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Effect of Organic Manures and Bio-Fertilizers on Growth, Yield and Quality of *Kharif* Cowpea [*Vigna unguiculata* (L.)]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Agronomy Instructional Farm of SDAU, Sardarkrushinagar, Gujarat, India during kharif season of 2020-2021. The experiment consisting nine treatments viz., T1-Absolute control, T2-100% RDF (20 kg N + 40 kg P2O5 ha-1), T3- FYM @ 5.0 t ha-1, T4-FYM @ 2.5 t ha-1 + Rhizobium + PSB, T5-vermicompost @ 2.0 t ha-1, T6-vermicompost @ 1.0 t ha-1 + Rhizobium + PSB, T7-castor cake @ 2.0 t ha-1, T8-castor cake @ 1.0 t ha-1 + Rhizobium + PSB, T9-Ghan Jeevamrut @ 250 kg ha-1 at sowing time + Seed treatment with Beejamrut @ 200 ml kg-1

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seed+ Jeevamrut @ 500 lit ha-1 with irrigation at sowing and 30 DAS were tested in randomized block design with four replications. The result revealed that the application of T8-castor cake @ 1.0 t ha-1 + Rhizobium + PSB showed significant improvement on plant height, number of branches per plant, dry matter accumulation, number of pods per plant, number of seeds per pod, length of pod and seed yield per plant whereas, application of T4-FYM @ 2.5 t ha-1 + Rhizobium + PSB gave significantly higher number of root nodules per plant, fresh and dry weight of root nodules. it is concluded that higher yield from kharif cowpea could be obtained by applying either castor cake @ 1.0 t ha-1 or FYM @ 2.5 t ha-1 along with Rhizobium + PSB in loamy sand soils of North Gujarat.

Keywords: Vermicompost; nodule; castor cake; Rhizobium; dry matter accumulation.

1. INTRODUCTION

"Pulses are wonder gift of nature to the living universe and the real gateway of sustainable agriculture. Cowpea [*Vigna unguiculata* (L.)] is highly responsive to fertilizer application. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions. Nitrogen plays important role in various metabolic process of the plant growth. Nitrogen is an essential constituent of protein and chlorophyll" [1]. "The manures are organic in nature, plant or animal origin and contain organic matter in large proportion and plant nutrients in small quantities and used to improve soil productivity by correcting soil physical, chemical and biological properties. Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil. to alleviate the problem, included nutrient management is the fine method in the protection of soil fertility and supply of plant vitamins to a foremost stage for maintaining the desired crop productiveness thru optimization of blessings from all feasible sources of plant nutrients in an incorporated way" [2]. "There is growing interest in using organic manures as a source of nutrient supply to crop production for long-term soil productivity, ecological stability and reducing the need for chemical fertilizer. Among the various organic manure sources, FYM and vermicompost are readily available on the market. Integration of inorganic and organic manures not only sustains crop production but also improves soil health and nutrient use efficiency" [3]. "Organic manures enhance 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" [4]. FYM play an important role for improving soil physical property. Organic fertilizer is considered as an important source of humus, macro and micro element carrier, and at the same time it increases the activity of the useful microorganisms [5,6]. Use of biofertilizer can have a greater importance in increasing fertilizer use efficiency.

