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Effect of organic manures and biofertilizers on growth and yield parameters of cowpea (*Vigna unguiculata* (L.) Walp.)

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Abstract
The response of cowpea *(Vigna unguiculata* (L.) Walp.) Viz. growth and yield performance to different organic manures alone and in combination with biofertilizers was evaluated by conducting a field experiment in clay soil. The growth attributes of cowpea viz. plant height, branches per plant, leaf area and leaf area index (LAI) was found highest in treatment involving the combined application of FYM + Vermicompost + *Rhizobium* + PSB culture. Similarly, the root growth and nodules count were also found higher in the treatment receiving combined application of organic manures with biofertilizers. The yield of cow pea was increased by 46% under the treatment receiving organic manures and biofertilizers as compared to control treatment. The results of the present study revealed that the cowpea crop responded positively to the combined application of organic manures and biofertilizers towards growth, growth and yield attributes and yield.

Keywords: *Vigna unguiculata* (L.) Walp, LAI, yield attributes, organic manures, biofertilizers

Introduction
Pulses have unique ability of maintaining and restoring soil fertility through biological nitrogen fixation as well as addition of ample amount of residues to the soil. Pulse crops leave behind reasonable quantity of nitrogen in soil to the extent of 30 kg/ha Ch. Vidhyashree Venkatarao, *et al.,* (2017). During the last few decades, agricultural production has increased due to use of high yielding varieties and enhanced consumption of chemical fertilizer. Imbalanced use of chemical fertilizers by farmers has deteriorated soil health and declined soil organic carbon content. It is essential to adopt a strategy of using organic manures. Organic manures enhances the soil fertility and yield of crops by rendering unviable sources of elemental nitrogen bound, phosphate and decomposed plant residues into available form in order to facilitate the plant to absorb the nutrients (Jagadish Timsina 2018) [29]. FYM is being used as major source of organic manure in field crops. Other sources such as Vermicompost, poultry manure and Neem cake has been advocated as good organic manure. Moreover, Cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereal crops grown in rotation with it (Carsky *et al.,* 2002; Tarawali *et al.,* 2002 [3, 28]; Sanginga *et al.,* 2003) [24], atmospheric nitrogen fixing ability is extremely valuable when it is cultivated with cereal crops in crop rotation system (Timko *et al.,* 2007). Cowpea crop increases soil nitrogen up to 40–80 kg per hectare (Quin, 1997) [21].
Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase the usage of organics. Use of organic manure alone or in combination with chemical fertilizers, helps in improving physio-chemical properties of the soil, improves the efficient utilization of applied fertilizers resulted in higher seed yield and quality (Salem 2006). Organic manures viz., FYM, vermicompost (VC), poultry manure (PM) and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil (Deepa Joshi *et al.*, 2016). Biofertilizers stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH. (Alabadan *et al.*, 2009) [1], though, they contain relatively low concentrations of nutrients and handling them is labour intensive, there has been largely increase in their use over inorganic fertilizers as nutrient source (Kannan *et al.*, 2005) [13]. The long term manurial studies conducted at many places have revealed the superiority of integrated nutrient supply system in sustaining crop productivity at comparison to chemical fertilizer alone (Gaur, 1991) [5, 7].

Materials and Methods

The experiment was conducted during *kharif* season, 2017 at the research farm of Amity Institute of Organic Agriculture, Amity University Noida, UP situated at 28^0 53′ N latitude and 77^0 39′ E longitude and at an altitude of 200 m above mean sea level. Soil samples (10-15 & 15-30 cm) were taken before start of the experiment which was analyzed for determining physical and chemical properties of the soil. It contained 61.20 % sand, 12.00 % silt and 26.80 % clay respectively and thus was sandy loam in texture. Organic carbon (0.52%), available N (178.4 kg/ha) and total N (0.043%) were low in status. The field was well levelled with even topography and good drainage system. The experiment was conducted in randomized block design with eight treatments and three replications. Pusa sukomal variety was sown @25 kg/ha. Before 10 days of sowing FYM and vermicompost were applied as per treatment and chemical fertilizers applied at the time of sowing. Seed was well inoculated with the use Rhizobium and PSB. In order to minimize weed competition, hoeing cum weeding was done 20 days after sowing. To maintain uniform plant stand at an intra-row spacing of 15 cm, extra plant were thinned out. Weeding and hoeing was done manually 30 and 45 Day after Sowing to facilitate aeration and removing the weeds. Neem oil 5% was sprayed to control insect-pest particularly aphids and pod borer. In all, 3sprays were done as and when early symptoms of insect were noticed. The crop was harvested at physiological maturity of the crop. Threshing of the crop was done after proper sun drying. Statistical analysis of data was done by using the method suggested by Gomez & Gomez.

