International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 705-708

Received: 04-03-2018
Accepted: 07-04-2018

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Performance of pearlmillet + greengram intercropping as influenced by different planting techniques and integrated nitrogen management under rainfed condition

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Abstract
Field experiments were conducted to evaluate the impact of planting techniques and integrated nitrogen management on growth attribute, yield attribute and yield of pearlmillet and greengram at agricultural research farm of Banaras Hindu University during kharif season of 2010 and 2011. The experiment comprised four planting techniques viz. uniform row, paired row, ridge-furrow and raised bed system and six integrated nitrogen management practices viz. 100% RDN (IF) to pearlmillet + no fertilizer to greengram, 100% RDN (IF) to pearlmillet + 100% RDF (IF) to greengram, 25% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram, 50% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram, 75% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram and 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram. Raised bed system being at par with ridge-furrow system showed its significant superiority over paired row and uniform row system in respect of yield attributes, yield, protein content, quality characters and protein harvest. Application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram was found significantly most effective in increasing growth attributes, yield attributes and yield over others treatments.

Keywords: Growth, integrated nitrogen, planting techniques and yield

1. Introduction
Pearlmillet is widely grown by resource per farmers of Varanasi region particularly under dryland condition. It is a short duration crop well adapted to less and erratic rainfall conditions. In order to utilize the receding profile moisture efficiently farmers follow intercropping mungbean with pearlmillet improving system productivity. It has been estimated that by inclusion of legumes in intercropping system, the extent of N addition would be 0.746 mt (Saraf *et al.*, 1990) [11]. Among all the pulses in India, greengram is third most important crop. Among various agronomic factors limiting crop production, planting pattern is considered of great importance. Increase in crop production can be ensured by maintaining appropriate plant population through different planting patterns. In this context, planting techniques play an impartment role in utilization resources particularly soil moisture and nutrients for enhanced crop production. Planting pattern is an important factor for agricultural sustainability development in influencing the soil protection (Govaerts, 2006) [4]. Planting pattern is an agronomic practice that optimizes the available natural and un-natural resources, the adjustment of row space and density is done to improve the effect of planting pat-terns on crop development. Sowing of pearlmillet in paired row system has been proved advantageous over uniform row system, as it widens the scope of introducing a legume as an intercrop without having any adverse effect on the productivity of the base crop. Modified planting patterns, viz. ridge and furrow, paired row and paired rows + intercrop recorded significantly higher growth, yield and nutrient uptake of pearimillet than uniform row system of planting (Rathore *et al.*, 2006) [10].

Application of nitrogenous fertilizer has played a key role in increasing food grains production in the country and will continue to do so in future. Integration of organic and inorganic nutrients also helps in improving soil health and crop production. The gap between nutrient removal and supply under rainfed situation, calls for integrated nutrient management strategy involving use of fertilizer, organic manure and bio-fertilizers.

Nitrogenous fertilizer has played a key role in increasing food grains production in India and will continue to do so in future (Prasad, 2011) [8]. Considering the importance of these factors in view, the present study was proposed to be undertaken for selecting suitable planting method and integrated nutrient practice for enhancing the productivity of pearlmillet + greengram intercropping system.

Materials and Methods

A field experiment was conducted for two years during *kharif* seasons of 2010 and 2011 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil of the experimental site was sandy loam texture with a pH of 7.30. It was moderately fertile, being low in organic carbon (0.35%), available nitrogen (191.12 kg/ha) and medium in available phosphorus (18.60 kg/ha) and potassium (198.15 kg/ha). The experiment was laid out in a split plot design with three replications. Four planting techniques, *viz*. uniform row, paired row, ridged furrow and raised bed planting were allocated to main plot. Six treatments of integrated nitrogen levels *viz*., 100% RDN (IF) to pearlmillet + no fertilizer to greengram, 100% RDN (IF) to pearlmillet + 100% RDF (IF) to greengram, 25% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram, 50% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram, 75% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram and 100% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram where, RDF represents recommended dose of N, P, K (20–40–20 kg/ha) through inorganic fertilizers to greengram and RDN recommended dose of N (80 kg/ha) through inorganic fertilizers and 25% N (20 kg/ha) through vermicompost and full dose of P, K (40-30 kg/ha) through inorganic fertilizers to pearlmillet were allocated to subplot. Thus, in all total twenty four treatment combinations were replicated thrice. 5 additional plots (one plot with all four planting techniques each for sole pearlmillet and 1 plot for sole greengram) were taken separately for comparison. The sources of inorganic fertilizers were urea, DAP, MOP. As per treatment, dose of nitrogen, phosphorus and potassium were applied as basal. Application of vermicompost was done on the basis of its nitrogen content only, ignoring the other nutrients. The pearlmillet cultivar 'TCTP-8203' and greengram cultivar 'HUM-16' were taken as test crops. The other crop management practices were preformed as per standard recommendation of the region. Crops were sown on 06.08.10 and 03.08.11 and harvested on 17.11.10 and 14.11.11, respectively during first and second year. The grain yield of each plot was recorded and converted in hectare. Statistical analysis was done as per the procedures given by Gomez and Gomez (1984) [3].

