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Effect of integrated nutrient management on growth and yield attributes of chickpea *Cicer arientinum* (L.)

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Abstract
Field experiment was conducted at BFIT group of institutions, Dehradun during 2020-2021 on effect of integrated nutrient management on growth and yield attributes of chickpea *Cicer arientinum* (L.) variety PANT G 5. Field experiment was laid out in Randomized Block Design with three replications. Nine different treatments were tested *viz.*, T1: 100%RDF + FYM @ 12.5t ha^{-1}, T2: 100%RDF + Rhizobium @ 2kg ha^{-1},T3: 100%RDF + FYM @ 12.5t ha^{-1}+ Vermicompost@ 5t ha^{-1}, T4: 100%RDF + FYM@ 12.5t ha^{-1} + Phosphobacteria@ 2kg ha^{-1},T5: 75% RDF + FYM@ 12.5t ha^{-1} + Vermicompost@ 2kg ha^{-1} + Rhizobium@ 2kg ha^{-1},T6: 100% RDF + Vermicompost@5t ha^{-1}+Phosphobacteria@2kg ha^{-1},T7: 100%RDF + Vermicompost@ 5t ha^{-1} + Rhizobium@ 2kg ha^{-1},T8: 75%RDF + FYM@ 12.5t ha^{-1} + Vermicompost@5t ha^{-1}+Phosphobacteria@ 2kg ha^{-1},T9: Absolute control (water application)**.** Considering the overall economics of the treatments, the net returns and benefit cost ratio were found to be higher with T8:75%RDF + FYM@ 12.5t ha^{-1} + Vermicompost@5t ha^{-1}+Phosphobacteria@ 2kg ha^{-1}.Based on the experimental results, it could be concluded that, 75%RDF + FYM@ 12.5t ha^{-1} + Vermicompost@5t ha^{-1}+Phosphobacteria@ 2kg ha^{-1} was found to be ideal for chickpea for high yield and assured income in irrigated condition.

Keywords: nutrient management, growth, yield attributes, *Cicer arientinum* (L.)

Introduction

Pulses occupy a unique position in agriculture in virtue of the fact that they provide the rich source of vegetable protein and calories to the average Indian diet. Pulses are important source of dietary protein, energy, minerals and vitamins for the mankind. It contains rich phosphoric acid with easily digestible protein and low flatulence contents and contains about 25% protein, 56% carbohydrates, 2% fat, 4% minerals and 0.4% vitamins.

The area under pulses has increased from 19 million ha in 1950-51 to 25 million ha in 2013-14, indicating an increase of 31 per cent whereas, production of pulses during the same period has increased from 8.41 million ha. To 19.27 million ha. (Mohanty and Satyasai, 2015). The area under pulse crop is increasing continuously but productivity decreasing year by year. The reasons for decreasing productivity are due to decreasing soil fertility especially macro and micro nutrients, imbalanced use of fertilizer and occurrences of physiological disorders factors such as inefficient partitioning of assimilates poor pod setting, excessive flower abscission and lack of nutrients during the critical stages of crop growth leads to nutrient stress, poor growth and productivity were found to be some of the yield barriers of pulse crop. (Ramesh *et al.*, 2016; Uma Maheswari and Karthik, 2017).

Keeping the above information in the background an experiment was conducted on “Effect of integrated nutrient management on growth and yield attributes of chickpea *Cicer arientinum* L.” with the following objectives.

Material and Methods

The present study entitled “Effect of integrated nutrient management on growth and yield attributes of chickpea *Cicer arientinum* L” was carried out during 2020-21. The field experiment was carried out at BFIT group of institution (Department of agronomy) Dehradun, Uttarakhand.

Experimental details

The experiment was carried out using randomized block design (RBD) with 3 replications and 9 treatments.

Treatment details

The details of treatments included for the study are mentioned below in the table.

T1: 100%RDF + FYM @ 12.5t ha^{-1}

T2: 100%RDF + Rhizobium @ 2kg ha^{-1}

T3: 100%RDF + FYM @ 12.5t ha^{-1}+ Vermicompost@ 5t ha^{-1}

T4: 100%RDF + FYM@ 12.5t ha^{-1} + Phosphobacteria@ 2kg ha^{-1}

T5: 75% RDF + FYM@ 12.5t ha^{-1} + Vermicompost@ 2kg ha^{-1} + Rhizobium@ 2kg ha^{-1}

T6: 100% RDF + Vermicompost@5t ha^{-1}+Phosphobacteria@2kg ha^{-1}

T7: 100%RDF + Vermicompost@ 5t ha^{-1} + Rhizobium@ 2kg ha^{-1}

T8: 75%RDF + FYM@ 12.5t ha^{-1} + Vermicompost@5t ha^{-1}+Phosphobacteria@ 2kg ha^{-1}

