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EFFECT OF LEGUME INTERCROPPING ON YIELD ATTRIBUTES, YIELD AND ECONOMICS OF PEARL MILLET-LEGUME INTERCROPPING SYSTEM

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SUMMARY

A Field experiment was conducted during *Kharif* 2020 to evaluate the performance of pearl millet–legume intercropping under rainfed conditions. The experiment comprises 11 treatments *viz*., pearlmillet sole at 45 cm, mungbean sole at 45 cm, clusterbean sole at 45 cm, pearlmillet + mungbean (2:2) at 45 cm, pearlmillet + clusterbean (2:2) at 45 cm, pearlmillet + mungbean (4:4) at 45 cm, pearlmillet + clusterbean (4:4) at 45 cm, pearlmillet + mungbean (6:6) at 45 cm, pearlmillet + clusterbean (6:6) at 45 cm, pearlmillet + mungbean (8:4) at 30 cm and pearlmillet + clusterbean (8:4) at 30 cm. Under experimentation, pearlmillet (HHB 67 Improved), mungbean (MH 421) and clusterbean (HG 2-20) were laid out in randomized block design with four replications. The results showed that yield attributes *viz*. total tillers/plant, effective tillers/plant and ear head length and yield *viz*. grain and stover yield of pearl millet were recorded significantly higher in sole pearlmillet while in intercropping system pearlmillet + mungbean (8:4) at 30 cm recorded higher yield attributes and yield as compared to rest of intercropping treatments. Among all treatments, pearlmillet equivalent yield (3109 kg/ha) and economics *viz*. gross, net return (Rs. 41256/ha) and B:C ratio (2.61) of pearlmillet + mungbean (8:4) at 30 cm observed higher over rest of the treatments.

Key words: Pearlmillet, mungbean, clusterbean, intercropping and economic

Pearl millet (*Pennisetum glaucum* L.), commonly known as bajra, is India's most important millet, ranking first among all millets, followed by sorghum and ragi. It is a summer annual crop excellent for rotation and double cropping. India is the world's top producer of pearl millet with an area of 6.70 million ha, production of 9.62 million tonnes and an average productivity of 1436 kg/ha (Anonymous, 2021-22).

Mungbean [*Vigna radiata* (L.) Wilczek.] and clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] are two of the most significant intercrops that can be grown with pearl millet in northwestern India. They are characterized as the most drought-resistant annual legumes in desert regions and are annual legumes with warm, dry habitats. Mungbean and Clusterbean, which have deep rapidly penetrating roots and the ability to withstand dryness, may survive and thrive for a long time in open fields despite rapid soil moisture loss and extremely hot weather. These crops have been able to adapt to a variety of cropping and agricultural systems in arid and semi-arid regions thanks to their multi-adaptive and adapting character.

The idea that non-legumes dissolving porous root walls could benefit from being planted alongside legumes was initially put forth by Lipman in 1913. To decrease competition and promote a symbiotic interaction in order to fulfill the goals of maximizing the exploitation of resources, legumes make a great combination with grains. As a result, the practice of intercropping pearl millet with other leguminous crops during the *kharif* season appears to be a good replacement for effective resource usage and to give farmers an economic gain. The spatial arrangement of intercropping has a considerable impact on the productivity, economics, and soil fertility status of the component crops as well as their growth and development. According to Willey and Heath (1969), the amount of polygonal space a plant occupies in a crop affects the yield of a single plant in a nonlinear way. Intercropping offers biological advantages over a single crop, which may be due to the complementary use of growth resources or because interspecific competition for growth resources is less than intraspecific competition. So, keeping the aforementioned factors in mind and in order to determine the optimal pearl millet-based intercropping method, the current study, "Effect of legume intercropping on yield attributes, yield and economics of pearl millet -legume intercropping system," was conducted.

