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Effect of integrated nutrients management through organic sources on growth parameters and yield of chickpea (*Cicer arietinum* L.)

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Abstract
The present investigation entitled "Effect of integrated nutrients management through organic sources on growth and yield chickpea (*Cicer arietinum* L.)" was carried out at the Research Farm at Faculty of Agriculture, Dr. C. V. Raman University, Vaishali, Bihar during Rabi season of the year 2020-21. The experiment was laid out in a randomized complete block design with three replications comprising nine treatments. Use of organic sources (FYM, Poultry manure and Vermicompost) significantly influenced growth parameters, yield attributes and yield of chickpea crop. The conjoint application of FYM + Vermicompost + Poultry manure + *Rhizobium* (T_8) resulted increased significantly all the growth parameters *viz,* plant height, root length, numbers of primary branches, no. of secondary branches plant^{-1}were noticed at 30, 60, 90 DAS and at maturity stage while all the growth parameters minimum recorded in T_0 (Control). Integrated nutrients management through organic source and sowing method significantly influenced the entire yield attributes *viz,* number of pod plant^{-1}, pod weight plant^{-1}, grain weight plant^{-1} and 100 seed weight were recorded with T_8 (FYM + Vermicompost + Poultry manure + *Rhizobium*) while T_0 (Control) recorded lowest in all the parameters. The maximum grain yield (Kg) ha^{-1} was recorded maximum T_8 (FYM + Vermicompost + Poultry manure + *Rhizobium*), presented 2289 kg ha^{-1} while T_0 (Control) recorded lowest grain yield recorded 1548 kg ha^{-1}. From present investigation, it can be concluded that above integrated nutrient management sources organic manure (FYM + Vermicompost + Poultry manure) and application of *Rhizobium* resulted in better growth, higher yield and besides enhanced soil health as evident by post-harvest soil fertility status. It can be suggested as a cost effective combination for getting higher yield with greater quality on a sustainable basis.

Keywords: Integrated nutrients management, organic sources, soil fertility, growth parameters, *Cicer arietinum* L. and grain yield

Introduction
Chickpea (*Cicer arietinum* L. 2n=14) is a legume crop of the Fabaceae family and Faboideae subfamily. It is also known as gram or Bengal gram, garbanzo, or garbanzo bean, and is sometimes known as Egyptian pea, or chana. Its seeds are high in protein. There are two different kinds of chickpea, Desi and Kabuli, based on the size, shape, and color of the seeds. Nutritionally, it contains 24% protein, 59.6% carbohydrates, and 3.2% minerals. It has the ability to fix atmospheric nitrogen and can also tolerate high temperatures during and after flowering. It is one of the earliest cultivated legumes: 7500-year-old remains have been found in the Middle East (Bell 2014) [4]. It is widely cultivated in India, Australia, Pakistan, Turkey, Myanmar and Ethiopia. It is an important winter season pulse crop and is also called Bengal gram. In terms of pulse production, India contributes about 25% to the total global pulses production (Pooniya *et al* 2015) [21]. This accounts for about 70% of the total global area with 67% of global production (Anonymous 2019) [2]. The major chickpea producing states in India are Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh, Uttar Pradesh and Karnataka.
Pulses are an important source of dietary protein and have the unique ability of maintaining and restoring soil fertility through biological nitrogen fixation as well as addition of ample amounts

of residues to the soil. Pulse crops leave behind a reasonable quantity of nitrogen in soil to the extent of 30 kg/ha. In India pulses are grown during 2018-19, pulses were cultivated over > 29 million ha (Mha) of area and recorded the highest ever production of 25.23 million tonnes (Mt) at a productivity level of 841 kg/ha. Under the individual crop category, Chickpea recorded a highest ever production of 11.23 Mt at a record productivity level of 1063 kg/ha in an area of 10.56 Mha. Major 07 states to contribute > 90 per cent in gram production have been Madhya Pradesh (4.60 Mt), Maharashtra (1.78 Mt), Rajasthan (1.67 Mt), Karnataka (0.72 Mt), Andhra Pradesh (0.59 Mt), Uttar Pradesh (0.58 Mt) and Gujarat (0.37 Mt). (Anonymous, 2020) [1]. In Uttar Pradesh, the area under chickpea is 6.11 lakh hectares with the production 6.84 lakh tonnes of chickpea with productivity of 1119 kg ha^{-1} in 2018-19 (Anonymous, 2019) [2]. The per capita availability of pulses in India is 35.5 g/day as against the minimum requirement of 70 g/day/capita as advocated by Indian Council of Medical Research. It is, therefore, imperative to increase the productivity of pulse crops, especially those of minor importance.

