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Effect of integrated nutrient management on growth and yield of vegetable cowpea (*Vigna unguiculata* L.)

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Abstract
The experiment entitled "Integrated nutrient management in vegetable cowpea (*Vigna unguiculata* L.)" was carried out during summer season of 2018 at the Horticulture Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Gujarat. The experiment was laid out in randomized block design with three replications. Total fourteen treatments were evaluated in the present study *viz*., T_1: 100% RDF (25: 50: 00: NPK kg/ha); T_2: 100% RDN through urea; T_3: 75% RDN through FYM + 25% N through urea; T_4: 50% RDN through FYM + 50% N through urea; T_5: 75% RDN through vermicompost + 25% N through urea; T_6: 50% RDN through vermicompost + 50% N through urea; T_7: 75% RDN through neem cake + 25% N through urea; T_8: 50% RDN through neem cake + 50% N through urea; T_9: T_3+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit / ha; T_{10}: T_4+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha; T_{11}: T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha; T_{12}: T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha; T_{13}: T_7+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha; T_{14}: T_8+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha. Among various treatments, treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha) was significantly superior over all other treatments with respect to growth and yield parameters. The growth parameters *viz.*, plant height at 30 DAS (23.72 cm) and 60 DAS (60.67 cm), number of branches (9.07) at 60 DAS and nodules per plant (19.87) and yield parameters *viz.*, number of green pods per plant (58.65), yield per plant (117.24 g/plant), yield per plot (2.30 kg/plot) and yield per hectare (85.06 q/ha) were recorded maximum with treatment T_{11}.

Keywords: Cowpea, FYM, vermicompost, neem cake, *Rhizobium* and PSB

Introduction
Cowpea (*Vigna unguiculata* L.) is one of the most important vegetable crops cultivated in *Kharif* as well as summer season and belongs to family Fabaceae. It is probably native of Central Africa. Cowpea is locally known as southern pea, black-eye pea and it is grown as grain, vegetable as well as fodder in *Kharif* and summer season throughout the tropics and subtropics. Tender pods and immature seeds of cowpea are used as vegetable and being rich in protein, fiber, minerals and vitamins particularly vitamin 'A' and vitamin 'C' that is why it is known as vegetable meat. This crop is of great importance because of availability of short duration, high yielding and quick growing habit. In India, cowpea is grown almost in all states, but the largest cultivating states are Gujarat, West Bengal, Tamil Nadu, Andhra Pradesh, Kerala and Orissa. In Gujarat, it is cultivated in 27, 029 hectares area with an annual production of 2, 80, 818 MT leading to an average productivity of 10.39 MT per hectare during 2017-18 (Anonymous, 2018) [2].

The uncontrolled and imbalanced use of chemical fertilizers has deteriorates the soil health, leading to drastic decline in crop productivity. Therefore, there is a need to balanced use of chemical fertilizers along with organic manures and biofertilizers. The crop yield and quality can be increased by the balanced nutrient application. Integrated or balance use of chemical and organic fertilizers not only increase the crop yield, but also improves the soil health. Organic manures like FYM, vermicompost, neem cake, *etc*. accelerates the soil microbial activities, which supplies nitrogen, phosphorus, sulphur and other nutrients in available form to the plants through biological decomposition. Indirectly, it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Chandramohan, 2002) [4].

Legume crops symbiotically fix the atmospheric nitrogen to meet a major part of nitrogen requirement of crops. The seed of legume is inoculated with *Rhizobium* with an objective of increasing their number in the rhizosphere, so that there is substantial increase in the microbiologically fixed nitrogen for the plant growth. The inoculation of seeds with suitable *Rhizobium* culture increased the green pod yield over un-inoculated control.

Biofertilizer is a product which contains living microorganisms when applied to seeds, plant surfaces or soil and it colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. The chemical fertilizers directly increase soil fertility by adding nutrients. However, biofertilizers add nutrients through the natural processes of fixing atmospheric nitrogen, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substances. Use of biofertilizers is being encouraged to save the chemical fertilizers and the environment (Karnan *et al.,* 2012) [10].

