pearl millet intercropping systems in increasing monetary returns was also reported by Yakadri *et al.* (1994). The trends of pearl millet equivalent yield, net monetary returns and LER showed that pearl millet + moth bean (2:1) or pearl millet + cowpea (2:1) appears the most productive, remunerative and profitable system for rainfed conditions of scarcity zone of north Maharashtra. Based on two year field study it can be concluded that to achieve relative advantages in terms of pearlmillet equivalent yield, land equivalent ratio, net return, B:C and more over to sustain our natural resources, the bajra growers should go for intercropping of bajra along with mung bean in 4:2 ratio instead of sole planting of maize.

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