The low productivity of chickpea crop in India may be ascribed besides other factors of its growing either in high rainfall areas or on very unproductive/ marginal lands. Nevertheless, it is imperative to increase productivity in different agro ecological zones by manipulating various agronomic practices. The two most commonly cultivated types of chickpea are white seeded “Kabuli " being grown in northern parts and brown seeded “Desi” grown in other parts of our country. The productivity ha^{-1} of chickpea in our county is very less (780 kg/ha) in comparison with the other countries like Mexico (1600 kg/ha), Myanmar (1105 kg/ha) and Australia (1008 kg/ha). Its protein quality is better than other legumes such as pigeon pea, black gram and green gram (Kaur and Singh, 2005) [6]. Chickpea is a main nutritive legume crop of rural and urban households of the poor in developing countries. Chickpea is an economical source of quality protein. Chickpea has nitrogen fixation properties which plays an important role in maintenance of the soil fertility, particularly in the arid and low rainfall areas as chickpeas are being cropped under crop rotation (Roy *et al.*, 2010) [15]. Chickpea is an important source of protein in the diets of the poor, and is particularly important in vegetarian diets and is an important substitute for animal protein. It is mostly consumed in the form of processed whole seed (boiled, roasted, fried, steamed, *etc*.), *dal* and as *dal* flour. It is used in preparing snacks, sweets and condiments. Fresh green seeds are also consumed as a green vegetable. It is an excellent source of protein (18-22%), carbohydrates (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron *etc*.) and vitamins. It is an excellent animal feed and its straw has good forage value (Prasad 2012) [20].

Application of organic matter to meet the nutrient requirement of crops would be an inevitable practice in years to come, particularly for resource-poor farmers. Also, ecological and environment concerns over the increased and indiscriminate use of inorganic fertilizers have resulted focus on use of organic materials as a source of essential nutrients. Availability of quality organic sources of nutrients for the cultivation of chickpea in organic farming is a great challenge which needs a be promotion of organic input production at farm itself. It can be achieved through using different sources of nutrients which have different nutrient release pattern and efficiency. Combined application of organic manures mainly composts, vermicompost and *Glyricidia* green leaf manure produced higher yield apart from improving soil health (Babalad *et al.*, 2009) [3]. Organic manures may increase soil fertility and thus the crop production potential possibly by changes in soils physical and chemical properties including nutrient bioavailability, soil structure, water holding capacity, cation exchange capacity, soil pH, microbial community and activity etc. Vermicompost is eco-friendly, low cost and an effective way to recycle agricultural and kitchen waste. Vermicompost is a recent innovation in composting technology. It is a mixture of earthworm’s castings, organic materials humus and other organisms. Agricultural residues, animal wastes, dairy and poultry wastes, food industry wastes, sluge can all be recycled to give vermicompost. In recent years, use of vermicompost has been advocated in integrated nutrient management system in field crops.

Materials and Methods

This experiment was conducted at the Laboratory of the Department of Agronomy, as well as a field experiment at Research Farm, Faculty of Agriculture, Dr. C. V. Raman University, Vaishali, Bihar. The experimental details are given below. The experiment was laid out in randomized block design with three replications. The net plot size (8 rows) 2.5 m x 2.5 m and the spacing used was 30 cm x 10 cm (row x plant). The experiment treatment details are given in table-1.