Looking towards the above facts, an experiment was conducted to find out the effect of integrated nutrient management on growth and yield of vegetable cowpea (*Vigna unguiculata* L.).

Materials and Methods

The experiment entitled "Integrated nutrient management in vegetable cowpea (*Vigna unguiculata* L.)" was carried out during summer season of 2018 at Horticulture Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Gujarat. The variety of vegetable cowpea, Anand Vegetable cowpea 1 was taken under investigation and conduct experiment in randomized block design with three replications. Total fourteen treatments were evaluated in the present study *viz*., T_1: 100% RDF (25: 50: 00: NPK kg/ha); T_2: 100% RDN through urea; T_3: 75% RDN through FYM + 25% N through urea; T_4: 50% RDN through FYM + 50% N through urea; T_5: 75% RDN through vermicompost + 25% N through urea; T_6: 50% RDN through vermicompost + 50% N through urea; T_7: 75% RDN through neem cake + 25% N through urea; T_8: 50% RDN through neem cake + 50% N through urea; T_9: T_3+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit / ha; T_{10}: T_4+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha; T_{11}: T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha; T_{12}: T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha; T_{13}: T_7+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha; T_{14}: T_8+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha.

The soil samples were collected from the experimental site before sowing of the test crop and analyzed using standard methods. The analyzed soil having sandy loam in texture, low in organic carbon (0.32%), slightly alkaline reaction (pH 7.86) with non saline in nature, low in available nitrogen (178.00 kg/ha), medium in available phosphorus (33.52 kg/ha) and potassium (264.72 kg/ha). The quantities of organic manures used for the treatment application were calculated on the basis of nitrogen content present in the dry sample and samples were analyzed using standard method of analysis. The analyzed samples of FYM, vermicompost and neem cake having nitrogen 1.5%, 0.5% and 5.1%, respectively.

Applications of organic manures as per treatment was broadcasted uniformly at the time of sowing and incorporated in the soil. Nitrogen and phosphorus was applied respectively as per treatments as basal dose. PSB (2.5 lit/ha) was applied in soil along with FYM, Vermicompost and Neem cake, whereas *Rhizobium* was applied through seed treatment (10 ml/kg seed). These fertilizers were applied in a single dose at the time of sowing as per treatment plan and application of 50% recommended dose of N and full dose of P given as a basal dose and remaining 50% of N was applied 30 days after sowing in control. Weeding and plant protection measure were followed as and when needed. Observations of growth and yield parameters were recorded at different number of picking and five tagged plant from each net plot were selected for recording observations of growth and yield parameters. The data were statistically analyzed using the method suggested by Panse and Sukhatme (1985) [15].

Results and Discussion

Growth and flowering parameters

Plant height at 30 and 60 days after sowing

The data presented in Table 1 revealed that the effect of integrated nutrient management on plant height at 30 and 60 DAS was found significant. The maximum plant height at 30 DAS (23.72 cm) and 60 DAS (60.67 cm) was observed with treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha), however, it was at par with treatment T_{12} (T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha) and T_5 (75% RDN through vermicompost + 25% N through urea), Whereas, the minimum plant height at 30 DAS (16.63 cm) and 60 DAS (46.56 cm) was recorded with the treatment T_2 (100% RDN through urea).

An increase in plant height in treatment T_{11} might be due to application of major and minor nutrients, through different levels of organic manures and chemical fertilizers, increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height. These results are in conformity with the finding of Das *et al.* (2011) [6] and Kumar and Pandita (2016) [13] in cowpea; Vidhale *et al*. (2012) [21] and Singh and Kumar (2016) [20] in cluster bean.

