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Growth, yield and quality of cluster bean (*Cyamopsis tetragonoloba*) as influenced by integrated nutrient management under alley cropping system

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ABSTRACT

A field study was conducted to assess the impact of integrated nutrient management (INM) on cluster bean (*Cyamopsis tetragonoloba* L.) under alley cropping system in *kharif* 2018 at Banaras Hindu University, Mirzapur (UP). The six treatments, viz. 75% RDF + *Rhizobium*, 75% RDF + Biochar + *Rhizobium*, 100% RDF + *Rhizobium*, 75% RDF + farm yard manure + *Rhizobium*, 100% RDF + Vermicompost + *Rhizobium* and 75% RDF + pressmud + *Rhizobium* were laid out in randomized block design with four replications. Highest growth parameters, viz. plant height, dry matter accumulation, number of nodules/plant, dry weight of nodules, crop growth rate, leaf area index, chlorophyll content, number of secondary branches/plant, and the highest yield attributes and yield, viz. number of pods/plant, length of pod, number of seeds/pod, test weight, seed yield (922.60 kg/ha), straw yield (2496.10 kg/ha), biological yield (3418.70 kg/ha) were recorded with the application of 75 % RDF + pressmud + *Rhizobium.* Similarly, the highest NPK content and their uptake, protein and gum content, and economics, viz. gross return (77241 ₹/ha), net return (46461 ₹/ha) were seen with the application of 75% RDF + pressmud + *Rhizobium,* while the highest B: C ratio (1.59) was observed with the application of 100% RDF+ *Rhizobium*.

Key words: Biochar, Cluster bean, FYM, Pressmud, RDF, Vermicompost, Yield.

Alley cropping is one of the most widely practiced land use systems in the world where woody perennials (trees, shrubs, etc.) are grown in association with crop plants or livestock. It leads to greater prosperity at the farm level through marketable products such as timber, firewood, animal fodder, fruits, medicines, etc. all generating extra income (Meena *et al.* 2017). The production of guar [*Cyamopsis tetragonoloba* (L.) Taub.] in India crossed 2.7 million metric tonnes during the agricultural year 2013–14 (GOI 2015). There is big demand for Indian guar gum products, food additives, food thickener (Dadhich *et al.* 2014). Guar is a drought-tolerant, multi-purpose legume crop cultivated mainly in the *kharif* season in arid environments and is used as animal feed and fodder, green manure and for extraction of gum for various industrial uses (Baviskar *et al.* 2010). It is from the endosperm that guar gum is derived, which is the prime marketable product of the plant. The spherical endosperm contains significant amount of galactomannan gum (19-43% of the whole seed), which forms a viscous gel in cold water (Chavan *et al.* 2015). The FYM improves the nutrient and water holding capacity of soils, increases nutrients availability, enhance the beneficial soil microorganism activity, and improves the soil structure (Wendimu 2017). Vermicompost is a rich source of major and micronutrients and it improves the physical, chemical and biological properties of the soil (Meena and Yadav 2015). The physical and chemical characteristics of biochar give it several beneficial uses from environmental aspects, such as the soil improvement for planting, waste management by conversion of biomass to biochar, and mitigation of climate change by reducing CO_2 emission levels and storing it as carbon for a long time (Agegnehua *et al.* 2016). Pressmud is one of the important organic by-products of sugar industry which is capable of supplying sufficient amount of plant nutrients to soil, due to its favourable effects on soil texture, structure, water holding capacity, infiltration, soil porosity, hydraulic properties, bulk density and fertility status (Niazi *et al.* 2015). Biofertilizers play an important role in increasing the availability of nitrogen and phosphorus besides the increase in biological fixation of atmospheric nitrogen and enhance availability to crop (Rana *et al.* 2006). The nutrient requirement of the crop is met by the chemical fertilizers. However, fertilizer alone cannot sustain the productivity of

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land in modern farming. Similarly, nutrient supply through organic manures and biofertilizers can hardly fulfil the need for a crop. So, integration of organic and inorganic sources may sustain productivity and may improve the soil properties. Keeping in view the above facts, the present investigation was carried out to identify the response of the inorganic chemical fertilizers in combination with organic amendment through biofertilizers in cluster bean.