Table 1: Details of Treatments

T_0	:	Control
T_1	:	FYM
T_2	:	VC (Vermicompost)
T_3	:	PM (Poultry manure)
T_4	:	FYM + VC (1:1)
T_5	:	FYM + PM (1:1)
T_6	:	VC+ PM (1:1)
T_7	:	FYM+ VC+ PM (1:1:1)
T_8	:	FYM+ VC+ PM (1:1:1) + *Rhizobium*

Results and Discussion

Growth parameters

The data are presented in table-2 which showed that the maximum plant height was found in T_8 -FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 13.12, 32.82, 49.62 and 58.91 cm followed by T_7 - FYM+ VC+ PM (1:1:1), representing 12.97, 32.20, 48.32 and 56.77 cm and T_6- Vermicompost + Poultry manure (1+1), presented 12.85, 30.87, 477.82 and 55.18 cm while minimum plant height was recorded T_0 - (Control) representing, 11.75, 27.95, 40.10 and 50.79 cm. The observations of plant height were taken at 30, 60, 90 and maturity stage days after sowing during 2019-20. This was supported by (Kene, 1990) [7] noted that the higher values of these growth parameters with this integrated nutrient might be due to supply of all the essential mineral nutrients in a balanced proportion and amount which resulted in better growth and development of plants.

The observations of root length were taken at 30, 60, 90 and maturity stage days after sowing during 2020-21. The data are presented in table-2 which reflect that the maximum root length was found in T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 6.93, 12.33, 21.13 and 34.07 cm followed by T_7- FYM+ VC+ PM (1:1:1), presenting 6.73, 12.20, 20.20 and 33.13 cm and T_6- Vermicompost + Poutry manure (1:1), presented 6.69, 11.87, 20.00 and 33.00 cm. Minimum root length was recorded T_0 (Control) representing, 5.53, 9.75, 15.10 and 28.45 cm. The results were in agreement with the findings of Solaiman (1999) [18] and Jain and Singh (2003) [5].

Number of primary and secondary branches $plant^{-1}$, the observations of plant height were taken at 30, 60, 90 and maturity stage days after sowing during 2019-20. It is obvious from data are presented in table-3 which showed that the maximum number of primary branches plant^{-1} were recorded with in T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 1.41, 4.11, 4.48 and 4.70 followed by T_7 - FYM+ VC+ PM (1:1:1), presenting 1.40, 3.90, 4.16 and 4.42 and T_6- Vermicompost + Poultry manure (1:1) presented 1.38, 3.85, 4.09 and 4.33 while minimum number of primary branches per plant was recorded T_0 –(Control) representing, 1.21, 3.18, 3.35 and 3.54 at 30, 60, 90 and at maturity stage. Similar trends were recorded in context of number of secondary branches plant^{-1} were influenced significantly by all the treatments combination at 30, 60, 90 DAS and maturity stages. It is obvious from data are presented in table-3 which reflected that the maximum number of secondary branches plant^{-1} were recorded with in T_8 - FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 2.90, 6.57, 7.10 and 7.16 followed by T_7 - FYM+ VC+ PM (1:1:1), representing 2.81, 6.52, 6.95 and 7.06 and T_6- Vermicompost + Poultry manure (1:1) presented 2.77, 6.43, 6.82 and 7.02 while lowest number of secondary branches plant^{-1} was found T_0 –(Control) presenting, 2.33, 5.64, 6.05 and 6.32. Similar, findings were recorded earlier by many researcher (Singh *et al*., 2003) reported that the growth of plants grown with vermicompost was much better than the growth of plants in control. The lowest values of growth parameters were recorded with the 100% RDF. Venkatesh and Basu (2011) [19] observed that the foliar application of urea apart from basal application of recommended dose of fertilizers increased branching in chickpea by 8-23% over no spray or water spray. The significant increase in the number of branches as a result of urea application also contributed towards overall biomass production under rainfed conditions.