Number of branches per plant at 60 days after sowing

In examination of mean data in Table 1 revealed that the effect of integrated nutrient management on number of branches per plant at 60 DAS was found significant maximum number of branches (9.07) was observed with treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha), which was statistically at par with treatment T_{12} (T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha), T_5 (75% RDN through vermicompost + 25% N through urea), T_6 (50% RDN through vermicompost + 50% N through urea) and T_{13} (T_7+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha).Whereas, the minimum number of branches (6.13) was recorded with the treatment T_2 (100% RDN through urea).

Number of branches per plant was increased with an increase in nitrogen level and enhances the development of strong cell walls. These results are in agreement with those reported by Abayomi *et al.* (2008) [1], Dekhane *et al.* (2011) [7], Khandelwal *et al*. (2013) [12] and Khan *et al.* (2015) [11].

Days taken for initiation of flowering

Data presented in Table 1 showed that the effect of integrated nutrient management on days taken for initiation of flowering was found not significant.

Days taken for last picking after sowing

The data pertaining to Table 1 showed that the effect of integrated nutrient management on days taken for last picking after sowing was found not significant.

Number of nodules per plant

The results showed that the effect of integrated nutrient management on number of nodules per plant was found significant. The maximum number of nodules (19.87) was observed under the treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha), which was statistically at par with treatment T_{12} (T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha), T_5 (75% RDN through vermicompost + 25% N through urea), Whereas, the minimum number of nodules (14.80) was recorded with the treatment T_2 (100% RDN through urea).

It might be due to favourable effect of organic manures for improving the overall physical, chemical and biological properties of the soil that helpful for enhancing symbiotic activity of *Rhizobium* and size of root nodules increased faster and larger quantity of nitrogen fixation. These results are in conformity with the findings of Goud *et al*. (2010) [8] in mung bean and Rajkhowa *et al.* (2002) [17] in green gram.

Yield parameters

Number of green pods per plant

The data presented in Table 2 revealed that the effect of integrated nutrient management on number of green pods per plant was found significant. Maximum number of green pods (58.67) was observed with treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha), which was statistically at par with treatment T_{12} (T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha) and T_5 (75% RDN through vermicompost + 25% N through urea). Whereas, the minimum number of green pods (39.00) was recorded with the treatment T_2 (100% RDN through urea).

The results of the present investigation showed an increase in pod per plant might be due to the application of organic and chemical fertilizers as well as by Rhizobium and PSB seed treatment. The treatment was effect on enhancement of vegetative and reproductive growth of plant due to release of more nutrients in the soil and thereby utilizing more nutrients and moisture from the soil. These results are in accordance with the findings of earlier researcher Mohite *et al*. (2011) [14] and Joshi *et al*. (2016) [9] in cowpea; Priyanka (2014) [16], Chavan *et al*. (2015) [5] in cluster bean.

Table 1: Effect of Integrated nutrient management on growth parameters of vegetable cowpea

Treatment No.	Plant height at 30 DAS (cm)	Plant height at 60 DAS (cm)	Number of branches per plant at 60 DAS	Days taken for initiation of flowering	Days taken for first picking after sowing	Days taken for last picking after sowing	Number of nodules per plant
T_1	17.35	48.33	6.33	39.33	54.00	86.33	15.20
T_2	16.63	46.56	6.13	40.33	55.00	84.67	14.80
T_3	18.06	49.46	7.13	39.00	52.67	87.00	16.00
T_4	17.51	49.64	6.73	39.00	53.67	86.33	15.60
T_5	21.82	57.20	8.87	36.00	49.33	90.67	17.73
T_6	21.20	56.54	8.73	36.33	49.00	90.00	17.07
T_7	19.80	52.81	7.93	37.33	50.33	88.67	16.53
T_8	19.60	51.87	7.73	37.00	51.00	87.67	16.40
T_9	19.16	51.19	7.53	38.00	51.33	87.33	16.40
T_{10}	18.13	50.13	7.27	41.00	52.00	87.00	16.13
T_{11}	23.72	60.67	9.07	34.67	47.67	91.33	19.87
T_{12}	22.87	59.27	9.00	35.00	48.33	90.67	18.00
T_{13}	20.87	53.48	8.07	36.67	49.33	89.33	16.93
T_{14}	20.33	53.19	8.00	36.67	49.67	89.00	16.80
S.Em. ±	0.95	2.45	0.36	1.81	2.38	3.81	0.83
C.D. (P=0.05)	2.76	7.12	1.05	NS	NS	NS	2.41
C.V. %	8.32	8.02	8.09	8.33	8.11	7.48	8.63