2. MATERIALS AND METHODS

A field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India to study the "Effect of organic manures and bio-fertilizers on growth and yield of *kharif* cowpea [*Vigna unguiculata* (L.)]" during *kharif* season of 2020-2021. Geographically, Sardarkrushinagar is situated at 24^0 19' North latitude and 72^0 19' East longitude with an elevation of 154.52 meter above the mean sea level and situated in the North Gujarat Agro-climatic region. Climate of this region is sub-tropical monsoon type and falls under semi-arid region. The soil of experimental field was loamy sand in texture with low in organic carbon (1.8 g kg^{-1}) and available nitrogen (138.0 kg ha^{-1}), medium in available phosphorus (38.6 kg ha^{-1}) and high in available potassium (215.2 kg ha^{-1}) having pH value of 7.56. The experiment consisting nine treatments *viz.,* T_1-Absolute control, T_2-100% RDF (20 kg N + 40 kg P_2O_5 ha^{-1}), T_3- FYM @ 5.0 t ha^{-1}, T_4-FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB, T_5-vermicompost @ 2.0 t ha^{-1}, T_6-vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB, T_7-castor cake @ 2.0 t ha^{-1}, T_8-castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB, T_9-*Ghan Jeevamrut* @ 250 kg ha^{-1} at sowing time + Seed treatment with *Beejamrut* @ 200 ml kg^{-1} seed+ *Jeevamrut* @ 500 lit ha^{-1} with irrigation at sowing and 30 DAS were tested in randomized block design with four replications. Cowpea variety GC 4 was used as a test crop. The required quantity of healthy cowpea seeds of cultivar GC 4 was inoculated with *rhizobium* and PSB @ 20 ml kg^{-1} seeds and required quantity of seeds inoculated with beejamrut @ 200 ml kg^{-1} seeds as per treatments. "The biometric observations were recorded from five randomly selected plants tagged earlier in each plot for the following parameters at grand growth and at harvest. The details of various growth parameters, yield attributes, quality and chemical parameters studied. The data recorded for various parameters during the course of investigation were statistically analysed" [7] The significance of difference was tested by "F" test at 5 per cent level. The critical difference was calculated when the differences among treatments were found significant under "F" test. In remaining cases, only standard error of mean was worked out.

3. RESULTS AND DISCUSSION

3.1 Effect of Organic Manures and Bio-Fertilizers on Plant Population

The data presented in Table 1 showed that the plant population per meter row length at 20 DAS and at the time of harvest were found not significant due to different integrated nutrient management treatments, which indicated that there was no any adverse effect of bio fertilizers and organic sources of nutrients on germination as well as on survival of the cowpea plants.

3.2 Effect Organic Manures and Bio-Fertilizers on Growth Parameters

Data on plant height, number of branches per plant, dry matter accumulation, number of root nodules per plant, fresh and dry root nodules weight per plant (mg) and days to physiological maturity are presented in Table 1.

3.2.1 Plant height (cm)

The data on plant height of cowpea recorded at the time of 30 DAS, 60DAS and at harvest are presented in Table 1 clearly indicated that the plant height was increased progressively and linearly up to the harvest with the advancement of crop growth and also significantly affected by the different integrated nutrient management treatments.The mean data on plant height presented in Table 1 indicated that different treatments had significant influence on plant height at 30 DAS.Significantly higher plant height (21.58 cm) was recorded by the application of 100 % RDF (T_2), but it was at par with FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) and vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6). At 60 DAS and at harvest, plant height was significantly influenced by different integrated nutrient management treatments. Significantly higher plant height at 60 DAS (48.07 cm) and at harvest (52.26 cm) was recorded by the application of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB(T_8), but it was at par with 100% RDF (T_2),FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4),vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6) and castor cake @ 2.0 t ha^{-1}(T_7) at the time of 60 DAS and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4),vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6)at the time of harvest. Significantly the lower plant height at 30 DAS(17.08 cm), 60 DAS(36.68 cm) and at harvest(44.97 cm) was observed by the absolute control (T_1). The probable reason might be positive effect of nutrient on growth character due to augment of cell division and cell expansion [8]. The increase in the plant growth in terms of plant height under treatment T_8(Castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB) is the combined use of organic manure and bio-fertilizer might be increased the fertilizer use efficiency and also nutrient availability leading to the higher growth of plant in terms of plant height by higher cell multiplication and cell elongation. "Moreover, organic manures also contain almost all essential elements in variable quantities, which had synergistic effect with other essential elements for their availability" [9].