Yield attributes

The data are presented in table-4, integrated nutrients management through organic sources (FYM, Poultry manure and Vermicompost) and application of *Rhizobium* significantly influenced the entire yield attributes *viz,* number of pod plant^{-1}, pod weight plant^{-1}, grain weight plant^{-1} and 100 seed weight were recorded with T_8 - FYM+ VC+ PM (1:1:1) + *Rhizobium*, followed by T_7 - FYM+ VC+ PM (1:1:1), and T_6- Vermicompost + Poultry manure (1:1) while minimum recorded T_0 (Control). Many research workers found the similar trend observed for the yield attributes perpetuated to build up the final outcome in terms of yield. Further, the nutrients of 100% RDF + 2% Urea spray have facilitated a greater economic sink capacity as the yield has a highly significant correlation with number of pods plant^{-1}, seeds pod^{-1} and 100-seed weight (Rajkhowa *et al.*, 2003, Patil and Padmani, 2007, Reddy *et al*., 2007 and Sharma *et al*., 2010) [12, 10, 14, 16]. This might be due to more effectiveness of combined application of organic manures due to complementarity in their response. It can facilitate the retention of added mineral fertilizers and the timing of their availability (Myers *et al*., 1994) [8]. Vermicompost application stimulated root growth, facilitating nutrient absorption and thereby favouring higher yield of the test crop (Padmavathiamma *et al*., 2008) [9]. Probably vermicompost alone may not provide all the necessary nutrient elements in adequate quantities and also due to slow release of nutrients from vermicompost as compared to chemical fertilizers for proper growth and yield in chickpea (Rajkhowa *et al*., 2003) [12]. Patil *et. al.* (2013) [11] reported that the yield attributing parameters like number of pods per plant (66.38), number of seeds per pod (1.23), test weight (20.91 g), grain yield (2400 Kg/ha) and halum yield (3156 Kg/ha) were recorded with the treatment combination of EC 1/3rd+VC 1/3rd+GLM 1/3rd equivalent to 100% RDN + panchagavya @ 3% spray at flower initiation and 15 days after flowering (DAF) compared to other treatment combinations and absolute control.

Yield

The data are presented in table-4 which showed that the maximum biological yield (Kg ha^{-1}) was recorded with T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 4945 Kg ha^{-1} followed by T_7- FYM+ VC+ PM (1:1:1), presented 4716 Kg ha^{-1} and T_6- Vermicompost + Poultry manure (1:1) presented 4665 Kg ha^{-1} while minimum biological yield was recorded T_0 (Control), representing, 3759 Kg ha^{-1}. Similar, pattern was recorded in grain yield (Kg) ha^{-1} and maximum grain yield was recorded in T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 2289 Kg ha^{-1} followed by T_7- FYM+ VC+ PM (1:1:1), representing 2157 Kg ha^{-1} and T_6- Vermicompost + Poultry manure (1:1), presented 2115 Kg ha^{-1} while minimum grain yield was recorded T_0 (Control) representing, 1548 Kg ha^{-1}. Similarly, maximum straw yield (kg) ha^{-1} was recorded with T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 2559 Kg ha^{-1} followed by T_7- FYM+ VC+ PM (1:1:1), presented 2556 Kg ha^{-1} and T_6- Vermicompost + Poultry manure (1:1), represented 2550 Kg ha^{-1} while minimum straw yield was recorded T_0 (Control) representing, 2211 Kg ha^{-1}. Maximum harvest index (%) was recorded with T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*, representing 47.24% followed by T_7- FYM+ VC+ PM (1:1:1), representing 45.73% and T_6- Vermicompost + Poultry manure (1:1), presented 45.33% while minimum harvest index was recorded T_0 (Control), presenting, 41.18%. The increase in stover yield might have attributed to the vigorous growth associated with increased dry matter production. This might be due to more effectiveness of combined application of organic manures and sowing methods due to complementarily in their response. It can facilitate the retention of added mineral fertilizers and the timing of their availability (Myers *et al*., 1994) [8]. Vermicompost application stimulated root growth, facilitating nutrient absorption and there by favouring higher yield of the test crop (Padmavathiamma *et al*., 2008) [9]. Similar trend was also observed in grain and straw yields by Rajput and Kushwah (2005) [13] and Patil *et. al.* (2013) [11] reported that the yield attributing parameters like number of pods per plant (66.38), number of seeds per pod (1.23), test weight (20.91 g), grain yield (2400 Kg/ha) and halum yield (3156 Kg/ha) were recorded with the treatment combination of EC 1/3rd+VC 1/3rd+GLM 1/3rd equivalent to 100% RDN + Panchagavya @ 3% spray at flower initiation and 15 days after flowering (DAF) compared to other treatment combinations and absolute control.

Table 2: Effect of integrated nutrients management through organic sources on plant height and root length (cm) of chickpea.