MATERIALS AND METHODS

A field experiment was carried out at the Agricultural Research Farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur (UP) situated in Vindhyan region of District Mirzapur, UP. It comes under the semi-arid region of India. The experimental site falls in sub-tropical zone, located at 25º 10'N, latitude 82º 37' E longitude and an altitude of 427 m amsl. The plow layer had available N (225.63 kg/ha), P (20.97 kg/ha), K (243.38 kg/ha), organic carbon (0.35%) and soil *p*H 5.92. The experiment was laid out during rainy (*kharif*) season of 2018 in 12 years old guava which was planted in August 2006 at the spacing of 7 × 7 m^2. Cluster bean was sown as a test crop. The experiment was conducted in randomized block design having different nutrient sources with four replication and six different treatments, viz. 75% RDF + *Rhizobium*, 75% RDF + biochar + *Rhizobium*, 100% RDF + *Rhizobium*, 75 % RDF + farmyard manure + *Rhizobium*, 100%RDF + vermicompost + *Rhizobium*, and 75 % RDF + pressmud + *Rhizobium*. RGC-936 variety of cluster bean was used in the experiment. The recommended dose of fertilizer was applied @ 20, 40 and 20 kg N, P_2O_5 and K_2O /ha. Complete amount of nitrogen, phosphorus, and potassium were given through urea (46% N), SSP (16% P_2O_5) and muriate of potash (60% K_2O) respectively. The seed was sown @ 30 kg/ha between the guava trees manually in the furrow at a row distance of 30 cm as per treatment. The critical differences were calculated to assess the significance of treatment mean, whenever the F test was found significant at 5% level. All these estimates were computed by the standard statistical procedure (Gomez and Gomez 1976).

RESULTS AND DISCUSSION

Effects on growth parameters of cluster bean: The data presented in Table 1 indicates that the nutrient sources significantly improved the growth parameters of cluster bean. These highest values of various parameters, viz. plant height at 60 DAS (85.67 cm), at harvest (97.32 cm), dry matter accumulation at 60 DAS (78.90 g/plant), at harvest (107.80 g/plant), number of nodules/plant at 45 DAS (41.01), dry weight of nodules at 45 DAS (26.46 mg/plant), crop growth rate at 30-60 DAS (2.17 g/m^2/day), 60 DAS- at harvest (0.96 g/m^2/day), leaf area index at 60 DAS (4.75), chlorophyll content (SPAD value 48.79), number of secondary branches/ plant at 60 DAS (5.98), at harvest (7.76) were observed with basal application of 75 % RDF + pressmud + *Rhizobium.* While the applications of 100% RDF+ vermicompost + *Rhizobium*, 75% RDF + FYM + *Rhizobium*, 100% RDF + *Rhizobium* and 75% RDF + biochar + *Rhizobium* was found at par to each other, respectively. The increase in all the growth parameters may be due to adequate availability of NPK, coupled with satisfactory moisture condition in field which in turn might have improved nutrient supplying capacity of soil. Good stand and better plant vigour in plots treated with 75% RDF + pressmud + *Rhizobium* indicated proper and balanced utilization of these nutrients by the crop. The increased availability of phosphorus to plant might have enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth in terms of plant height, dry matter accumulation and LAI. The pressmud + *Rhizobium* play an important role in root development and proliferation resulting in better nodules formation and nitrogen fixation by supplying assimilates to the root. They also increase the CEC, water holding capacity and phosphate availability in soil thus provide better environment in rhizosphere for growth and development. The beneficial effect of pressmud+ *Rhizobium* in growth attribute was probably due to enhanced supply of macro as well as micronutrients during the growing season. This study was supported by Rajkhowa *et al.* (2002), Jamil *et al.* (2004), Meena *et al.* (2016).