T9: Absolute control (water application)

Results and Discussion

The results of experimental study on "Effect of integrated nutrient management on growth and yield attributes of chickpea *Cicer arientinum* L" conducted during *Rabi* 2020-21 on the research farm of agronomy department, BABA FARID institute of technology,

Plant height (cm)

The plant height of chickpea was significantly influenced by integrated nutrient management practices. The plant height gradually increased at the stage of vegetative and flowering stage, further, decreased at harvesting stage. Significantly, the highest plant height was recorded (43.9 cm) in T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1} during flowering stage, which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (42.2 cm) whereas, there is no significant difference in vegetative and harvesting stage of both the treatments. The lowest was registered in T_9 – Control (37.2 cm).

Leaf Area Index (LAI)

Measurement of leaf area is a basic tool for growth analysis and it is directly related to both biological and economical yield. In general, Leaf Area Index (LAI) increased linearly and attained maximum level at flowering stage. The maximum Leaf area index was significantly registered in T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1}(3.50) during peak flowering stage, which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (3.07). The control (water spray) recorded the lowest leaf area index in (2.61).

Table 1: Plant height at different growth stages of chickpea as influenced by integrated nutrient management

Treatments	Plant height (cm)		
	30DAS	60DAS	At harvest
T1-100%RDF + FYM @ 12.5 t ha^{-1}	26.9	32.9	36.0
T2-100%RDF + Rhizobium @ 2kg ha^{-1}	27.1	33.2	37.8
T3-100%RDF + FYM @12.5t ha^{-1} + Vermicompost @2t ha^{-1}	27.7	35.3	38.2
T4-100%RDF + FYM @12.5t ha^{-1} + Phosphobacteria @2kg ha^{-1}	27.7	35.9	39.2
T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	27.2	37.8	42.2
T6-100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1}	27.5	35.8	40.0
T7-100%RDF + Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	26.7	36.5	41.1
T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1}	28.8	40.0	43.9
T9: Absolute control	25.0	31.3	37.2
S. Em. ±	0.6	1.0	0.9
CD @ 5%	1.7	3.1	2.6
Influence of integrated nutrient management on leaf area index (LAI) of chickpea			
Treatments	**30 DAS**	**60DAS**	**At Harvest**
T1-100%RDF + FYM @ 12.5 t ha^{-1}	2.38	2.81	2.69
T2-100%RDF + Rhizobium @ 2kg ha^{-1}	2.32	2.79	2.63
T3-100%RDF + FYM @12.5t ha^{-1} + Vermicompost @2t ha^{-1}	2.42	2.94	2.90
T4-100%RDF + FYM @12.5t ha^{-1} + Phosphobacteria @2kg ha^{-1}	2.41	2.91	2.85
T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	2.46	3.07	2.93
T6-100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1}	2.44	3.03	2.92
T7-100%RDF + Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	2.39	2.87	2.83
T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1}	2.52	3.50	3.05
T_9 – Control	2.09	2.61	2.40
Mean	2.38	2.95	2.80
SE.d	NS	0.17	NS
CD (P=0.05)	NS	0.33	NS

Dry Matter Production (DMP)

Different integrated nutrient management practices significantly influenced the dry matter production of chickpea.

Table 2: Dry matter production at different growth stages of chickpea as influenced by integrated nutrient management

Treatments	Dry matter (g plant^{-1})		
	30DAS	60DAS	At harvest
T1-100%RDF + FYM @ 12.5 t ha^{-1}	3.0	14.9	23.7
T2-100%RDF + Rhizobium @ 2kg ha^{-1}	3.2	15.8	25.3
T3-100%RDF + FYM @12.5t ha^{-1} + Vermicompost @2t ha^{-1}	3.5	15.6	24.9
T4-100%RDF + FYM @12.5t ha^{-1} + Phosphobacteria @2kg ha^{-1}	3.3	16.7	25.6
T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	3.4	19.4	28.5
T6-100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha $^{-1}$	3.5	17.8	26.1
T7-100%RDF + Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	3.3	16.4	27.1
T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$	3.5	21.6	29.0
T9: Absolute control	3.3	11.5	17.9
S. Em. ±	0.3	1.1	1.6
CD @ 5%	NS	3.2	4.8

The influence of integrated nutrient management on dry matter production of chickpea was found to be significant at flowering and harvest stage and non-significant at vegetative stage. The highest dry matter production in chickpea was recorded in T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha $^{-1}$ (21.6 and 29.0 g plant^{-1}) which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (19.4 and 28.5 g plant^{-1}) during flowering and harvesting stage of the crop. The lowest dry matter production was recorded in T_9 – control (Water application) (11.5 and 17.9 g plant^{-1}) respectively.

