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Effect of intercropping system and nitrogen levels on chemical properties of soil, nutrient content and uptake by pearl millet

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Abstract

The experiment was conducted in clayey texture soil at College Farm, Navsari Agricultural University, Navsari (Gujarat) during summer seasons of 2021 and 2022 to investigate the effects of different intercropping systems and nitrogen levels on chemical properties of soil, nutrient content and uptake by pearl millet. The experimental outcomes revealed that significantly the higher nitrogen content in grain and straw were observed in treatment I₆ - pearl millet + black gram (paired 3:2) while, significantly the higher N uptake in pearl millet grain and straw were obtained in I₄- Pearl millet + black gram (paired row 2:1) and remained at par with I₁- Sole pearl millet and I₅- Pearl millet + cow pea (paired row 2:1) although, significantly the higher P₂O₅ and K₂O uptake in grain and straw were noted in I₁- Sole pearl millet and remained at par with I₄- Pearl millet + black gram (paired row 2:1) and I₅- Pearl millet + cow pea (paired row 2:1). Sole cow pea was recorded significantly higher available nitrogen after crop harvest in soil.

Keywords: Intercropping, nitrogen, pearl millet, cow pea, content and uptake

Introduction

Pearl millet having a popular name *bajra*, Indian millet, bulrush millet and cattail millet in India. It is the fourth most important food grain crop in India after rice, wheat and sorghum. It has high protein content with slightly superior amino acid profile. The grain contains 13-14% protein, 5-6% fat, 74% carbohydrate and 1-2% minerals. It also contains higher amount of carotene, riboflavin (Vitamin B2) and niacin (Vitamin B4). (Anon., 2008)^[1].

Cultivation of pearl millet is mainly carried out during *kharif* season throughout the country and it occupies an area of about 6.70 million hectares with the total production of 9.62 million tones with productivity of 1436 kg/ha (Anon., 2022)^[3]. Pearl millet is also grown during summer season in Punjab, Rajasthan and Gujarat. In Gujarat, summer pearl millet occupies an area of 2.76 lakh hectares with an annual production of 7.67 lakh tones and productivity of 2779 kg/ha while, *Kharif* pearl millet occupies an area of 1.84 lakh hectares with an annual production of 2.82 lakh tones and productivity of 1534 kg/ha (Anon., 2021)^[2].

The "paired row system" was utilized to quantify mixture yield advantages. In the paired row system, row spacing between the main crops is narrowed down to have more space between two pairs of main crops which is utilized to plant intercrop to obtain additional yield. Sowing of pearl millet in paired row system has been proved advantageous over uniform row system as it widens the scope of introducing a pulse as an intercrop without having any adverse effect on the productivity of the base crop. The basic concept of intercropping system involves growing together two or more crops with the assumption that two crops can exploit the environment better than one and ultimately produce higher yield since the component crops differ in resources use and when grown together, they complement each other and make overall better use of resources.

Among the different factor responsible for augmenting yield, fertilizer singularly contributes about 41%, hence fertilizer even through comparatively costly input is key essential production input for securing higher yields. Among different essential elements, nitrogen is an important element which promotes vegetative growth and influence the seed production also. It is an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis.

Materials and Methods

Field trials were conducted in the summer season of 2021 and 2022 at Navsari Agricultural University's College Farm in Navsari (Gujarat). The topography of the experimental site was fairly uniform and leveled. Geographically, university campus is situated at 20°57' N latitude, 72°54' E longitudes and has an altitude of 10 meters above the mean sea level. The soil of south Gujarat is locally known as "Deep Black Soil". The soil of the experimental site was characterized by flat topography with medium to poor drainage and good water holding capacity. According to soil analysis data, the experimental site's soil quality was clay in texture, low in organic carbon (0.48% and 0.51%) and available nitrogen (196.20 kg/ha and 201.42 kg/ha), medium in available phosphorus (38.78 kg/ha and 40.20 kg/ha), and high in available potassium (298.20 kg/ha and 311.16 kg/ha). The soil was slightly alkaline with normal electrical conductivity.

The experiment was carried out with total of fourteen treatments, seven intercropping treatments *viz.*, I₁ - sole pearl millet, I₂ - sole black gram, I₃ - sole cow pea, I₄ - pearl millet + black gram (paired 2:1), I₅ - pearl millet + cow pea (paired 2:1), I₆ - pearl millet + black gram (paired 3:2) and I₇ - pearl millet + cow pea (paired 3:2) and two nitrogen levels *viz.*, N₁ - 100% RDN and N₂ - 75% RDN were evaluated in RBD with factorial concept with three replications. Pearl millet, black gram and cow pea varieties GHB-732, GU-3 and GC-6, respectively were tested in the investigation. The pearl millet was seeded at 45 x 10 cm² spacing, and the recommended fertilizer dose for the main crop (pearl millet) was 80-40-0 N-P₂O₅-K₂O kg/ha, along with all other approved crop procedures. Area based fertilizer dose for the intercrops (black gram and cowpea) was given to the different treatments. Crop growth and yield characteristics were collected from the five tagged plants in each plot. The net plot area was used to calculate grain and straw yield, which was then converted into kilograms per hectare.

