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Harsh A Kamani
Ph.D Scholar, Department of Agronomy, Navsari Agricultural University, Navsari, Gujarat, India

Arvadiya LK
Associate Research Scientist, I.F.S. Department of Agronomy, Navsari Agricultural University, Navsari, Gujarat, India

Corresponding Author:
Harsh A Kamani
Ph.D Scholar, Department of Agronomy, Navsari Agricultural University, Navsari, Gujarat, India

Growth, yield attributes and yield of pearl millet as influenced by pearl millet based intercropping system with different levels of nitrogen

Harsh A Kamani and Arvadiya LK

Abstract
The experiment was conducted in clayey texture soil at College Farm, Navsari Agricultural University, Navsari (Gujarat) during summer seasons of 2021 and 2022. The experiment was carried out with seven intercropping treatments *viz*., I_1 - sole pearl millet, I_2 - sole black gram, I_3 - sole cow pea, I_4 - pearl millet + black gram (paired 2:1), I_5 - pearl millet + cow pea (paired 2:1), I_6 - pearl millet + black gram (paired 3:2) and I_7 - pearl millet + cow pea (paired 3:2) and two nitrogen levels *viz*., N_1 - 100% RDN and N_2 - 75% RDN were evaluated in RBD with factorial concept with three replications. The growth parameters of pearl millet *viz*., plant height, number of functional leaves, number of effective tillers, dry matter accumulation and yield attributes *viz*., length, girth, weight and grain weight of ear head as well as grain yield (3310 kg/ha), straw yield (5853 kg/ha) and biological yield (9163 kg/ha) were recorded significantly higher under sole pearl millet and remained at par with 2:1 paired intercropping systems in case of plant height, dry matter accumulation, all the yield attributes and yield during both the years of experiment and in pooled analysis. Among the nitrogen levels, all growth parameters, yield attributes as well as grain yield (3117 kg/ha), straw yield (5470 kg/ha) and biological yield (8588 kg/ha) were found significantly higher under application of 100% RDN (N_1) over 75% RDN (N_2) during both the years of experiment and in pooled results.

Keywords: Growth, intercropping, nitrogen, pearl millet, yield

Introduction
Pearl millet having a popular name *bajra*, Indian millet, bulrush millet, cattail millet and pencillaria 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 (Yadav *et al*., 2015) [4].
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 40.20kg/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*., I_1 - sole pearl millet, I_2 - sole black gram, I_3 - sole cow pea, I_4 - pearl millet + black gram (paired 2:1), I_5 - pearl millet + cow pea (paired 2:1), I_6 - pearl millet + black gram (paired 3:2) and I_7 - pearl millet + cow pea (paired 3:2) and two nitrogen levels *viz*., N_1 - 100% RDN and N_2 - 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 cm^2 spacing, and the recommended fertilizer dose for the main crop (pearl millet) was 80-40-0 N-P_2O_5-K_2O 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 to 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 growth of pearl millet

The growth parameters of pearl millet *viz*., plant height (50.79, 136.05 and 177.08 cm at 30, 60 DAS and at harvest, respectively), number of functional leaves (4.75, 7.75 and 6.92 cm at 30, 60 DAS and at harvest, respectively), number of effective tillers (4.42) and dry matter accumulation (10.39, 27.23 and 49.67 g at 30, 60 DAS and at harvest, respectively) were recorded significantly higher under sole pearl millet which was remained at par with the treatment I_4 - pearl millet + black gram (paired 2:1) and I_5- pearl millet + cow pea (paired 2:1) in case of plant height and dry matter accumulation. The treatments of sole cropping and 2:1 paired row intercropping system recorded significantly increase in almost all the growth parameters it may probably due to absence or lower competition exist for non-renewable resources like water, nutrients and incoming sunlight as compared to 3:2 paired row intercropping system. The present findings are also in agreement with the results of Ramulu *et al*. (2000) [5], Baldevram *et al*. (2005) [6], Ram *et al*. (2005) [7], Chaudhary *et al*. (2012) [6], Yadav *et al*. (2015) [4] in pearl millet and Pathak *et al*. (2013) [9] in sorghum.

While, among the nitrogen levels all growth parameters were found significantly higher under application of 100% RDN over 75% RDN during both the years of experiment and in pooled results. The increase in all the growth parameters with increased nitrogen levels would be attributed to favorable effect of nitrogen in increasing cell wall material and size of cell, proper leaf expansion, increase in leaf surface area and the number of leaves and results in better efficiency of chlorophyll during photosynthesis and these overall improvement resulted into better vegetative growth of the pearl millet. These results were also in conformity with the findings of Patel and Parmar (1987) [10], Singh and Singh (1991) [11], Dixit *et al*. (2005) [13] and Jakhar *et al*. (2013) [14].