Result and Discussion

Growth attributes

The plant height, branches and numbers of leaves and LAI at 60DAS (table-1) was significantly differed due to different treatments. Application of (FYM @ 5t ha^{-1} + Vermi compost @ 2t ha^{-1} + *Rhizobium* + PSB) produced significantly higher plant height (T_8) (67.12 cm), Higher no of branches (13.99), higher number of leaves (52.03) and LAI (4.02) while control treatment T_1 recorded lower plant height (58.12 cm), branches (11.52), number of leaves (43.86) and LAI (2.46). The factors which are responsible for growth (branches per plant, plant height, leaf area, and seed yield) were augmented significantly due to increased supply of nutrients from integrated nutrient use of organic manures along with biofertilizers (Singh *et al.,* 2014) [31]. The interaction due to manure with biofertilizers for fresh weight per plant at maturity stage was found more significant. Ramawtar *et al.,* (2013) observed that the application of vermicompost increased growth parameters over control treatment. Similar results were observed by Tiwari *et al.,* (2008), Singh *et al.,* (2011) [26], Das *et al.,* (2002) [4].

Root length, fresh weight and dry weight of roots at 60 DAS

At 60 DAS the significantly highest root length per plant (table-2) was (29.04), weight of root per plant (35.03) and dry weight of roots (1.61) were recorded under treatment T_8 (FYM @ 5t ha^{-1} + Vermi compost @ 2t ha^{-1} + *Rhizobium* + PSB.). Whereas, minimum root length per plant (22.04), root fresh weight (11.10) and root dry weight (0.85) were recorded significantly lower under the treatment T_1 (control). The effect of FYM and humic acid walong with biofertilizer plays an important role in root development and proliferation resulting in better nodule formation and nitrogen fixation by supplying assimilates to the roots, better environment in rhizosphere for growth and development. Since, the fertility being a representative of almost all the plant nutrient required for proper growth and development of plants, its addition in the soil enhanced availability of these nutrients. These results corroborate with the finding of Kimti (2011) [15], Kumar (2011) [17], Mahetele and Kushwaha (2011) [19], Singh and Kumar (2012) [27] Magdi *et al.,* (2011) [18], these results were conformity with Mahatele *et al.,* (2011) in Pigeon pea crop, Kachhave *et al*., (2009) [11].

Number of Root nodules, fresh weight of root nodules and dry weight of root nodules per plant at 60 DAS

At 60 DAS stage number of root nodules per plant was (28.30), fresh weight (1250.24) and dry weight (133.11) of root nodules recorded (table-2) significantly higher under the treatment T_8 (FYM @ 5t ha^{-1} + Vermi compost @ 2t ha^{-1} + *Rhizobium* + PSB). Whereas, minimum root nodules per plant (20.81), root fresh weight (579.36) and root dry weight (126.07) was recorded under the treatment T_1 (control). The growth of nodules in response bacterium rhizobium and phosphate stimulates the formation of nodules and it may be because of the synergetic effect of these two. Nagaraj and Balachandar (2001) reported that application of organics like biodigested slurry + *Rhizobium* inoculation significantly increased the plant height, number of nodules per plant and dry weight of nodules of Black gram.

Table 1: Effect of organic manures and biofertilizers on growth attributes of cowpea

Treatment	Plant height (cm) at maturity	Branches/ plant at maturity	Leaves/plant at 60 DAS	LAI at 60 DAS	Fresh weight / plant (g) at maturity	Dry weight / plant (g) at maturity
T1	58.12	11.52	43.86	3.93	111.1	25.53
T2	63.09	13.01	49.95	5.03	116.59	30.52
T3	59.81	11.73	44.86	4.29	113.83	27.35
T4	60.33	11.89	46.88	4.39	114.93	27.41
T5	65.18	13.54	51.85	5.41	118.53	32.47
T6	62.15	12.55	48.79	4.55	115.61	29.12
T7	64.51	13.4	51.25	5.18	117.12	31.01
T8	67.12	13.99	52.03	5.51	119.08	33.12
Mean	62.54	12.7	48.68	4.79	115.85	29.57
SEm±	1.07	0.32	1.12	0.2	0.91	0.94
CD (P=0.05)	0.841	0.332	0.737	0.489	0.631	0.352

Table 2: Effect of organic manures and biofertilizers on roots and root nodules attributes of cowpea