MATERIALS AND METHODS

An experiment was carried out at Dryland Agriculture Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar, which is situated at a latitude of 290 10' North, longitude of 750 46' East, and elevation of 215.2 m above mean sea level in the subtropical climate zone of India. The soil of the experimental site was sandy loam with good drainage capabilities and neutral (pH 7.5) in reaction. The soil was found low in available nitrogen (112 kg ha^{-1}), medium in available phosphorus (15.5 kg ha^{-1}) and available potassium (235 kg ha^{-1}) and low in organic carbon (0.29%). RBD (Randomized Block Design) was applied to set up the experiment, and four replications were used. The trial consisted of 11 treatments comprising of three sole treatments (pearlmillet, mungbean and clusterbean) and eight intercropping treatments. The eleven treatments are pearl millet sole at 45 cm (T1), mungbean sole at 45 cm (T2), clusterbean sole at 45 cm (T3), pearl millet + mungbean (2:2) at 45 cm (T4), pearl millet + clusterbean (2:2) at 45 cm (T5), pearl millet + mungbean (4:4) at 45 cm (T6), pearl millet + clusterbean (4:4) at 45 cm (T7), pearl millet + mungbean (6:6) at 45 cm (T8), pearl millet + clusterbean (6:6) at 45 cm (T9), pearl millet + mungbean (8:4) at 30 cm (T10) and pearl millet + clusterbean (8:4) at 30 cm row spacing (T11). Under experimentation, pearlmillet (HHB 67 Improved), mungbean (MH 421) and clusterbean (HG 2-20) crop were tested. After receiving rain (41.4 mm) during the month of July, the field was prepared. To get a good soil tilth, the seedbed was prepared using three plowing techniques (two harrowing + one cultivator). Using urea and diammonium phosphate, a homogeneous dose of 40 kg of nitrogen and 20 kg of phosphorus per hectare was drilled in the field. Although the soil in the experimental field had medium potassium availability, no potash was used. According to the advice, nitrogen and phosphorus were applied to solitary mungbean and clusterbean at rates of 20 and 40 kg/ha, respectively.

Following field marking and planned arrangement, main and intercrop sowing was carried out manually in level beds using a hand plough. Pearl millet, mungbean, and cluster beans were sown as a single crop in rows 45 cm apart, whereas in intercropping treatments, T4 to T9 sowing was done in replacement series at 45 cm spacing while maintaining an equal number of plant populations, but in intercropping treatments T10 and T11 sowing was done in an 8:4 ratio at 30 cm spacing. On July 14, 2020, pearlmillet, mungbean and clusterbean were sown at seed rates of 5, 23 and 15 kg/ha, respectively.

Five randomly selected and tagged plants were used to record the total and effective tillers per plant in pearl millet from each plot, and the average was calculated. The length (cm) of five ear heads of pearl millet was recorded from each plot of pearl millet and the average ear head length was worked out. The girth (cm) of five ear heads of pearl millet was recorded from each plot of pearl millet with Vernier caliper and the average ear head girth was calculated. The samples were randomly collected from the grain produced by each plot of pearl millet. Then, a thousand seeds from each of the samples were counted manually, and their weight (g) was recorded.

The dried ear heads of pearl millet for each plot were weighed and then threshed to record grain yield per plot, which was converted to grain yield per hectare (kg/ha). The pearl millet stover, after separating ear heads at harvest, was left in the plots for sun drying. After proper drying, it was weighed to record the stover yield per plot by converting it into kilogram per hectare. In pearl millet, the biological yield was obtained by adding the ear head to the stover weight of each plot.

The seed yield of clusterbean and mungbean was calculated in terms of pearl millet for all intercropping treatments. Based on their market price, they were then statistically analyzed to determine the equivalent grain yield of pearl millet.

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

The gross returns (Rs./ha) from different treatments were calculated based on prevailing market rates of the produce at the time of marketing of the produce after harvest. The rates used for the produce were Rs. 21.50/-, 71.96/- and 40.00/- per kilogram for grain and Rs. 1.80/-, 1.00/- and 2.40/- per kilogram for stover/straw of pearlmillet, mungbean and clusterbean respectively. To find out the most profitable treatment, the economics of different treatments were worked out in terms of net returns (Rs./ha) by taking into account the cost of cultivation and gross returns of the crop, which were calculated based on the prevailing market rates for inputs during the crop season and for outputs at the time of marketing of the produce after harvest. Treatment-wise benefit:cost (B:C) was calculated to as particular economic viability using the following formula:

$$\text{B:C ratio} = \frac{\text{Gross returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

The data obtained from an experiment conducted in RBD were analyzed as per the standard method suggested by Panse and Sukhatme (1985). The significance difference among treatments was tested with the help of the ‘F’ (variance) test and by calculating C. D. at a 5% level of significance.

RESULTS AND DISCUSSION

Yield attributes and yield

The results showed that yield attributes *viz.* total tillers/plant, effective tillers/plant and ear head length and yield *viz.* grain and stover yield of pearl millet were recorded significantly higher in sole pearl millet while in intercropping system pearl millet + mungbean (8:4) at 30 cm recorded higher yield attributes and yield as compared to rest of intercropping treatments (Table 1 & 4). This was due to less competition for resources by the intercrops during the growth and development of the crop. Similar results were obtained by Renu *et al.* (2018), Yadav *et al.* (2005), Bangali (1987) and Kiroriwal (2009). Data regarding ear head length and ear head girth (Table 1) revealed that sole pearl millet at 45 cm produced significantly higher ear head length and ear head girth that was found superior to all other intercropping treatments. The higher length and girth of the ear head in this treatment may be due to the lower number of pearl millet density and wider space available for more growth and development of pearl millet. Baldev *et al.* (2005) had similar observations regarding yield attributes and yield. They noted significantly increased ear length and girth in sole pearl millet when compared to other intercropping systems. Whereas, Pal *et al.* (2000) and Singh and Agrawal (2004) also reported that ear head length and test weight of pearl millet were not influenced by intercropping systems. Similar results were obtained by Renu *et al.* (2018), Bangali (1987) and Kiroriwal (2009). The test weight of pearl millet grain was not significantly varied when pearl millet was sown sole as well as intercropping treatments.

