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Effect of pearl millet based intercropping systems on yield and economics of pearl millet [*Pennisetum glaucum* (L.) R.Br.]

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ABSTRACT

The field experiment was carried out during kharif season of 2019 at Chaudhary Charan Singh Haryana Agricultural University, Hisar to study the effect of different intercropping systems of pearl millet with legumes and oilseed on yield and economics of pearl millet. The eleven treatments were evaluated in randomized block design with three replications. The performance of sole pearl millet hybrid HHB 299 at 45 cm row spacing proved the best in terms of grain (48.83 q ha^{-1}) and stover (100.11 q ha^{-1}) yield and yield attributing traits. It was comparable to sole pearl millet in paired row and pearl millet + green gram (2:1). Among intercropping systems, maximum values of yield attributes of pearl millet were obtained in pearl millet + green gram (2:2) and maximum pearl millet yield (44.68 q ha^{-1}) was in pearl millet + green gram (2:1). Pearl millet equivalent yield (PEY) and net returns of pearl millet-green gram in 2:1 row ratio was found superior than all the sole and intercropping treatments. The highest benefit-cost ratio was recorded under sole pearl millet crop (2.84) followed by intercropping of pearl millet with green gram in 2:1 row ratio (2.77).

Key words: Pearl millet, intercropping, economics, net return, PEY, yield,

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R.Br.] is the third most important food grain crop of India after paddy and wheat. In India, it is mainly cultivated in Rajasthan, Gujarat, Uttar Pradesh, Haryana and Maharashtra. The Haryana has 0.42 million ha area under pearl millet cultivation with a production of 0.88 million tons having average productivity of 20.68 q ha^{-1} (Anonymous, 2019). Pearl millet can produce good fodder and grain yield in poor soil with low organic matter. It can also tolerate high temperature and is able to extract water and mineral nutrients from poor soils. One of the major challenges for farmers today under various agro- ecological environments is to increase crop productivity in a sustainable manner. Pearl millet is mostly grown as monocrop under rainfed situations. Crop failure is observed due to extreme drought situation and formation of crust. Intercropping is one of the best options under such situations because the use of total water is almost same for sole as well as intercropping, but here total output is increased, thus leads to increased available water use efficiency (Pawar and Khanna, 2018). Legumes or oilseeds intercropping in pearl millet can ensure some yield in case of failure of main crop in drought prone areas and can give additional income along with returns of main crop (Rani *et al.,* 2017). Leguminous crops benefit non-leguminous crops through biologically fixed atmospheric nitrogen (Tanwar *et al.,* 2011). Pigeon pea, cowpea, black gram, green gram, cluster bean are the most compatible intercrops with pearl millet because of their complementary or synergistic effect to the base crop. The objective of *intercropping* is to produce a greater yield on a given land by utilizing available resources or ecological processes that would otherwise not be utilized by a sole crop. Intercropping results in maximum sunlight utilization as compared to sole stand and also higher crop productivity, land use efficiency and monetary returns. For success of an intercropping system the component crops should have different growing period and make resource demand at different times so that they do not compete with each other (Gharineh and Telavat, 2009). Therefore, this experiment was conducted to study the complementary or antagonistic effects of intercropping of legumes/oilseeds on the newly developed biofortified hybrid HHB 299.