Yield parameters

Number of pods per plant

The number of pods per plant had significantly increased (55.9) by application of 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ (T8) followed by application of T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}(54.6). The lowest number of pods per plant (36.5) was recorded in T_9 control (Water application).

Seed yield

Higher seed yield noted under 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ (T8)(2604 kg ha^{-1}) which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (2481kg ha^{-1}). The lowest number of pods per plant was registered T_9 - control (water spray) (1428 kg ha^{-1}).

Stover yield

Higher Stover yield was recorded 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ (T8)(2257kg ha^{-1}) which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (2175 kg ha^{-1}). The lowest number of pods per plant was registered T_9 - control (1503 kg ha^{-1}).

Table 3: Yield attributes of chickpea as influenced by integrated nutrient management

Treatments	Number of pods plant-1	100 seeds weight (g)
T1-100%RDF + FYM @ 12.5 t ha^{-1}	42.3	29.6
T2-100%RDF + Rhizobium @ 2kg ha^{-1}	45.5	32.5
T3-100%RDF + FYM @12.5t ha^{-1} + Vermicompost @2t ha^{-1}	45.1	30.6
T4-100%RDF + FYM @12.5t ha^{-1} + Phosphobacteria @2kg ha^{-1}	45.9	32.6
T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	54.6	33.1
T6-100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha $^{-1}$	47.5	31.6
T7-100%RDF + Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	53.5	32.7
T8- 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$	55.9	33.1
T9: Absolute control	36.5	25.6
S. Em. ±	1.3	0.9
CD @ 5%	4.0	2.7

Table 4: Yield and harvest index of chickpea as influenced by integrated nutrient management

Treatments	Seed yield (kg ha-1)	Stover yield (kg ha-1)	Harvest Index %
T1-100%RDF + FYM @ 12.5 t ha^{-1}	2014	1970	50.6
T2-100%RDF + Rhizobium @ 2kg ha^{-1}	2266	2105	51.8
T3-100%RDF + FYM @12.5t ha^{-1} + Vermicompost @2t ha^{-1}	2170	1984	52.2
T4-100%RDF + FYM @12.5t ha^{-1} + Phosphobacteria @2kg ha^{-1}	2370	2166	52.3
T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @2kg ha^{-1}	2481	2175	53.4
T6-100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha $^{-1}$	2467	2165	53.3
T7-100%RDF + Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	2578	2215	53.5
T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$	2604	2257	53.6
T9: Absolute control	1428	1503	48.7
S. Em. ±	89	117	1.1
CD @ 5%	268	350	NS

Table 5: Influence of integrated nutrient management on economics of chickpea cultivation

Treatments	Cost of cultivation Rs/ha	Gross return Kg/ha	Net return Kg/ha	Benefit cost Ratio
T1-100%RDF + FYM @ 12.5 t ha^{-1}	32750	90645	57895	2.8
T2-100%RDF + Rhizobium @ 2kg ha^{-1}	33501	101951	68451	3.0
T3-100%RDF + FYM @12.5t ha^{-1} + Vermicompost @2t ha^{-1}	34587	97650	63063	2.8
T4-100%RDF + FYM @12.5t ha^{-1} + Phosphobacteria @2kg ha^{-1}	35475	106635	71160	3.0
T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1}	37105	111628	74523	3.0
T6-100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha $^{-1}$	35361	111032	75671	3.1
T7: T2 + Foliar spray of Grade-1 @ 5 ml L^{-1} of water at flowering and pod development stage	36204	116015	79811	3.2
T8: 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$	37792	117180	79388	3.1
T9: Absolute control	29831	68760	38929	1.9
S. Em. ±	---	---	4520	0.1
CD @ 5%	---	---	13552	0.4

Harvest Index (HI)

The harvest index numerically higher in75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$(T8) (53.6)which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (53.4) The lowest harvest index plant was registered T_9 - control (48.7).

Economics

Gross Income

75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ (T8) was recorded higher gross income(₹.117180 ha^{-1}) which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (₹. 111628 ha^{-1}). The lowest gross income was registered T_9 - control (water spray) (₹.68760 ha^{-1}).

Net Income

The maximum net income was recorded in 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ (T8) was recorded higher gross income (₹. 79388 ha^{-1}) which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (₹. 74523 ha^{-1}). The lowest gross income was registered T_9 - control (₹.38929 ha^{-1}).