A significant reduction in grain and stover yield (Table 4) was observed under intercropping treatments. The reduction in yield of pearl millet in the intercropping system was mainly due to a reduction in plant stand, so pearl millet in different intercropping treatments as replacement and additive type of intercropping system was followed in the present study. These results are supported by those of Kumar *et al.* (2006), who have recorded the maximum grain and stover yields of pearl millet in the sole system over inter and strip cropping systems. Mishra (1996) also reported a similar reduction in grain yield of base crops in intercropping treatments, thereby corroborating the present finding.

TABLE 1

Yield attributes of pearl millet as affected by different intercropping treatments

Treatments	Total tillers/ plant	Effective tillers/ plant	Ear head length (cm)	Ear head girth (cm)	Test weight (g)
T_1 - Pearl millet sole at 45 cm	5.05	4.15	23.15	9.02	8.97
T_4 - Pearl millet + mungbean (2:2) at 45 cm	4.45	3.44	22.12	8.08	8.72
T_5 - Pearl millet + clusterbean (2:2) at 45 cm	4.00	3.05	22.16	7.94	8.74
T_6 - Pearl millet + mungbean (4:4) at 45 cm	4.50	3.47	22.37	8.52	8.79
T_7 - Pearl millet + clusterbean (4:4) at 45 cm	4.30	3.35	22.81	8.48	8.72
T_8 - Pearl millet + mungbean (6:6) at 45 cm	4.80	3.75	22.94	8.84	8.91
T_9 - Pearl millet + clusterbean (6:6) at 45 cm	4.60	3.70	23.03	8.82	8.89
T_{10} - Pearl millet + mungbean (8:4) at 30 cm	4.90	4.03	23.09	9.11	8.85
T_{11} - Pearl millet + clusterbean (8:4) at 30 cm	4.63	3.71	22.71	8.72	8.85
SEm$\pm$	0.19	0.16	0.14	0.15	0.07
CD (P=0.05)	0.56	0.46	0.40	0.44	NS

It is evident from Tables 2 & 3 that seed and straw yield of mungbean and clusterbean was very much positively correlated with yield attributes, i.e., branches per plant and pods per plant in mungbean and pods per plant and seeds per pod in clusterbean. A significant variation in the seed and straw yield of both intercrops among different intercropping treatments was recorded. The highest seed and straw yield of intercrops was found in the sole crops of mungbean and clusterbean, respectively. It might be due to less competition for resources by the other crops during growth and development of the crop. Kumar *et al.*

TABLE 2

Yield attributes of mungbean as influenced by different intercropping treatments

Treatments	Branches/ plant	Pods/ plant	Seeds/ pod	Seed index (g)
T_2 - Mungbean sole at 45 cm	5.60	25.79	8.93	4.58
T_4 - Pearl millet + mungbean (2:2) at 45 cm	5.01	23.65	8.83	4.12
T_6 - Pearl millet + mungbean (4:4) at 45 cm	5.20	24.44	8.85	4.14
T_8 - Pearl millet + mungbean (6:6) at 45 cm	5.35	24.84	8.88	4.28
T_{10} - Pearl millet + mungbean (8:4) at 30 cm	5.28	24.72	8.90	4.31
SEm±	0.11	0.40	0.15	0.13
CD (P=0.05)	0.35	1.25	NS	NS

TABLE 3

Yield attributes of clusterbean as influenced by different intercropping treatments

Treatments	Branches/ plant	Pods/ plant	Seeds/ pod	Seed index (g)
T_3 - Clusterbean sole at 45 cm	5.25	37.01	6.52	2.21
T_5 - Pearl millet + clusterbean (2:2) at 45 cm	5.05	33.19	5.85	2.16
T_7 - Pearl millet + clusterbean (4:4) at 45 cm	4.60	33.36	5.90	2.11
T_9 - Pearl millet + clusterbean (6:6) at 45 cm	4.73	34.34	6.11	2.12
T_{11} - Pearl millet + clusterbean (8:4) at 30 cm	4.83	35.82	6.37	2.17
SEm±	0.23	0.76	0.06	0.04
CD (P=0.05)	NS	2.35	0.19	NS

TABLE 4

Grain yield of pearl millet and legumesas affected by different intercropping treatments