Effects on yield attributes and yield of cluster bean: It is indicated from Table 2 that the nutrient sources significantly improved the yield attributes and yield of cluster bean. Among the nutrient sources 75 % RDF + pressmud + *Rhizobium* gave highest number of pods/plant (36.48), length of pod (8.31 cm), number of seeds /pod (8.61), test weight (29.22 g), seed yield (922.60 kg/ha), straw yield (2496.10 kg/ha), biological yield (3418.70 kg/ha). However, 100% RDF + vermicompost + *Rhizobium* was statistically at par with application of 75 % RDF + pressmud + *Rhizobium*. Results indicate that all the nutrient sources were non-significant in improving the harvest index of cluster bean. The combined application of 75% RDF + pressmud + *Rhizobium* to the cluster bean increased availability of major nutrients to plant due to enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth attributes and finally increased crop growth rate. It is further supported that soil of the experimental field contained available nitrogen (225.63 kg/ ha), phosphorus (20.97 kg/ha) and potassium (243.38 kg/ ha) and this might be the cause in high response of the crop to the application of 75% RDF + pressmud + *Rhizobium*. This may be attributing primarily to the beneficial role of 75% RDF + pressmud + *Rhizobium* which improved overall physical condition of the soil. This was supported by Rathore *et al.* (2007), Sardana *et al.* (2006), Suman *et al.* (2007), Meena *et al.* (2018).

Effects on nutrient content, uptake and quality of cluster bean: It is indicated in Table 3 that the highest N content in seed and straw (3.57% and 0.80%), protein content (22.34%), total N uptake (52.86 kg/ha), P content in seed and straw (0.350% and 0.144%), total P uptake (6.81 kg/ha), K content

Table 1 Effect of integrated nutrient management practices on growth parameters of cluster bean under alley cropping system

Treatment	Plant height (cm)			Dry matter accumulation (g/plant)			No of nodules	Dry weight of nodules (mg/plant)	Crop growth rate (g/m^2/day)		Leaf area index		Chlorophyll content (SPAD value)	No. of secondary branches/plant	
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	45 DAS	45 DAS	30-60 DAS	60-harvest	30 DAS	60 DAS	45 DAS	60 DAS	At harvest
75 % RDF + *Rhizobium*	21.84	68.30	69.23	11.92	53.69	73.37	27.91	18.01	1.39	0.66	0.54	3.23	27.91	4.07	5.28
75 % RDF +Biochar + *Rhizobium*	22.33	80.21	80.97	12.18	74.43	88.03	33.49	21.61	2.07	0.45	0.74	4.48	33.49	5.64	6.34
100 % RDF + *Rhizobium*	23.25	83.98	84.04	12.68	75.63	93.09	35.42	22.85	2.10	0.58	0.75	4.55	35.42	5.73	6.70
75 % RDF + Farm yard manure + *Rhizobium*	24.30	84.23	86.01	13.26	77.21	95.27	36.25	23.39	2.13	0.60	0.77	4.65	36.25	5.85	6.86
75 % RDF + Vermicompost + *Rhizobium*	24.98	84.37	95.85	13.63	77.71	106.17	40.39	26.07	2.14	0.95	0.77	4.68	40.39	5.89	7.64
75 % RDF + Pressmud + *Rhizobium*	25.36	85.67	97.32	13.84	78.90	107.80	41.01	26.46	2.17	0.96	0.79	4.75	41.01	5.98	7.76
SEm±	0.94	1.97	1.92	0.52	2.72	3.44	0.94	0.67	0.09	0.06	0.03	0.16	0.94	0.21	0.25
CD (P =0.05)	NS	5.93	5.79	NS	8.18	10.37	2.84	2.03	0.26	0.17	NS	0.49	2.84	NS	0.75

Table 2 Effect of integrated nutrient management on yield attributes, yield and economics of cluster bean under alley cropping system