Benefit Cost Ratio

Higher benefit cost ratio noticed in 100%RDF + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1} (T8) was recorded higher gross income (3.1) which was followed by T5-75%RDF + FYM @12.5t ha^{-1}+Vermicompost @2t ha^{-1} + Rhizobium @ 2kg ha^{-1} (3.0). The lowest gross income was registered T_9 - control (water spray) (1.9).

Discussion

Effect of different integrated nutrient management practices on growth characters of chickpea.

In the present study vegetative growth with combined application of 75 per cent recommended dose of fertilizer, basal application of Phosphobacteria along with vermicompost were observed to be significantly greater than those from control**.** Among the treatment tested, T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ showed the maximum plant height, Leaf area index number of branches per plant and dry matter production. The easy transfer of nutrients and growth stimulants to plants through application of optimum dose of Phosphobacteria might be the reason for enhancement in chickpea. There are several reasons for increased growth in chickpea due to application of optimum dose of phosphobacteria. P solubilizes (PSB) can solubilizes insoluble P and 10-20% yield will be increased, Growth promoting substance are all so increased. Phosphate solubilizing bacteria (PSB) are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds. P-solubilization ability of rhizosphere microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. It is generally accepted that the mechanism of mineral phosphate solubilization by PSB strains is associated with the release of low molecular weight organic acids, through which their hydroxyl and carboxyl groups chelate the cations bound to phosphate, thereby converting it into soluble forms. These results were also supported by Kushwaha (2007) also got maximum grain yield, seeds per pod, growth parameters and nodules per plant were recorded in Rhizobium + Phosphobacteria combined with N @ 10 kg ha-1 + P @ 20 kg ha-1 followed by Rhizobium + Phosphobacteria + N15 + P30. Inoculation of Rhizobium and PSB saves 25% chemical fertilizer in chickpea. The same results were also got by Khan *et al.,* (2009).

Application of biofertilizers on vegetative growth, number of branches per plant and reproductive growth, number of pods per plant, number of seeds per pod and test weight, which were the important yield attributes having significant positive correlation with seed and straw yield. The pronounced increase in yield might be due to sustained availability of nutrients *viz*., N, P, K, S, Zn and Fe at growth phases of chickpea and also due to enhanced carbohydrate synthesis and effective translocation of photosynthates to the developing sink. Biofertilizers increased synthesis of growth promoting substances which is turn helped in increased growth and yield attributes and finally grain yield. Similarly, findings have been reported by Bhattacharya (2000).

Effect of different integrated nutrient management practices on yield characters of chickpea

Economic yield is a complex inter-relationship of its components, which are determined from the growth rhythm in vegetative phase and its subsequent reflection in reproductive phase. Grain yield is the manifestation of yield attributing characters in chickpea. In the present study, all the yield attributing parameters were significantly higher with75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} $^{+}$ Phosphobacteria @2kg ha $^{-1}$ respectively.The increase in grain yield and Stover yield of chickpea due to basal application of bio fertilizer such as rhizobium and phosphobacteria could be due to better availability of nutrients throughout the crop growth which might be the result of improved microbial activity in the soil.The same findings were supported by Sanjeev kumar *et al.*, (2011). Among the treatments,T8-75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1} increased the grain yield of black gram which determined by various yield attributing characters like number of flowers per plant, number of pods per plant, pod setting per cent, number of seeds per pod and test weight. This increase might be due to availability and optimum supply of nutrients to the plants favorably influenced the flowering and seed formation. As a consequence of increased rate of photosynthates from source (leaf and stem) to sink (pods) which could increase number of branches per plant, which might have resulted in the development of more number reproductive parts and there by increased sink size to obtain higher seed yield Pramanik and Bera (2012) [11].

Increasing the grain and Stover yield by the influence of application of 75%RDF + FYM @ 12.5 t ha^{-1} + Vermicompost @2t ha^{-1} + Phosphobacteria @2kg ha^{-1}this might be due to higher supply of all nutrients at flower initiation and pod formation stages of crop growth might have caused efficient translocation of photosynthates from source to sink. Further, the basal applied nitrogen and phosphorus at the initial stages might have been effectively absorbed and trans-located to the pods resulting in a greater number of pods per plant. The results obtained by Goud and Kale (2010).

The increase in yield might be due to enhanced yield attributes like number of pods per plant, number of seeds per pod. It is due to increased uptake of nutrients by chickpea by effective translocation of nutrients from sink to reproductive area of crop.

Conclusion

From above summary the following conclusion could be drawn. Suitable post flowering nutrient management techniques are essential for increasing the flowers, reducing flowers shedding, improve the pod setting percent and finally increase the yield of chickpea. Generally basal application of biofertilizers at 2.5kg ha^{-1} favored improved performance of the chickpea crop with higher yield.

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