Effect on yield attributes and yield of pearl millet

The yield attributes *viz*., length (22.88 cm), girth (8.65 cm), weight (34.18 g) and grain weight per ear head (16.37 g) as well as grain (3310 kg/ha), straw (5853 kg/ha) and biological yield (9163 kg/ha) of pearl millet were recorded significantly higher under sole pearl millet and remained at par with 2:1 paired intercropping systems during both the years of experiment and in pooled analysis. It is due to availability of space, light, nutrient and water in sufficient amount and having limited disturbance of habitat although, the complementary interaction between intercrops and pearl millet, intercrops fix atmospheric nitrogen and utilized by pearl millet and increased the growth and yield attributes and overall increase the yield. Similar results have also been reported by Mukta *et al*. (2005) [15], Tetarwal and Rana (2007) [16], Choudhary (2009) [17], Ansari *et al*. (2011) [18], Patel and Sadhu (2013) [19], Ghilotia *et al*. (2015) [20], c Baldev *et al*. (2018) [1], and Goswami *et al*. (2020) [22]. However, 1000 grain weight and harvest index did not reached to the level of significant.

Among the nitrogen levels application of 100% RDN (N_1) recorded significantly higher values for all the yield attributes and yield over 75% RDN (N_2) during both the years and in pooled results. It is due to amount of nitrogen plays an important role in plant metabolism by virtue of being an essential constituent of diverse types of metabolically active compounds like amino acids, proteins, nucleic acid, enzymes, co-enzymes and alkaloids which are important for higher growth and yield. These findings are in close agreement with those obtained by Singh and Singh (1991) [11], Lal *et al*. (1992) [24], Khafi *et al*. (2000) [25] and Chaudhary *et al*., (2002) [26].

Table 1: Effect of intercropping system and nitrogen levels on growth of pearl millet

Treatments	Plant height (cm)			Number of functional leaves			Numbers of effective tillers	Dry matter accumulation (g/plant)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	At harvest	30 DAS	60 DAS	At harvest
A. Intercropping system										
I_1. Sole Pearl millet	50.79	136.05	177.08	4.75	7.75	6.92	4.42	10.39	27.23	49.67
I_2. Sole black gram	-	-	-	-	-	-	-	-	-	-
I_3. Sole cow pea	-	-	-	-	-	-	-	-	-	-
I_4. Pearl millet + Black gram (2:1)	48.41	127.86	156.40	4.08	6.67	6.00	4.08	9.96	26.35	47.45
I_5. Pearl millet + Cow pea (2:1)	47.63	125.80	155.26	4.00	6.58	5.67	3.58	9.67	25.65	46.55
I_6. Pearl millet + Black gram (3:2)	44.36	115.39	151.03	3.75	5.75	5.33	3.67	9.40	24.56	42.82
I_7. Pearl millet + Cow pea (3:2)	43.59	111.77	149.34	3.58	5.75	5.25	3.58	9.16	24.17	43.45
SEm±	1.15	3.86	4.50	0.12	0.17	0.13	0.11	0.21	0.52	1.04
CD at 5%	3.29	11.07	12.91	0.33	0.48	0.38	0.32	0.60	1.48	2.98
B. Nitrogen levels										
N_1. 100% RDN	48.58	130.63	164.73	4.33	7.27	6.60	4.13	9.95	26.66	47.08
N_2. 75% RDN	45.34	116.12	150.92	3.67	5.73	5.30	3.60	9.39	24.75	43.45
SEm+	0.72	2.44	2.85	0.07	0.11	0.08	0.07	0.13	0.33	0.66
CD at 5%	2.08	7.00	8.16	0.21	0.31	0.24	0.20	0.38	0.94	1.89
Interaction (I x N)										
SEm+	1.62	5.46	6.36	0.16	0.24	0.19	0.16	0.29	0.73	1.47
CD at 5%	NS	NS	NS	NS	NS	0.54	NS	NS	NS	NS
Sig. interactions with Y	-	-	-	-	-	-	-	-	-	-
CV (%)	8.45	10.84	9.88	9.98	8.98	7.72	10.08	7.43	6.97	7.96

Table 2: Effect of intercropping system and nitrogen levels on yield attributes and yield of pearl millet

Treatments	Length of ear head (cm)	Girth of ear head (cm)	Weight of ear head (g)	Grain weight per ear head (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
A. Intercropping system							
I_1. Sole Pearl millet	22.88	8.65	34.18	16.37	3310	5853	9163
I_2. Sole black gram	-	-	-	-	-	-	-
I_3. Sole cow pea	-	-	-	-	-	-	-
I_4. Pearl millet + Black gram (2:1)	21.96	8.35	32.60	15.76	3283	5753	9036
I_5. Pearl millet + Cow pea (2:1)	21.68	8.23	32.29	15.42	3203	5599	8802
I_6. Pearl millet + Black gram (3:2)	19.84	7.87	27.45	13.09	2643	4589	7232
I_7. Pearl millet + Cow pea (3:2)	19.36	7.75	27.12	12.94	2516	4375	6891
SEm±	0.51	0.12	0.65	0.30	92	176	220
CD at 5%	1.46	0.36	1.87	0.86	264	505	630
B. Nitrogen levels							
N_1. 100% RDN	21.83	8.33	31.34	15.33	3117	5470	8588
N_2. 75% RDN	20.14	7.89	29.50	13.86	2864	4997	7862
SEm+	0.32	0.08	0.41	0.19	58	111	139
CD at 5%	0.93	0.23	1.18	0.54	167	319	398
Interaction (I x N)							
SEm+	0.72	0.18	0.92	0.42	130	249	310
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Sig. interactions with Y	-	-	-	-	-	-	-
CV (%)	8.42	5.34	7.42	7.08	10.66	11.65	9.25

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