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MATERIALS AND METHODS

The experiment was conducted during Kharif season 2019 at Chaudhary Charan Singh Haryana Agricultural University, Hisar. The soil of the experimental field was sandy loam in texture with pH 8.0, organic carbon (4.4 g kg^{-1}), available N, P and K (142, 17 and 196 kg ha^{-1} respectively). The experiment was laid out in randomized block design with three replications. There were eleven treatments having five sole treatments and six intercropping treatments. These are T_1: Sole pearl millet at 45 cm row spacing, T_2: Pearl millet in paired row (30:60), T_3: Sole green gram (MH-421) at 45 cm**,** T_4 : Sole cluster bean (HG 2-20) at 45 cm, T_{5c}: Sole sesame (HT 1) at 45 cm, T_6: Pearl millet (paired row) + green gram (one row) at 30 cm spacing (2:1), T_7: Pearl millet (paired row) + cluster bean (one row) at 30 cm spacing (2:1), T_8: Pearl millet (paired row) + sesame (one row) at 30 cm spacing (2:1), T_9: Pearl millet + green gram (2:2) at 45 cm row spacing, T_{10}: Pearl millet + cluster bean (2:2) at 45 cm row spacing and T_{11}: Pearl millet + sesame (2:2) at 45 cm row spacing. The main crop (pearl millet) as well as intercrops were sown manually by hand plough on July 24th, 2019. Nitrogen and phosphorus were applied in the form of urea and diammoium phosphate (DAP). Half dose of nitrogen (20 kg ha^{-1}) and full dose of phosphorus (20 kg ha^{-1}) were applied as basal at the time of sowing in the sole as well as in 2:1 and 2:2 row ratio pearl millet based intercropping. Rest of nitrogen (20 kg ha^{-1}) was top dressed after thinning and weeding operations. In sole crop of green gram and cluster bean, full dose of Nitrogen @ 20 kg ha^{-1} and phosphorus @ 40 kg ha^{-1} was applied as basal whereas, in sesame crop full amount of N @ 37.5 kg ha^{-1} was applied before sowing of the crop.

Number of effective tillers $plant^{-1}$, length of ear heads, girth of ear heads and test weight were recorded at harvest. The grain and stover yield were also recorded at harvest. Tiller conservation index was calculated by division of number of effective tillers to total tillers $plant^{-1}$ and multiplied by 100. Pearl millet equivalent yield (PEY) was computed as it is the conversion of intercrop yield to the equivalent yield of pearl millet based on price. Net returns (Rs. ha^{-1}) were calculated by subtracting the total cost of cultivation from the gross returns to find most profitable treatment. Benefit: cost is the ratio of gross returns (Rs ha^{-1}) to cost of cultivation (Rs ha^{-1}).

Data for different characters like yield and yield attributing features were analyzed statistically by ANOVA. Then significance of treatment effects was tested using 'OP STAT and critical difference (CD) was worked out to differentiate the effects of different treatments.

RESULTS AND DISCUSSION

Yield attributes

Perusal of data (Table 1) indicated that the ear head length varied from 25.4 to 28.4 cm. Sole pearl millet at 45 cm had maximum earhead length (28.4 cm) which was statistically at par with pearl millet in paired row system (27.4 cm) and significantly higher as compared to other the intercropping treatments. Among intercropping systems, pearl millet-green gram in 2:2 row ratio had the highest and pearl millet-sesame in 2:1 cropping system had the lowest earhead length. The ear head girth in the sole pearl millet at 45 cm spacing and in paired row (3.6 cm) was statistically at par with intercropping system of pearl millet + cluster bean (3.5 cm) and pearl millet + green gram (3.5 cm) in 2:2 row ratio. The earhead girth remained statistically at par among all the 2:1 intercropping systems but was significantly lower than the sole pearl millet at 45 cm spacing and paired row planting except in pearl millet- cluster bean 2:1 intercropping system. Highest test weight (11.35 g) was recorded in sole pearl millet at 45 cm row spacing (Table 1). However, it was statistically at par with paired row planting of pearl millet (11.13 g) and pearl millet-green gram in 2:2 row ratio (10.60 g). The other intercropping systems registered significantly lower test weight (9.63-10.13 g) as compared to sole pearl millet in 45 cm and 30:60 (except over pearl millet + sesame in 2:2) row spacing. Similar results were reported by Mathukia *et al.* (2015).