Treatments	Plant height (cm)				Root length (cm)			
	30 DAS	60 DAS	90 DAS	Maturity stage	30 DAS	60 DAS	90 DAS	Maturity stage
T_0- Control (100% RDF)	11.75	27.95	40.1	50.79	5.53	9.75	15.10	28.45
T_1- FYM	12.31	28.83	44.75	52.84	6.13	11.00	19.20	31.08
T_2- VC (Vermicompost)	12.57	29.83	43.61	52.84	6.47	11.60	19.73	31.47
T_3- PM (Poultry manure)	12.55	29.35	45.68	53.79	6.47	11.20	19.27	31.13
T_4- FYM+ VC (1:1)	12.79	30.56	46.48	54.97	6.64	11.67	19.67	32.07
T_5- FYM+ PM (1:1)	12.65	29.88	46.2	54.80	6.53	11.33	19.40	31.80
T_6- VC+ PM (1:1)	12.85	30.87	47.82	55.18	6.69	11.87	20.00	33.00
T_7- FYM+ VC+ PM (1:1:1)	12.97	32.2	48.32	56.77	6.73	12.20	20.20	33.13
T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*	13.12	32.82	49.62	58.91	6.93	12.33	21.13	34.07
SEm±	0.18	0.46	0.63	0.70	0.09	0.12	0.21	0.41
CD at 5%	0.57	1.40	1.93	2.13	0.27	0.35	0.62	1.24

Table 3: Effect of integrated nutrients management through organic sources on number of primary and secondary branches plant^{-1} of chickpea.

Treatments	Number of Primary branches plant^{-1}				Number of secondary branches plant^{-1}			
	30 DAS	60 DAS	90 DAS	Harvest stage	30 DAS	60 DAS	90 DAS	Harvest stage
T_0- Control (100% RDF)	1.21	3.18	3.35	3.54	2.33	5.64	6.05	6.32
T_1- FYM	1.26	3.49	3.63	3.90	2.51	5.87	6.45	6.56
T_2- VC (Vermicompost)	1.32	3.65	3.86	4.27	2.61	6.10	6.55	6.77
T_3- PM (Poultry manure)	1.29	3.57	3.74	4.06	2.57	6.01	6.5	6.61
T_4- FYM+ VC (1:1)	1.35	3.79	4.02	4.30	2.71	6.29	6.78	6.88
T_5- FYM+ PM (1:1)	1.33	3.71	3.97	4.31	2.63	6.15	6.71	6.86
T_6- VC+ PM (1:1)	1.38	3.85	4.09	4.37	2.77	6.43	6.82	7.02
T_7- FYM+ VC+ PM (1:1:1)	1.40	3.9	4.16	4.42	2.81	6.52	6.95	7.06
T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*	1.41	4.11	4.48	4.70	2.90	6.57	7.1	7.16
SEm±	0.02	0.04	0.05	0.06	0.03	0.11	0.11	0.12
CD at 5%	0.05	0.14	0.15	0.17	0.09	0.33	0.34	0.37

Table 4: Effect of integrated nutrients management through organic sources on yield attributes and yield of chickpea.

Treatments	No. of pod plant^{-1}	Pod wt. plant^{-1} (g)	Grain wt. plant^{-1} (g)	100 seed weight (g.)	Biological Yield (Kg) ha^{-1}	Grain yield (Kg) ha^{-1}	Straw yield (Kg) ha^{-1}	Harvest index (%)
T_0- Control (100% RDF)	35.8	12.04	5.16	15.84	3759	1548	2211	41.18
T_1- FYM	37.44	12.87	6.22	16.82	4216	1866	2350	44.26
T_2- VC (Vermicompost)	38.04	13.39	6.55	17.54	4355	1965	2390	45.12
T_3- PM (Poultry manure)	37.67	13.06	6.47	16.89	4318	1941	2377	44.96
T_4- FYM+ VC (1:1)	38.87	13.65	6.91	17.81	4617	2073	2404	44.89
T_5- FYM+ PM (1:1)	38.39	13.44	6.74	17.64	4461	2022	2439	45.32
T_6- VC+ PM (1:1)	39.63	14.25	7.05	18.23	4665	2115	2550	45.33
T_7- FYM+ VC+ PM (1:1:1)	40.49	14.78	7.19	18.42	4716	2157	2559	45.73
T_8- FYM+ VC+ PM (1:1:1) + *Rhizobium*	41.42	15.22	7.63	18.89	4845	2289	2556	47.24
SEm±	0.55	0.22	0.09	0.32	65.661	31.814	32.840	0.430
CD at 5%	1.64	0.65	0.29	0.95	196.600	95.258	98.330	1.286

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