3.2.2 Number of branches per plant

"Maximum number of branches per plant with castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) might be due to the integrated use of organic manures and bio fertilizers offers more balanced nutrition and favourable soil conditions for better growth of the plant. Moreover, higher availability of nutrients might be reflected on higher number of branches per plant" [10,11].

3.2.3 Number of root nodules per plant

An appraisal of data presented in Table 1 indicated that the number of root nodules per plant was significantly influenced by different integrated nutrient management treatments. An application of FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) to cowpea crop recorded significantly higher number of root nodules per plant (25.00), but it was at par with vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6), Castor cake @ 2.0 t ha^{-1} (T_7) and Castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8). Significantly a smaller number of root nodules per plant (18.32) was noted under absolute control (T_1). Improvement in number of root nodules per plant could be attributed due to favorable aeration and moisture regime with the integration of organic manures with bio-fertilizers. Moreover, seed inoculation of bio-fertilizers (*Rhizobium* + PSB) may be provided more conducive environment for better root growth and respiration along with higher soil biological activity. "The PSB liquid bio-fertilizer might also have enhanced the availability of phosphorus to plants which must have utilized in greater root development and nodulation" [12].

3.2.4 Dry matter accumulation per plant (g)

The mean data on dry matter accumulation of cowpea presented in Table 1 indicated that different treatments had significant influence on dry matter accumulation at 30 DAS.Treatment T_2 (100% RDF) registered significantly higher dry matter per plant (37.30 g) which was at par with FYM @ 5.0 t ha^{-1}(T_3), FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB(T_4), vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB(T_6),castor cake @ 2.0 t ha^{-1}(T_7) and castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB(T_8). Data presented in Table 1. Showed that significantly higher dry matter per plant at 60 DAS (63.44 g) and at harvest (92.02 g) was observed with treatment T_8 (castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB) which was at par with treatment 100% RDF (T_2),FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB(T_4),vermicompost @ 1.0 t ha-1 + *Rhizobium* + PSB (T_6) and castor cake @ 2.0 t ha^{-1}(T_7).Significantly the lower dry matter accumulation at 30 DAS (30.43 g), 60 DAS (47.85 g) and at harvest (60.14 g) was observed by the absolute control (T_1). Adequate major nutrients might have helped in harvesting of solar energy as reflected by increased dry matter accumulation. The beneficial effect of organic manures and bio-fertilizers in growth attributes are close agreement with the findings reported by Pargi et al. [13].

3.2.5 Fresh and dry root nodules weight per plant (mg) at 45 DAS

Results presented in Table 1 indicated that the fresh and dry root nodules weight per plant was significantly influenced by different integrated nutrient management treatments. Significantly maximum fresh nodules weight per plant (69.80 mg) and dry nodules weight per plant (26.77 mg) was recorded with treatment T_4 (FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB), but it was at par with castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8). Significantly the minimum fresh nodules weight per plant (53.71 mg) and dry nodules weight per plant (15.99 mg) was registered under the treatment of absolute control (T_1). Improvement in fresh and dry root nodules weight per plant could be attributed due to favorable aeration and moisture regime with the integration of organic manures with bio-fertilizers. Moreover, seed inoculation of bio-fertilizers (*Rhizobium* + PSB) may be provided more conducive environment for better root growth and respiration along with higher soil biological activity. The positive response of organic manures and bio fertilizer to increase the nodulation might be due to the organic matter provides energy for nodulation. "The PSB liquid bio-fertilizer might also have enhanced the availability of phosphorus to plants which must have utilized in greater root development and nodulation" [14].