Total tillers per plant were highest (4.2) in sole pearl millet at 45 cm spacing and in paired row which was statistically at par with pearl millet-green gram gram (4.1). The total tillers $plant^{-1}$ in pearl millet + sesame and pearl millet + cluster bean in 2:1 row ratio was significantly lower than sole pearl millet crop sown at 45 cm row spacing. (Table 1) The effective tillers $plant^{-1}$

varied from 2.5 to 3.0 and maximum number was noticed in sole pearl millet at 45 cm (3.0) and minimum in pearl millet-sesame intercropping system of 2:1 row ratio (2.5). Similar findings were also reported by Mathukia and Ghilotia *et al.* (2015). The TCI was maximum in sole pearl millet at 45 cm spacing (73.8%). It was at par with pearl millet-green gram intercropping system in 2:2 row ratio (72.5%) and significantly higher than other treatments. TCI values were significantly lesser among all the remaining treatments as compared to sole crop at 45 cm and minimum was recorded in 2:1 intercropping system of pearl millet-sesame (66.7%).

The data showed that harvest index ranged from 28.9 to 32.8% and highest value was noticed in sole pearl millet at 45 cm spacing (32.8%). The lowest value of 28.9% was recorded in pearl millet-sesame (2:1 row ratio) intercropping system. Highest yield attributes were obtained in sole pearl millet at 45 cm spacing and in paired row stand due to high plant population, less competition of sole stand as compared to intercropping system. Among different intercropping systems, pearl millet intercropped with green gram performed the best. This might be due to less competitiveness of green gram with pearl millet in comparison to other two intercrops.

Table 1: Effect of intercropping systems on yield attributes of pearl millet

Treatments	Earhead length (cm)	Earhead girth (cm)	Test weight (g)	Tillers plant^{-1}	Effective tillers plant^{-1}	Tiller conservation Index (%)	Yield (q ha^{-1})		Harvest index (%)
							Grain	Stover	
T_1	28.4	3.6	11.35	4.2	3.0	73.8	48.83	32.8	32.8
T_2	27.4	3.6	11.13	4.2	2.9	70.6	47.45	32.4	32.4
T_3	-	-	-	-	-	-	-	-	-
T_4	-	-	-	-	-	-	-	-	-
T_5	-	-	-	-	-	-	-	-	-
T_6	26.2	3.4	9.86	3.9	2.8	71.7	44.68	31.4	31.4
T_7	25.9	3.5	9.70	3.8	2.7	69.7	41.28	30.2	30.2
T_8	25.4	3.4	9.63	3.6	2.5	66.7	36.86	28.9	28.9
T_9	26.4	3.5	10.60	4.1	2.9	72.5	30.28	29.9	29.9
T_{10}	26.2	3.5	10.13	4.0	2.8	70.3	29.63	29.7	29.7
T_{11}	25.8	3.5	10.00	3.9	2.6	67.4	28.84	29.7	29.7
SEm ±	0.6	0.1	0.35	0.1	0.1	0.7	1.21	1.0	1.0
C. D. (P= 0.05)	1.9	0.1	1.08	0.3	0.2	2.0	3.69	NS	NS

T_1: Sole pearl millet at 45 cm row spacing, T_2: Pearl millet in paired row (30:60), T_3: Sole green gram (MH-421) at 45 cm, T_4: Sole cluster bean (HG 2-20) at 45 cm, T_5: Sole sesame (HT 1) at 45 cm, T_6: Pearl millet (paired row) + green gram (one row) at 30 cm spacing (2:1), T_7: Pearl millet (paired row) + cluster bean (one row) at 30 cm spacing (2:1), T_8: Pearl millet (paired row) + sesame (one row) at 30 cm spacing (2:1), T_9: Pearl millet + green gram (2:2) at 45 cm row spacing, T_{10}: Pearl millet + cluster bean (2:2) at 45 cm row spacing and T_{11}: 3Pearl millet + sesame (2:2) at 45 cm row spacing