Treatment	Yield attributes				Yield (kg/ha)			Harvest index (%)	Economics		
	No. of pods/ plant	Pod length (cm)	No. of seeds/ pod	Test weight (g)	Seed	Straw	Biological		Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
75% RDF + *Rhizobium*	24.83	5.66	5.86	21.14	628	1593	2220	28.22	62600	35820	1.34
75% RDF + Biochar + *Rhizobium*	29.79	6.79	7.03	23.86	753	2225	2978	25.24	69330	40050	1.37
100% RDF + *Rhizobium*	31.50	7.18	7.44	25.23	797	2245	3043	26.19	71257	43766	1.59
75% RDF + Farmyard manure + *Rhizobium*	32.24	7.35	7.61	25.83	815	2254	3069	26.57	72087	40307	1.27
100% RDF + Vermicompost + *Rhizobium*	35.93	8.19	8.48	28.78	909	2340	3250	27.97	76324	46544	1.56
75% RDF + Pressmud + *Rhizobium*	36.48	8.31	8.61	29.22	923	2496	3419	26.99	77241	46461	1.51
SEm±	1.16	0.27	0.27	0.77	29	20	31	0.88	1273	1273	0.05
CD (P =0.05)	3.51	0.80	0.83	2.32	89	60	94	NS	3836	3836	0.14

Table 3 Effect of integrated nutrient management on NPK content and uptake, protein and gum content in cluster bean under alley cropping system

Treatment	N content (%)		Total N uptake (kg/ha)	P content (%)		Total P uptake (kg/ha)	K content (%)		Total K uptake (kg/ha)	Protein content seed (%)	Gum content (%)
	Seed	Straw		Seed	Straw		Seed	Straw			
75 % RDF + *Rhizobium*	2.65	0.60	26.31	0.259	0.106	3.33	0.144	0.518	9.16	16.53	22.43
75 % RDF +Biochar + *Rhizobium*	3.03	0.68	37.83	0.297	0.122	4.94	0.166	0.594	14.46	18.95	25.72
100 % RDF + *Rhizobium*	3.09	0.69	40.05	0.302	0.124	5.19	0.169	0.605	14.92	19.29	26.17
75 % RDF + FYM + *Rhizobium*	3.16	0.70	41.65	0.309	0.127	5.39	0.173	0.619	15.35	19.74	26.79
75 % RDF + Vermicompost + *Rhizobium*	3.55	0.79	50.73	0.348	0.143	6.50	0.194	0.695	18.03	22.17	30.08
75 % RDF + Pressmud + *Rhizobium*	3.57	0.80	52.86	0.350	0.144	6.81	0.195	0.700	19.28	22.34	30.31
SEm±	0.07	0.03	1.68	0.007	0.003	0.15	0.004	0.014	0.29	0.44	0.60
CD (P =0.05)	0.21	0.09	5.06	0.021	0.009	0.45	0.012	0.042	0.87	1.34	1.82

in seed and straw (0.195% and 0.700%), total K uptake (19.28 kg/ha) and gum content (30.31%) were found with basal application of 75 % RDF + pressmud + *Rhizobium*. While the applications of 100% RDF+ vermicompost + *Rhizobium* was found statistically at par. Increased nitrogen availability might have increased the synthesis of protein in grain. The uptake of major nutrients, viz. NPK is the function of crop yield and its content. The higher nitrogen, phosphorus and potassium content with increased seed and straw yields probably led to more uptake of major nutrients by the cluster bean. Favourable effect of pressmud + *Rhizobium* on NPK content and uptake may be attributed to reduced losses of released NPK during decomposition of narrowed C:N ratio. Thus, the addition of pressmud + *Rhizobium* together with applied fertilizer increased the availability of these nutrients in soil and consequently the higher uptake by plant owing to improvement in soil physical condition and availability of water. The increase in content and uptake of NPK in cluster bean seed due to 75% RDF + pressmud + *Rhizobium* might also have been contributed by pressmud + *Rhizobium* and chemical fertilizers. Further, the uptake of nutrient being the function of nutrient content and seed and straw yield, also increased significantly with the increase in these parameters. This study was supported by studies of Tanwar *et al.* (2003), Ramesh *et al.* (2006), Singh and Prasad (2008).

Effects on economics of cluster bean production: It is clear from Table 2 that highest gross return (77241 ₹/

ha) and net return (46461 ₹/ha) were observed with the application of 75% RDF + pressmud + *Rhizobium*. While the applications of 100% RDF+ vermicompost + *Rhizobium* was found statistically at par. Among the nutrient sources, the highest B:C ratio (1.59) was observed with the application of 100% RDF + *Rhizobium*. It is clear that in both the treatments there was significant increase in seed and straw yield which ultimately gave more net returns over the input cost incurred in these treatments in comparison to other treatments.

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