Yield per plant

The data presented in Table 2 revealed that the effect of integrated nutrient management on yield per plant was found significant. Maximum yield per plant (117.24 g) was observed with treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha). However, it was statistically at par with treatment T_{12} (T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha) and T_5 (75% RDN through vermicompost + 25% N through urea), Whereas, the minimum yield per plant (78.04 g) was recorded with the treatment T_2 (100% RDN through urea).

Among various manures and their levels, the application of vermicompost treatments have effects on greater root extension due to phosphorus availability and balance uptake of other nutrients, which ultimately improve the yield attributing characters. Due to better nitrogen and phosphorus availability, better translocation within plants and favourable sink source ratio of photosynthates. These results are in conformity with the finding of Shukla and Dixit (1996) in green gram; Joshi *et al.* (2016) [9] in cowpea; Reddy *et al.* (2014) [18], Bhathal and Kumar (2016) [3] and Singh and Kumar (2016) [20] in cluster bean.

Table 2: Effect of Integrated nutrient management on yield parameter of vegetable cowpea

Tr. No.	Number of green pods per plant	Yield per plant (g)	Yield per plot (kg)	Yield per ha (q)	Number of picking
T_1	40.27	80.58	1.56	57.70	7.00
T_2	39.00	78.04	1.50	55.73	6.67
T_3	43.67	87.34	1.69	62.74	7.33
T_4	42.33	84.56	1.64	60.77	7.33
T_5	50.20	100.32	1.96	72.52	8.33
T_6	50.07	100.04	1.95	72.22	8.00
T_7	47.60	95.22	1.85	68.67	7.67
T_8	47.00	93.98	1.82	67.28	7.67
T_9	46.07	92.08	1.79	66.40	7.67

T_{10}	45.13	90.26	1.75	64.91	7.33
T_{11}	58.67	117.24	2.30	85.06	9.00
T_{12}	54.60	109.03	2.13	79.04	8.67
T_{13}	49.07	98.20	1.91	70.84	8.00
T_{14}	48.87	97.60	1.90	70.54	8.00
S.Em. ±	2.94	5.91	0.12	4.33	0.45
C.D. (P=0.05)	8.54	17.17	0.34	12.58	NS
C.V. %	10.75	10.81	11.00	11.00	10.09

Yield per plot and yield per hectare

The data presented in Table 2 and revealed that the effect of integrated nutrient management on yield per plot and yield per hectare was found significant. Maximum yield per plot at (2.30 kg) and yield per hectare (85.06 q) was observed with treatment T_{11} (T_5+ *Rhizobium* @ 10 ml / kg + PSB @ 2.5 lit /ha), which was statistically at par with treatment T_{12} (T_6+ *Rhizobium* @ 10 ml / kg+ PSB @ 2.5 lit /ha) and T_5 (75% RDN through vermicompost + 25% N through urea), while, the minimum yield per plot at (1.50 kg) and yield per hectare (55.73 q) was recorded with the treatment T_2 (100% RDN through urea).

Number of picking

Data presented in Table 2 showed that the effect of integrated nutrient management on number of picking was found not significant.

Conclusion

The results of present study reflected and could be concluded that the application of 75% RDN through vermicompost + 25% N through urea + *Rhizobium* @ 10 ml/kg + PSB @ 2.5 lit/ha was found superior in respect to growth parameter and yield of vegetable cowpea.

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