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Fodder productivity of pearl millet with intercropping of legumes under various row proportions

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Abstract
A field experiment was conducted during *kharif* 2019 to study the effect of legume intercropping at various row ratios on productivity of fodder pearlmillet. Ten treatments comprising of sole fodder crops (pearl millet, cowpea, clusterbean and mothbean) and intercropping of fodder pearl millet with each fodder legume crop (cowpea, clusterbean and mothbean) in 2:2 and 4.2 ratios were tried in randomized block design with four replications at Agronomy Instructional Farm, C.P.C.A, S. D. Agricultural University, Sardarkrushinagar. Fodder pearl millet + cowpea in 2:2 row ratio resulted in significantly higher fodder pearl millet growth attributes like number of tillers per plant, leaf to stem ratio, leaf length and leaf width. Whereas, growth and yield attributes like stem girth, green fodder yield and dry fodder yield of fodder pearl millet were significantly higher under sole fodder pearl millet. The treatment fodder pearl millet + cowpea in 2:2 row ratio proved significantly superior over others for total green fodder, total dry fodder and pearl millet green fodder equivalent yield.

Keywords: fodder pearlmillet, fodder cowpea, fodder clusterbean, fodder mothbean, intercropping

Introduction
According to 20th all India livestock census, total livestock population of India and Gujarat in 2019 was 536.76 and 26.9 million, respectively. Livestock alone contributes to 28.4% (Anonymous, 2019) [1] of the India's agricultural GDP. More than half of the cost of milk production to the farmer lies with the feed supply to the livestock. As per estimates of Directorate of Economic & Statistics, Department of Agriculture, Co-operation and Farmers Welfare, Government of India, fodder crops are cultivated only in about 4.9% (9.13 m ha) of the gross cropped area of the country and this area has been static for the last 25 years. Therefore, focus on enhancing the fodder productivity from the limited available land is the prime issue to be addressed for achieving food security of the livestock. Pearl millet occupies a distinguished place among cereal fodder crops because of its wider adaptability to climatic conditions, drought tolerance, vigorous growth, high yield, low seed cost and absence of toxic substances to animals like HCN. Intercropping with specific planting geometry and selection of compatible crops is a profitable practice to make use of available light, soil moisture and nutrients more efficiently thus, improving productivity of dryland crops.

Materials and Methods
A field experiment was planned during *kharif* season 2019 at the Agronomy Instructional farm, Chimanbhai Patel college of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. The soil of the experiment plot was loamy sand, low in organic carbon as well as available nitrogen (149.5 kg/ha), medium in available phosphorus (38.4 kg/ha) and high in potassium status (282 kg/ha) with pH (7.5) and electrical conductivity 0.15 dS/m.
The experiment comprised of ten treatments *viz;* Sole fodder pearl millet, sole fodder cowpea, sole fodder clusterbean, sole fodder mothbean, fodder pearlmillet + fodder cowpea (2:2), fodder pearlmillet + fodder cowpea (4:2), fodder pearlmillet + fodder clusterbean (2:2), fodder pearlmillet + fodder clusterbean (4:2), fodder pearlmillet + fodder mothbean (2:2), fodder pearlmillet + fodder mothbean (4:2). The varieties selected for different crops were GFB 1 for fodder pearl millet, EC 4216 for fodder cowpea, BG 1 for fodder clusterbean and GMo 1 for fodder mothbean. Sowing was done in the furrows opened at 30 cm apart. The crops were fertilized with nitrogen and phosphorus using urea and DAP. Nitrogen recommendation was 100 kg/ha for fodder pearlmillet which was applied as 25 kg in basal application and 75 kg as topdressing with 25 kg in first split at 33 DAS and 50 kg in second split after first cut whereas

for fodder legumes, entire requirement of nitrogen was applied as basal @ 20 kg/ha. Entire requirement of phosphorous was applied in basal @ 40 kg/ha for each fodder crop. Bio fertilizers *Azotobacter* and phosphorous solubilising bacteria were used in seed treatment @ 250 g/8 kg seed for all the fodder crops. Seed rates of fodder pearlmillet and legumes adopted in the experiment were 12 and 40 kg/ha, respectively. GFB 1 was a multicut variety hence two cuts were taken with first cut at 53 DAS and the second at 33 days after the first cut. All the fodder legumes were harvested in a single cut. Girth of the stem without leaf sheath was measured between 3rd and 4th node from base. Leaf to stem ratio was measured by dividing leaf weight of the plant with stem weight of the plant. Length of the leaf was measured from ligule to tip of the leaf (at 4th node from tip of the main stem) Width of leaf was measured at the widest point of leaf. Pearl millet green fodder equivalent yield was calculated using the formula given below for comparing the yield of various treatments with different crops.