Results and Discussion

Effect on growth character

Planting techniques significantly influenced the growth attributes (plant height, number of tillers/plant, number of branches/plant, LAI and dry matter production/plant), (Table 1) of both crop. The highest values were recorded with raised bed system and minimum with uniform row system during both the years. Raised bed and ridge-furrow systems, being at par to each other, proved significantly superior to paired and uniform row planting systems. This improvement in growth attributes could be assigned to highest moisture availability for crop as a result of low water loss through evaporation, percolation and seepage, low weed infestation and better soil environment in raised bed planting system. The results of the present investigation are in close conformity with the findings of Ardeshna *et al*. (2013) [1], Parihar *et al*. (2013) [7], Rathore *et al*. (2006) [10] and Singh & Sharma (20005) [12]

Integrated nutrient levels caused significant variation in growth parameters [*viz*., plant height, number of tillers/plant, number of branches/plant, LAI and dry matter production /plant at all the stages (except at 20 DAS)] of both crops. In the case of pearlmillet, application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) proved significantly superior over rest of the integrated nitrogen levels during both the years. However, application of 75% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_5) was found statistically at par with 100% RDN (IF) to pearlmillet + 100% RDF (IF) to greengram (F_2) but significantly better than F_4, F_1 and F_3. While, in the case of greengram, application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) was found significantly superior to all the integrated nitrogen levels during both the years, except application of 75% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram which remained at par during both the years. Organic manures have synergistic relationship with inorganic fertilizers, thereby helping in mineralization of applied nitrogen and phosphorus, which might have helped in increased growth parameters, yield attributes and yield of crops. These findings are in agreement with the results reported by Das *et al*. (2013) [2], Parihar *et al*. (2013) [7], Yakadri and Gautam (2001) [13].

Effect on yield attribute and yield

Planting techniques significantly influenced the yield attributes (number of effective tillers/plant, ear weight, grains weight/ear, number of pods/plant, number of seeds/pod and 1000-grain weight) and yields (grain and stover yield) (Table 2 and 3) of both crop. Raised bed system registered highest values of yield attributes and yields which was found comparable to ridge-furrow system and both the planting systems proved significantly superior to others in this respect. Similarly, paired row system showed its significant superiority over uniform row system during both the years. This improvement in growth attributes could be assigned to highest moisture availability for crop as a result of low water loss through evaporation, percolation and seepage, low weed infestation and better soil environment in raised bed planting system. The results of the present investigation are in close conformity with the findings of Parihar *et al*. (2013) [7], Hosmath *et al*. (2011) [5] and Idnani & Gautam (2008) [6].

The integration of nitrogen with vermicompost improved the yield-attributing characters and yields of pearlmillet and greengram significantly (Table 2) during both the years. Application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) produced highest number of effective tillers/plant, ear weight, grain weight /ear, 1000-grain weight and yields (grain and stover) of pearlmillet and proved significantly superior to rest of the integrated nutrient levels during both the years of investigation. However, significantly lowest values were observed with 25% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_3). Similarly, application of 75% RDN (IF) + 25% RDN (VC) to main crop + 100% RDF (IF) to intercrop (F_5) and 100% RDN (IF) to main + 100% RDF (IF) to intercrop (F_2) were found comparable to each other and proved significantly superior to rest of the levels (F_4, F_1, and F_3) during both the years.