Treatments	Pearl millet (kg/ha)		Intercrop yield (kg/ha)				PM equivalent yield (kg/ha)
	Grain yield	Stover yield	Mungbean		Clusterbean		
			Seed yield	Straw yield	Seed yield	Straw yield	
T_1 - Pearl millet sole at 45 cm	1409	2927	-	-	-	-	1654
T_2 - Mungbean sole at 45 cm	-	-	704	1141	-	-	2410
T_3 - Clusterbean sole at 45 cm	-	-	-	-	942	2092	1960
T_4 - Pearl millet + mungbean (2:2) at 45 cm	722	1563	366	597	-	-	2105
T_5 - Pearl millet + clusterbean (2:2) at 45 cm	715	1541	-	-	551	1223	1981
T_6 - Pearl millet + mungbean (4:4) at 45 cm	782	1671	378	631	-	-	2247
T_7 - Pearl millet + clusterbean (4:4) at 45 cm	745	1595	-	-	572	1283	2067
T_8 - Pearl millet + mungbean (6:6) at 45 cm	861	1807	388	639	-	-	2340
T_9 - Pearl millet + clusterbean (6:6) at 45 cm	825	1777	-	-	593	1322	2207
T_{10} - Pearl millet + mungbean (8:4) at 30 cm	1079	2220	538	904	-	-	3109
T_{11} - Pearl millet + clusterbean (8:4) at 30 cm	1065	2139	-	-	715	1624	2730
SEm±	23	49	22	29	21	46	66
CD (P=0.05)	68	143	67	92	66	144	192

TABLE 5
Effect of different intercropping treatments on economics of crops

Treatments	Gross return (Rs./ha)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1 - Pearl millet sole at 45 cm	35561	23695	11866	1.50
T_2 - Mungbean sole at 45 cm	51815	23630	28185	2.19
T_3 - Clusterbean sole at 45 cm	42140	20763	21378	2.03
T_4 - Pearl millet + mungbean (2:2) at 45 cm	45258	25033	20225	1.81
T_5 - Pearl millet + clusterbean (2:2) at 45 cm	42592	23600	18992	1.80
T_6 - Pearl millet + mungbean (4:4) at 45 cm	48311	25033	23278	1.93
T_7 - Pearl millet + clusterbean (4:4) at 45 cm	44441	23600	20841	1.88
T_8 - Pearl millet + mungbean (6:6) at 45 cm	50310	25033	25278	2.01
T_9 - Pearl millet + clusterbean (6:6) at 45 cm	47451	23600	23851	2.01
T_{10} - Pearl millet + mungbean (8:4) at 30 cm	66844	25588	41256	2.61
T_{11} - Pearl millet + clusterbean (8:4) at 30 cm	58695	24633	34063	2.38

(2017) observed a significantly higher number of pods per plant, no. of seeds per pod, test weight, seed yield, and straw yield of mungbean in sole RMG 62 than other sole varieties and their intercropping treatments. Similar results were found by Ghilotia *et al.* (2015).

Data presented in Table 4 revealed that intercropping treatments significantly influenced the pearl millet grain equivalent yield. The highest pearl millet grain equivalent yield (3109 kg/ha) was obtained under pearl millet + mungbean (8:4) at 30 cm followed by pearl millet + clusterbean (8:4) at 30 cm (2730 kg/ha) due to an additional yield of mungbean and clusterbean was recorded in 8:4 row ratio of intercropping treatments and higher availability of price of mungbean in the market. Similarly, significantly higher pearl millet equivalent yield was observed by Ansari *et al.* (2012) in intercropping between pearl millet and pigeon pea comparatively to either of sole cropping. Similar results were found by Ram and Meena (2014) and Tetarwal and Rana (2007).

ECONOMICS

It is evident from Table 5 that among various intercropping treatments, pearl millet + mungbean in 8:4 at 30 cm had considerably maximum gross (Rs. 66884/ha), net return (Rs. 41256/ha) and B:C ratio (2.61). The highest net return and B:C ratio was associated with its higher grain and stover yield per unit of added cost. Renu *et al.* (2018) observed similar results, Hooda *et al.* (2004) also reported that intercropping of pearl millet with mungbean recorded the highest net return and B:C ratio over sole pearl millet. Kuri *et al.* (2012) reported that maximum pearl millet equivalent yield, LER, and net returns were observed in intercropping of pearl millet with moth bean in 1:7 row ratio closely followed by 4:4, 2:6 and 3:5 row ratio in comparison with sole and other intercropping treatments. They also reported that the intercropping of pearl millet with mungbean produced maximum pearl millet equivalent yield (PMEY), net returns, and benefit-cost (B:C) ratio by these treatments compared to sole and other intercropping treatments (Ram and Meena, 2014).

CONCLUSION

From the experimental findings, it can be concluded that intercropping peralmillet with mungbean in an 8:4 ratio and 30 cm row spacing significantly enhances yields and profits (economics), offering a viable and profitable option for farmers under rainfed conditions.

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