3.3 Effect on Yield and Yield Attributes

3.3.1 Number of pods per plant

The set of data furnished in Table 1 confirms that the number of pods per plant was influenced significantly by different treatments. Significantly the greater number of pods per plant (12.80) was recorded under the application of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8). Treatment100% RDF(T_2) and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) remained at par with treatment T_8. The increment in number of pods per plant under $T_8$and T_4 was to the tune of 55.15 and 51.51per cent higher than treatmentT_1 (absolute control), respectively. Significantly the smaller number of pods per plant (8.25) was recorded under the treatment T_1 (absolute control). The data in Table 1 displayed that the application of treatment T_8 of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB on number of pods per plant was found significant over rest of the treatments except treatment 100% RDF (T_2) and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4). More number of pods $plant^{-1}$ might be due to more survival of flowers under high supply of photosynthates under treatment castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB(T_8) as compared to other treatments. Higher number of pods per plant might be owing to better vegetative growth and photosynthetic activity ascribed by larger uptake of nutrients and water from the soil by well-developed root system and profuse nodulation which caused an increase in nitrogen supply from symbiotically fixed nitrogen in root nodules [13].

3.3.2 Number of seeds per pod

The data presented in Table 1 disclosed that the number of seeds per pod was significantly influenced by application of different treatments. Significantly the higher number of seeds per pod (10.39) was obtained under treatment T_8 i.e. application of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB which remained at par with treatment FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4), 100% RDF (T_2), vermicompost @ 2.0 t ha^{-1} (T_5), vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6) and castor cake @ 2.0 t ha^{-1} (T_7). Significantly the lower number of seeds per pod (8.61) was gained under absolute control (T_1). The increment in number of seeds per pod under T_8 and $T_4$was to the tune of 20.67 and 18.93 per cent higher than treatment T_1 (absolute control), respectively. "The highest number of seeds per pod was obtained with application of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB probably due to the fact that supplying of ample amount of nutrients in form of organic manure and bio-fertilizer must have increased carbohydrate accumulation and their remobilization to reproductive parts of the plant, being closest sink and hence, resulted into increased flowering, fruiting and seed formation and thus a greater number of seeds per pod" [15].

3.3.3 Length of pod (cm)

The results from Table 1 revealed that different treatments including organic manure and bio-fertilizer significantly influenced on length of pod of cowpea. Significantly higher length of pod (11.56 cm) was obtained through the application of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8). Treatment 100% RDF (T_2), FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4), vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6) and castor cake @ 2.0 t ha^{-1}(T_7) remained at par with treatment castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB(T_8) and the lower value of pod length (9.78 cm) was obtained by absolute control. The length of pod measured under castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) was 18.20 and 17.58 per cent higher than treatment T_1 (absolute control), respectively. The length of cowpea pod was significantly influenced by different organic manures as well as bio fertilizers (Table 2). Lengthier pods were observed with application of castor cake @ 1.0 t ha-1 + *Rhizobium* + PSB probably due to the fact that increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and resulted in increased pod length. "The increase in pod length might be due to better partitioning of assimilates from source to sink. Resultant utilization of accumulated photosynthates influenced the growth and development of yield attributes" [16].

3.3.4 Seed yield per plant (g)

An appraisal of data presented in Table 2 clearly indicated that seed yield per plant of *kharif* cowpea was differed significantly due to various integrated nutrient management treatments. Significantly higher seed yield per plant (8.73 g) was obtained under treatment castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8), but it remained at par with treatment of 100% RDF (T_2), FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) and vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6). The magnitude of increase in seed yield per plant due to castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) over T_1 (absolute control) was to the tune of 40.80 and 38.87 per cent, respectively. Significantly the lower seed yield per plant (6.20 g) was noted under treatment absolute control (T_1). Castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) recorded higher seed yield per plant than other treatments. The seed yield per plant was higher due to higher pod length, seeds per pod, number of pods per plant and also higher test weight due to better growth of plant. This result is in conformity with the findings of Vikrant et al.[17].

3.3.5 Seed index (g)

The data presented in Table 2 disclosed that seed index was not varied significantly due to different treatments. However, marginally higherseed index was observed in treatmentcastor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) (9.98 g) than rest of treatments.