Yield

The perusal of data (Table 1) exhibited that grain and stover yield of sole pearl millet at 45 cm row spacing was statistically at par with paired row planting of pearl millet. The grain yield in sole pearl millet was significantly higher than all the intercropping treatments (2:1 and 2:2 row ratios) but stover yield of sole pearl millet was also at par with 2:1 intercropping systems. Among intercropping systems, maximum grain (44.68 q ha^{-1}) and stover yield (31.4 q ha^{-1}) was obtained with pearl millet-green gram in 2:1 row ratio Higher yield of sole stand was due to more number of plants of pearl millet per unit area of land. There might be less competition offered by green gram as compared to other intercrops and 2:1 row ratio also had higher plant population of pearl millet as compared to 2:2 row ratio, that resulted in higher yield of pearl millet- green gram 2:1 intercropping system after sole stand. The results are concurrent with the findings of Mathukia *et al.* (2015) in pearl millet intercropped with green gram and black gram and Barod *et al.* (2017) in pearl millet-pigeon pea intercropping systems. The PEY among the different treatments ranged from 20.01 to 64.67 q ha^{-1} and maximum value of PEY was recorded under pearl millet-green gram in 2:1 row ratio (64.67 q ha^{-1}). The minimum PEY was recorded in the sesamum when it was grown as a sole crop (20.01 q ha^{-1}). The results of pearl millet-green

gram intercropping was in close proximity with the findings of Yadav *et al.* (2015) in pearl millet and green gram intercropping in 1:1 and 1:2 row ratio. The protein content of pearl millet ranged from 10.21 to 11.13 %. Maximum protein content in pearl millet was recorded with pearl millet-green gram intercropping system in 2:2 row ratio followed by pearl millet-green gram in 2:1 in comparison to sole pearl millet. Similar results of higher value of protein content in pearl millet-legume interaction were also reported by Bana *et al.* (2016) in pearl millet-cluster bean intercropping and Sharma *et al.* (2009) in 2:2 pearl millet + cowpea intercropping system.

Economics

The net returns were higher by Rs 7,690 and 10,618 ha^{-1} in the pearl millet-green gram intercropping 2:1 row ratio as compared to sole pearl millet at 45 cm and paired pearl millet 30:60 cm spacing, respectively. This was due to additional returns of intercrops. The minimum net returns were noticed in sole sesame and pearl millet-sesame intercropping because sesamum might be more competitive as compared to other two intercrops, therefore affect yield of pearl millet which led to lower returns. Similar results were recorded by Hooda *et al.* (2004). Maximum benefit cost ratio was recorded in sole pearl millet crop at 45 cm spacing (2.84) followed by intercropping system of pearl millet with green gram in 2:1 row ratio (2.77), pearl millet in 30:60 cm paired row (2.77) showing the advantage of intercropping of green gram and cluster bean in 2:1 as compared to other intercropping treatments.

Table 2: Pearl millet equivalent yield and economics as affected by various treatments

Treatments	Protein (%)	PEY (q ha^{-1})	Net returns (Rs ha^{-1})			B:C ratio
			Pearl millet	Inter-crop	Total	
T_1	10.6	57.84	74993	-	74993	2.84
T_2	10.5	56.38	72065	-	72065	2.77
T_3	-	31.27	-	31298	31298	2.00
T_4	-	28.06	-	24882	24882	1.80
T_5	-	20.01	-	11223	11223	1.39
T_6	11.0	64.65	66216	16467	82683	2.77
T_7	10.8	59.68	59057	13687	72744	2.56
T_8	10.2	51.84	49336	7892	57228	2.23
T_9	11.1	51.25	35533	23272	58805	2.35
T_{10}	10.9	49.98	34125	22148	56273	2.29
T_{11}	10.4	45.47	32208	15224	47433	2.09

From the result it may be concluded that the yield and its attributing traits were comparable in sole pearl millet at 45 cm spacing, paired row pearl millet sowing at 30:60 cm and intercropping system of pearl millet and green gram in 1:1 row ratio. Sesame in 2:1 ratio caused maximum reduction in yield contributing traits in pearl millet whereas such reduction with green gram and cluster bean intercropping system were not significant. The benefit-cost ratio was highest in sole pearl millet followed by intercropping of pearl millet with green gram in 2:1 row ratio. Thus it is recommended that intercropping should be done with rainfed crop like pearl millet to overcome crop failure in drought situations and to get maximum output from available resources.

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