Treatment	Root length /plant (cm)	Fresh weight of root/plant (g)	Dry weight of root/plant (g)	Root nodules/plant	Fresh weight of root nodules/plant	Dry weight of root nodules/ plant (mg)
	at 60 DAS					
T1	22.04	11.1	0.85	20.81	579.36	126.07
T2	25.87	23.5	1.31	25.24	955.5	130.13
T3	23.27	14.71	1.09	22.88	735.3	128.06
T4	23.52	18.15	1.11	23.18	800.27	128.22
T5	28.05	30.85	1.51	27.23	1150.9	132.15
T6	24.93	19.5	1.22	24.22	850.33	129.58
T7	27.03	26.46	1.4	26.22	1060.51	131.03
T8	29.04	35.03	1.61	28.3	1250.24	133.11
Mean	25.47	1.2625	1.26	24.76	922.8	129.79
SEm±	0.87	2.87	0.087	0.87	79.35	0.81
CD (P=0.05)	0.584	0.566	0.256	0.572	1.125	0.57

Table 3: Effect of organic manures and biofertilizers on yield attributes and yield of cowpea

Treatment	pod/plant	Pod length	Seed/pod	Test weight in (g)	Seed yield/ ha (Qtls.)	Harvest Index (%)
T1	20.92	19.72	8.6	125.6	11.02	25.2
T2	25.01	24.32	11.47	134.3	16.4	34.1
T3	22.02	20.95	9.5	128.45	14.2	26.85
T4	23.01	22.01	10.13	129.5	15.4	28.12
T5	26.85	26.42	12.67	138.2	19.45	37.4
T6	23.95	23.15	12.03	132.2	16.45	32.15
T7	25.95	26.3	12.07	136.6	17.95	36.3
T8	27.01	27.5	13.5	140.05	20.25	38.5
Mean	24.34	23.8	11.25	133.11	16.39	32.33
SEm±	0.79	0.99	0.59	1.79	1.04	5.08
CD (P=0.05)	0.572	0.547	0.306	0.569	0.614	0.738

Yield attributes and yield

Number of pod per plant, pod length and number of seeds per pod and test weight

The significantly highest number of pod per plant was (27.01), pod length (27.50), number of seed per pod (13.5) and test weight of seed (140.05) were recorded (table-3) in treatment T_8 (FYM @ 5t ha^{-1} + Vermi compost @ 2t ha^{-1} + *Rhizobium* + PSB). minimum number of pod per plant (20.92), minimum pod length (19.17), number of seed per pod (8.60) and test weight of seed (125.60) were recorded under the treatment T_1 (control). Increase in yield attributes in combination of organic manures and biofertilizer (T8-FYM @ 5t ha^{-1} + Vermi compost @ 2t ha^{-1} + *Rhizobium* + PSB) over control may. The increased seed yield was obtained in organic manures combination with biofertilizers application (*Rhizobium* and PSB) could be attributed to the effect of growth hormones like IAA and cytokinins produced by *Rhizobium* which stimulated root morphology. This in turn, would have improved assimilation of nutrients and thus seed yield. The phosphate solubilizing bacteria increase the availability of phosphorus to the plants and its greater uptake. The present results are in collaboration with the findings of Rajkhowa *et al*., (2002 and 2003) [22, 23] in green gram, Khandelwal *et al*., (2012) [14] and Balachandran *et al.,* (2005) [2].

Seed yield per ha

In table-3, The highest seed yield per ha (20.25), biological yield were 40.1 and harvest index was (38.5%) were observed under treatment T_8 (FYM @ 5t ha^{-1} + Vermi compost @ 2t ha^{-1} + *Rhizobium* + PSB). whereas, the minimum seed yield per ha (11.02), biological yield 30.5 and harvest index (24.20 %) were recorded under the treatment T_1 (control). Mahatele *et al.,* (2011) reported that addition of FYM @ 10 t ha^{-1} to soil improved the supply of available nutrient to the plant and brought about favorable soil environment which ultimately increased nutrient and water holding capacity of soil for longer period and that resulted in better growth, yield attributes and yield of Pigeon pea.

The beneficial effect of FYM and vermicompost on crop yields and soil productivity is the result of their usefulness as a store-house of plant nutrients. These organic sources of nutrients improved soil aeration, root development and increase microbial and biological activities in the rhizosphere. As reported by Shukla *et al.,* (2013) [25], Gandhi *et al.,* (1991) [6] and Chatterjee *et al.,* (2014). Gupta and Sharma (2006) [8].

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