Application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + full recommended dose of nutrient to greengram (F_6) produced maximum number of pods/plant, number of seeds/pod, 1000-grain weight and highest yield (seed and straw) of greengram which was statistically at par with 75% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_5) and both were found significantly instrumental in enhancing the yield attributes and yield as compared to other nutrient levels during both the years of study. Similarly, applying full dose of nutrients to both the component crops (F_2) resulted into significantly higher seed yield of greengram than other three nutrients levels. However, lowest yield of greengram was observed under F_1 [100% RDN (IF) to pearlmillet + no fertilizers to greengram] which appeared to be least performer in this respect during both the years. Similar results were reported by Rajkhowa *et al*. (2002) [9].

Table 1: Plant height (cm) of pearlmillet and greengram as influenced by treatments

Treatments	Plant height (cm)				LAI				Dry matter production/plant(g)				Tillers/Branches/plant			
	Pearlmillet		Greengram		Pearlmillet		Greengram		Pearlmillet		Greengram		Pearlmillet		Greengram	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Planting Techniques																
P_1	147.94	151.97	27.68	29.04	2.27	2.35	2.34	2.38	3.71	4.18	17.06	19.89	3.7	4.2	1.7	1.9
P_2	158.34	162.47	30.67	32.24	2.44	2.53	2.58	2.62	4.63	5.10	19.34	22.58	4.6	5.1	2.1	2.4
P_3	171.00	175.25	33.56	35.27	2.64	2.72	2.79	2.88	5.42	6.02	21.66	25.31	5.4	6.0	2.7	2.9
P_4	177.67	181.99	34.51	36.26	2.72	2.82	2.87	2.93	6.00	6.58	22.71	26.54	6.0	6.6	2.8	3.0
SE m±	2.68	2.71	0.70	0.73	0.04	0.04	0.05	0.05	0.20	0.22	0.44	0.51	0.2	0.2	0.1	0.1
CD (P=0.05)	9.29	9.38	2.44	2.52	0.15	0.15	0.17	0.19	0.71	0.75	1.51	1.78	0.7	0.7	0.4	0.4
CV (%)	6.96	6.85	9.46	9.31	7.08	7.11	7.77	8.47	17.54	16.87	9.19	9.26	17.5	16.9	20.5	19.1
Integrated Nitrogen Management																
F1	152.81	155.43	25.13	26.51	2.38	2.47	2.20	2.23	4.13	4.63	15.17	17.67	4.1	4.6	1.1	1.3
F2	169.46	175.27	33.18	34.84	2.61	2.69	2.76	2.82	5.42	6.02	21.36	24.95	5.4	6.0	2.5	2.8
F3	143.43	145.95	28.30	29.79	2.23	2.32	2.38	2.44	3.34	3.81	17.33	20.21	3.3	3.8	1.7	1.9
F4	156.99	161.67	30.89	32.46	2.40	2.50	2.55	2.64	4.52	5.01	19.38	22.62	4.5	5.0	2.2	2.4
F5	175.42	179.95	35.56	37.30	2.66	2.74	2.95	3.01	5.76	6.31	23.65	27.65	5.8	6.3	3.1	3.3
F6	184.32	189.25	36.56	38.33	2.82	2.90	3.05	3.06	6.46	7.03	24.28	28.38	6.5	7.0	3.4	3.6
SE m±	2.87	2.90	0.77	0.79	0.05	0.05	0.05	0.06	0.21	0.21	0.38	0.45	0.2	0.2	0.1	0.1
CD (P=0.05)	8.21	8.30	2.19	2.27	0.13	0.14	0.14	0.16	0.59	0.60	1.10	1.29	0.6	0.6	0.4	0.4
CV (%)	6.08	5.99	8.40	8.27	6.29	6.29	6.55	7.24	14.59	13.34	6.58	6.63	14.6	13.3	19.1	17.8

Table 2: Yield attributes of pearlmillet and greengram as influenced by treatments