$$PGEY = \frac{P_I}{P_M} \times Y_I + Y_M$$

PGEY= Pearl millet green fodder equivalent yield
P_I = Price of intercrop (fodder legume)
P_M = Price of main crop (fodder pearlmillet)
Y_I = Yield of intercrop
Y_M = Yield of main crop

Results and Discussion

Growth Parameters

The tallest plants of fodder pearl millet were noticed in the treatments with intercropping. This could be because of inter specific competition which produced taller plants but was not so intense to produce significant effect. Significantly the highest number of tillers/plant (4.04) were noticed in fodder pearl millet + fodder cowpea in 2:2 row ratio. Which could be because of better utilization of space, natural resources and better availability of nitrogen supplied from the suitable intercrop and its row ratio with fodder pearl millet. These results are similar with the results obtained to Sharma (2008) [2]. An increase in the number of tillers per plant of pearl millet with legume intercropping was observed. The highest leaf to stem ratio (0.88) of fodder pearlmillet noticed in fodder pearl millet + fodder cowpea 2:2in row ratio and was at par with the fodder pearl millet in fodder pearl millet + fodder clusterbean with 2:2 row ratio of 0.79 and fodder pearl millet + fodder clusterbean in 4:2 row ratio of 0.78. The highest leaf to stem ratio in intercropping might be due to the fodder legume contribution of nitrogen supply to cereal (fodder pearl millet). These results are similar with that of Dhonde *et al.* (2016) [3] and Islam *et al.* (2018) [4]. The best performance of pearl millet + cowpea (2:2 row ratio) over all the other intercrops in varying row proportion is thought to be because of the intercrop associated with fodder pearl millet and also the row ratio. Significantly the highest number of leaves per plant (59.50) were noticed in it. These results are similar with the results obtained by Ginwal (2019) [5]. Significantly the highest leaf length (83.63 cm) of fodder pearl millet was noticed in treatment fodder pearl millet + cowpea in 2:2 row ratio and was at par with rest of the treatments except sole fodder pearl millet which recorded the lowest leaf length (64.44 cm). Alalade *et al.* (2013) [6] also reported increase in leaf length of cereal with legume intercropping. The superior result in it could be because of the favorable intercropping row ratio of fodder cowpea and better supply of nutrients. These results are in fully agreement with Ginwal *et al.* (2019) [5] in intercropping of maize with different row ratios with cowpea and *guar* in which they recorded the highest number of leaves in cereal maize when intercropped with cowpea. Leaf width is also an essential parameter to determine green fodder yield and quality. Leaf width of the fodder pearl millet was significantly affected with the intercropping of fodder legumes at various row ratios. Significantly the highest leaf width (2.88 cm) of fodder pearl millet was noticed under fodder pearl millet + fodder cowpea in 2:2 row ratio. Results of Alalade *et al.*(2013) [6] also showed increase in leaf width of cereal crop with legume intercropping. Record of the maximum leaf width of fodder pearl millet might be because of the highly favorable combination of row ratio (2:2) and intercrop (fodder cowpea).