The cost of inputs, including seed, fertilisers, irrigation, and more, were determined using current local costs. The gross realization per hectare in rupees was derived from the grain yield and straw yield from each treatment, taking into account of local market values. The net return for each treatment was calculated by taking the total cost of cultivation and dividing it by the gross returns. The benefit-to-cost (B:C) ratio was calculated by dividing the total income by the cost of cultivation.

Results and Discussion

Effect on content of nutrients

The significantly higher nitrogen content in grain was observed in treatment I₆ - pearl millet + black gram (paired 3:2) which remained at par with treatment I₇ - pearl millet + cow pea (paired 3:2), I₅ - pearl millet + cow pea (paired 2:1) and I₄ - pearl millet + black gram (paired 2:1) during both the years as well in pooled analysis. While, in case of nitrogen content in straw, the significantly higher nitrogen content was reported in treatment I₆ - pearl millet + black gram (paired 3:2) and remained at par with treatment I₄ and I₇ in the first year while, in second year treatment I₆ remained at par with treatments I₄, I₅ and I₇ and in pooled analysis treatment I₆ remained at par with treatment I₇. The reason for improvement in nitrogen content of pearl millet with legumes may be attributed to "mutual avoidance" which implies that the roots tend to avoid the areas that have already been

depleted of resources by an associated crop. However, phosphorus and potassium content (grain and straw) remained unaffected by intercropping system. The findings are in close agreement with those obtained by Sharma and Gupta (2002)^[15], Dadhich and Gupta (2005)^[4], Keshwa and Kumar (2012)^[12], Desai *et al.* (2014)^[6] and Gaina *et al.* (2014)^[7].

When the Pearl millet fertilized with 100% RDN (N₁) recorded significantly higher nitrogen content in grain and straw over the 75% RDN (N₂) during both the years and in pooled analysis because of the increase in nitrogen concentration might be outcome of the increased availability of nitrogen to plant. However, the phosphorus and potassium content (grain and straw) remained unaffected by nitrogen levels. The results are in conformity with the work of Jat *et al.*, (2002)^[11], Sharma and Gupta (2002)^[15], Jakhar *et al.*, (2003)^[10], Dalal *et al.* (2005)^[5], Jakhar *et al.* (2011)^[9], Vari and Sadhu (2013)^[18].

Effect on uptake of nutrients

Among the different intercropping system examined, significantly higher nitrogen uptake of pearl millet grain and straw were recorded with treatment I₄ - pearl millet + black gram (paired 2:1) but it remained at par with the treatment (I₁) sole pearl millet and treatment I₅ - pearl millet + cow pea (paired 2:1) during both the years and in pooled analysis. While, the significantly higher P₂O₅ and K₂O uptake in grain and straw were noted in I₁: Sole pearl millet and remained at par with I₄: Pearl millet + black gram (paired row 2:1) and I₅: Pearl millet + cow pea (paired row 2:1).

The significantly higher NPK uptake of grain and straw were observed under sole cropping and 2:1 paired row intercropping system (Table 1 and 2) due to the fact that pearl millet utilized the nutrient more efficiently than that 3:2 paired row planting wherein more competition existed due to intercrops. It was also found that, the higher dry matter accumulation as well as grain and straw grain were found in sole cropping and 2:1 paired row intercropping system and it directly affects the NPK uptake of pearl millet grain and straw. The results are in conformity with the work of Sharma and Gupta (2002)^[15], Tatarwal and Rana (2007)^[17], Kujur *et al.* (2010)^[13], Keshwa and Kumar (2012)^[12] and Gaina *et al.* (2014)^[7].

The data further indicate that application of 100% RDN (N₁) resulted in significantly superior NPK uptake by grain and straw in both the years and pooled analysis over the 75% RDN because the higher yields (grain and straw) of pearl millet coupled with higher nutrient content resulted in higher uptake of nutrients. The results are in conformity with the work of Jat *et al.*, (2002)^[11], Sharma and Gupta (2002)^[15], Jakhar *et al.*, (2003)^[10], Dalal *et al.* (2005)^[5], Jakhar *et al.* (2011)^[9] and Vari and Sadhu (2013)^[18].

Effect on availability of nutrients in soil

Sole cow pea was recorded significantly higher available N during both the seasons which was found at par with treatment I₂ - sole black gram, I₆ - pearl millet + black gram (paired 3:2) and I₇ - pearl millet + cow pea (paired 3:2) in first season while treatment I₂ and I₆ in second season. Although, available P₂O₅ and K₂O were remained unaffected with intercropping system. The available N status of the soil in sole pearl millet was the lowest which might be the result of high exhaustive nature of pearl millet in sole cropping condition while, the highest available N was recorded with sole black

gram and cow pea which might be due to more nitrogen fixation and less dry matter accumulation of legume crop. The findings are in close agreement with those obtained by Kumar *et al.* (2006)^[14] and Singh *et al.* (2019)^[16].