Treatments	Pearlmillet								Greengram					
	Effective tillers /plant		Ear weight (g)		Grain weight /ear (g)		1000- grain weight (g)		Pods/plant		Seeds/pod		1000- seed weight (g)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Planting Techniques														
P_1	1.75	2.19	36.04	37.61	21.42	22.17	8.36	8.80	13.54	14.49	7.54	9.68	38.59	41.50
P_2	2.37	2.83	40.23	41.98	23.94	24.77	9.37	9.83	15.21	16.21	8.42	10.58	43.16	46.14
P_3	3.43	3.93	43.98	45.87	26.18	27.08	10.27	10.76	16.70	17.73	9.20	11.37	47.24	50.27
P_4	3.65	4.16	45.80	47.78	27.28	28.21	10.71	11.21	17.43	18.48	9.59	11.76	49.22	52.29
SE m±	0.13	0.14	0.73	0.75	0.44	0.45	0.18	0.18	0.29	0.30	0.15	0.16	0.80	0.81
CD (P=0.05)	0.44	0.48	2.53	2.60	1.52	1.56	0.61	0.63	1.01	1.03	0.53	0.54	2.76	2.79
CV (%)	19.26	17.97	7.48	7.37	7.54	7.51	7.70	7.57	7.86	7.54	7.51	6.07	7.59	7.19
Integrated Nitrogen Management														
F_1	2.41	2.84	38.23	39.86	22.80	23.66	8.84	9.25	13.03	13.82	7.27	9.46	36.49	38.88
F_2	3.07	3.57	43.08	44.86	25.99	26.46	10.08	10.70	16.25	17.45	9.03	11.18	46.77	50.09
F_3	1.82	2.23	35.41	37.22	21.14	21.73	8.04	8.24	14.30	15.01	7.88	10.04	39.68	42.60
F_4	2.56	3.00	40.49	42.19	23.58	24.87	9.31	9.74	15.27	16.35	8.44	10.60	43.18	46.13
F_5	3.10	3.70	44.58	46.49	26.35	27.30	10.44	11.02	17.31	18.50	9.57	11.76	49.67	53.04
F_6	3.84	4.32	47.29	49.25	28.37	29.33	11.35	11.95	18.17	19.24	9.93	12.05	51.52	54.56
SE m±	0.14	0.14	0.82	0.85	0.49	0.51	0.20	0.20	0.33	0.34	0.17	0.18	0.90	0.91
CD (P=0.05)	0.39	0.41	2.35	2.43	1.41	1.45	0.56	0.58	0.94	0.96	0.49	0.50	2.56	2.60
CV (%)	16.87	15.28	6.87	6.81	6.92	6.89	7.07	6.95	7.23	6.95	6.89	5.59	6.97	6.62

Table 3: Yield of pearlmillet and greengram as influenced by treatments

Treatments	Pearlmillet yield (kg/ha)				Greengram yield (kg/ha)			
	Grain		Stover		Seed		Straw	
	2010	2011	2010	2011	2011		2010	2011
Planting Techniques								
P_1	1400	1485	4537	4648	521	615	1647	1854
P_2	1680	1788	5259	5350	610	700	1868	2049
P_3	2012	2113	6147	6365	666	770	2005	2218
P_4	2061	2189	6269	6441	692	797	2062	2297
SE m±	35	36	105	109	13	13	39	39
CD (P=0.05)	122	126	364	376	44	45	134	135
CV (%)	8.36	8.17	8.04	8.10	8.66	7.62	8.67	7.86
Integrated Nitrogen Management								

F_1	1581	1662	4897	5073	491	578	1532	1714
F_2	1906	2019	5906	6025	634	742	1961	2167
F_3	1364	1440	4376	4509	535	630	1679	1873
F_4	1691	1777	5238	5426	590	692	1818	2019
F_5	2007	2131	6232	6374	729	831	2168	2404
F_6	2181	2334	6669	6798	752	851	2214	2451
SE m±	40	41	123	127	14	15	45	46
CD (P=0.05)	114	117	353	364	41	42	130	132
CV (%)	7.70	7.52	7.70	7.74	7.97	7.03	8.31	7.58

Sole Green gram yield- 844.47 kg/ha (2010), 935.37 kg/ha (2011)

Sole Pearlmillet yield- P_1= 1648.28 kg/ha (2010), 1736.53 kg/ha (2011), P_2= 1786.67 kg/ha (2010), 1883.39 kg/ha (2011), P_3= 1973.83 kg/ha (2010), 2053.32 kg/ha (2011), P_4= 2008.67 kg/ha (2010), 2113.32 kg/ha (2011)

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