Yield Parameters

Sole fodder pearl millet recorded significantly the highest green fodder yield (734.47 q/ha) of fodder pearl millet which was statistically at par (708.41 q/ha) with fodder pearl millet + cowpea in 2:2 row ratio. This could be probably because of the positive effect through additional nitrogen fixation of the associated fodder cowpea with fodder pearl millet in 2:2 ratio. Maximum light and better resource use efficiency might have enhanced the yield of pearl millet (even at reduced land area under fodder pearl millet) which is comparable to that of sole fodder pearl millet. Among fodder legumes, cowpea recorded the maximum green fodder yield (326.15 q/ha) when compared with the different treatments that involved legumes which might be attributed to its suitable variety under intercropping. These results are similar with the results obtained by Ahamdi *et al.* (2017) [7], Anitha and Lakshmi (2017) [8] and Asangla & Gohain (2016) [9]. Significantly the highest pearl millet green fodder equivalent yield (919.50) was observed under the treatment of fodder pearl millet + fodder cowpea with 2:2 row ratio.

Table 1: Effect of various ratios of legumes on growth parameters of fodder pearlmillet

Treatment (All fodder crops)	Mean plant height(cm)	Mean no. of tillers per plant	Mean leaf to stem ratio	Mean stem girth (cm)	Mean leaf length (cm)	Mean leaf width(cm)	Mean no. of leaves per plant
T_1: Sole pearl millet	130.6	1.91	0.62	2.44	64.44	2.09	40.25
T_2: Sole cowpea	-	-	-	-	-	-	-
T_3: Sole clusterbean	-	-	-	-	-	-	-
T_4: Sole mothbean	-	-	-	-	-	-	-
T_5: Pearl millet + cowpea (2:2)	134.8	4.04	0.88	2.38	83.63	2.88	59.50
T_6: Pearl millet + cowpea (4:2)	138.9	2.33	0.75	2.40	78.38	2.81	44.13
T_7: Pearl millet + clusterbean (2:2)	128.1	2.64	0.79	2.30	76.13	2.30	46.38
T_8: Pearl millet + clusterbean (4:2)	133.7	3.35	0.78	2.26	76.38	2.46	52.88
T_9: Pearl millet + mothbean (2:2)	1266	2.40	0.70	2.23	76.50	2.48	43.88
T_{10}: Pearl millet + mothbean (4:2)	130.2	2.30	0.69	2.26	76.00	2.29	44.25
S.Em.±	4.25	0.11	0.03	0.07	2.70	0.08	2..07
C.D. at 5 %	NS	0.35	0.10	NS	8.03	0.24	6.16
C.V. %	6.45	8.73	9.21	6.5	7.13	6.78	8.75

Table 2: Effect of various ratios of legumes on yield parameters of fodder pearlmillet

Treatment (All fodder crops)	Fodder pearl millet			Fodder legumes			Total green fodder yield (q/ha)	Pearl millet green fodder equivalent yield (q/ha)
	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Green and dry matter ratio	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Green and dry matter ratio		
T_1: Sole pearl millet	734.47	128.96	5.69	-	-	-	734.47	734.47
T_2: Sole cowpea	-	-	-	326.15	44.44	7.34	326.15	433.78
T_3: Sole clusterbean	-	-	-	202.91	28.74	7.05	202.91	269.86
T_4: Sole mothbean	-	-	-	230.05	32.90	6.99	230.05	305.96
T_5: Pearl millet + cowpea (2:2)	708.41	124.31	5.69	158.72	21.66	7.33	867.13	919.50
T_6: Pearl millet + cowpea (4:2)	604.53	105.98	5.70	109.73	14.94	7.34	714.26	750.46
T_7: Pearl millet + clusterbean (2:2)	482.08	84.29	5.71	103.01	14.60	7.05	585.09	619.08
T_8: Pearl millet + clusterbean (4:2)	544.49	95.51	5.70	58.83	8.31	7.08	603.32	632.84
T_9: Pearl millet + mothbean (2:2)	406.61	71.14	5.71	106.16	15.17	6.99	512.76	547.79
T_{10}: Pearl millet + mothbean (4:2)	525.29	92.49	5.67	79.12	11.31	6.99	604.41	630.51
S. Em.±	21.29	3.82	0.05	7.38	1.03	0.03	20.57	21.97
C.D. at 5 %	63.27	11.37	NS	21.54	3.01	0.10	59.71	63.76
C.V. %	7.44	7.62	1.76	9.67	9.68	1.03	7.65	7.52

Selling price of pearl millet green fodder: ₹ 150/q
Selling price of legumes green fodder : ₹ 200/q

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