The results further revealed that different nitrogen levels in pearl millet exerted their non-significant effect on available N, P₂O₅ and K₂O of soil during both the years

Table 1: N, P₂O₅ and K₂O content and uptake in grain and straw of pearl millet as influenced by intercropping and nitrogen levels

Treatments	Grain						Straw					
	Content (%)			Uptake (kg/ha)			Content (%)			Uptake (kg/ha)		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
A. Intercropping system												
I ₁ . Sole Pearl millet	1.73	0.32	0.63	57.60	10.68	21.00	0.36	0.20	1.03	21.31	11.48	60.27
I ₂ . Sole black gram	-	-	-	-	-	-	-	-	-	-	-	-
I ₃ . Sole cow pea	-	-	-	-	-	-	-	-	-	-	-	-
I ₄ . Pearl millet + Black gram (2:1)	1.83	0.31	0.63	60.30	10.25	20.68	0.39	0.19	1.03	22.32	11.02	58.96
I ₅ . Pearl millet + Cow pea (2:1)	1.83	0.33	0.63	58.73	10.61	20.00	0.38	0.20	1.04	21.48	11.07	58.14
I ₆ . Pearl millet + Black gram (3:2)	1.89	0.32	0.61	49.86	8.58	16.15	0.42	0.19	1.02	18.83	8.91	46.68
I ₇ . Pearl millet + Cow pea (3:2)	1.86	0.32	0.62	46.74	8.06	15.49	0.40	0.20	1.01	17.55	8.81	44.28
S.Em±	0.02	0.00	0.01	1.68	0.34	0.59	0.01	0.00	0.02	0.71	0.33	1.64
CD at 5%	0.06	NS	NS	4.83	0.99	1.71	0.02	NS	NS	2.03	0.95	4.69
B. Nitrogen levels												
N ₁ . 100% RDN	1.89	0.33	0.63	58.85	10.14	19.63	0.40	0.20	1.03	21.92	10.84	56.21
N ₂ . 75% RDN	1.77	0.32	0.62	50.44	9.13	17.70	0.38	0.19	1.03	18.68	9.68	51.12
S.Em±	0.01	0.00	0.01	1.06	0.22	0.38	0.00	0.00	0.01	0.45	0.21	1.03
CD at 5%	0.04	NS	NS	3.05	0.62	1.08	0.01	NS	NS	1.28	0.60	2.97
Interaction (I X N)												
S.Em±	0.03	0.01	0.01	2.38	0.49	0.84	0.01	0.01	0.02	1.00	0.47	2.31
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sig. interactions with Y	-	-	-	-	-	-	-	-	-	-	-	-
CV (%)	3.87	5.31	5.87	10.67	12.37	11.04	4.87	5.50	5.79	12.06	11.19	10.56

Table 2: Available N, P₂O₅ and K₂O status in soil after harvest of pearl millet as influenced by different treatments

Treatments	Available N (kg/ha)		Available P ₂ O ₅ (kg/ha)		Available K ₂ O (kg/ha)	
	2021	2022	2021	2022	2021	2022
A. Intercropping system						
I ₁ . Sole Pearl millet	193.76	205.24	37.47	38.88	298.55	308.93
I ₂ . Sole black gram	226.93	238.78	39.34	40.88	301.05	314.80
I ₃ . Sole cow pea	232.69	247.28	40.20	41.39	302.14	318.21
I ₄ . Pearl millet + Black gram (2:1)	206.73	223.46	37.65	38.93	298.86	311.84
I ₅ . Pearl millet + Cow pea (2:1)	211.05	224.99	38.14	39.97	299.10	313.39
I ₆ . Pearl millet + Black gram (3:2)	217.56	228.67	38.36	40.05	299.70	315.32
I ₇ . Pearl millet + Cow pea (3:2)	223.32	237.17	38.56	40.10	300.14	316.29
S.Em±	6.50	6.02	1.11	0.93	10.22	11.19
CD at 5%	18.89	17.49	NS	NS	NS	NS
B. Nitrogen levels						
N ₁ . 100% RDN	217.72	231.08	37.90	39.56	301.89	316.08
N ₂ . 75% RDN	214.29	227.66	39.16	40.49	297.98	312.15
S.Em±	3.47	3.22	0.60	0.49	5.46	5.98
CD at 5%	NS	NS	NS	NS	NS	NS
Interaction (I x N)						
S.Em±	9.19	8.51	1.58	1.31	14.45	15.83
CD at 5%	NS	NS	NS	NS	NS	NS
CV (%)	7.43	6.46	7.08	5.67	8.35	8.75
Initial value	196.20	201.42	38.78	40.20	298.20	311.16

Conclusion

Based on the findings of two years experimental results, it can be concluded that for getting higher nutrient content and uptake from pearl millet based intercropping system, pearl millet crop should be intercrop with black gram or cow pea in a 2:1 paired row intercropping system and supply 100% RDN. Beside this the intercropping of pearl millet with pulses also improve the nitrogen status over sole pearl millet at the end of the crop harvest.

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