3.3.6 Seed yield (kg ha-1)

A close examination of result indicated that application of organic manure and bio-fertilizer manifest significant influence on seed yield. Significantly the higher seed yield (1109 kg ha^{-1}) was recorded under the treatment T_8 (castor cake @ 1.0 t ha-1 + *Rhizobium* + PSB) which was at par with treatment100% RDF (T_2), FYM @ 2.5 t ha-1 + *Rhizobium* + PSB (T_4) and vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6). Whereas, absolute control (T_1) gave the lower seed yield (707 kg ha^{-1}) among the treatments. The magnitude of increase in seed yield of cowpea due to castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) over T_1 (absolute control)

Table 1. Effect of different integrated nutrient sources on plant population, plant height, number of branches, root nodules, dry matter and growth parameters of *kharif* cowpea

Treatments	Plant population (per meter row length)		Plant height (cm)			Number of branches per plant	Number of root nodules /plant at 45DAS	Dry matter/plant(g)			Fresh root nodules weight per plant (mg)	Dry root nodules weight per plant (mg)	Number of pods per plant	Number of seeds per pod	Length of pod (cm)
	20 DAS	**At harvest**	**30 DAS**	**60 DAS**	**At harvest**			**30 DAS**	**60 DAS**	**At harvest**					
T_1-Absolute control	8.51	7.89	17.08	36.68	44.97	3.86	18.32	30.43	47.85	60.14	53.71	15.99	8.25	8.61	9.78
T_2 -100% RDF	8.77	8.13	21.58	44.18	46.97	5.36	19.82	37.30	59.30	83.32	62.20	21.67	11.45	10.12	11.28
T_3-FYM @ 5.0 t ha-1	8.60	8.06	19.08	42.67	45.37	4.89	21.19	33.60	56.74	80.51	63.83	22.76	10.65	9.07	10.19
T_4 -FYM @ 2.5 t ha-1 + R*hizobium* + PSB	8.88	8.24	19.82	47.53	51.73	6.17	25.00	36.90	61.30	86.17	69.80	26.77	12.50	10.24	11.50
T_5 -Vermicompost @ 2.0 t ha-1	8.58	8.16	18.88	42.27	45.26	4.78	20.81	33.10	54.10	76.67	62.47	21.86	9.70	9.64	10.20
T_6-Vermicompost @ 1.0 t ha-1 + *Rhizobium* + PSB	8.78	8.14	19.77	47.07	50.40	5.52	24.43	36.70	59.40	86.07	66.26	24.40	11.25	10.05	11.46
T_7 -Castor cake @ 2.0 t ha-1	8.70	8.09	19.18	44.23	46.86	5.23	21.81	35.60	58.42	84.00	63.97	22.87	10.75	9.78	10.86
T_8 -Castor cake @ 1.0 t ha-1 + *Rhizobium* + PSB	8.98	8.24	19.08	48.07	52.26	6.23	24.46	33.30	63.44	92.02	68.96	26.21	12.80	10.39	11.56
T_9 –*Ghan Jeevamrut* @ 250 kg ha-1 at sowing time + Seed treatment with *Beejamrut* @ 200 ml kg-1 seed+ *Jeevamrut* @ 500 lit ha-1 with irrigation at sowing and 30 DAS	8.53	7.90	18.79	41.98	45.17	4.49	20.70	32.23	53.40	66.04	62.33	21.77	9.30	9.29	9.99
S.Em. ±	**0.21**	**0.16**	**0.67**	**1.57**	**1.65**	**0.25**	**1.15**	**1.42**	**1.76**	**3.14**	**1.55**	**0.74**	**0.47**	**0.36**	**0.33**
C.D. at 5 %	**NS**	**NS**	**1.97**	**4.59**	**4.82**	**0.73**	**3.34**	**4.15**	**5.13**	**9.16**	**4.53**	**2.17**	**1.36**	**1.05**	**0.98**
C.V. %	**4.87**	**4.08**	**7.00**	**7.17**	**6.93**	**9.67**	**10.49**	**8.27**	**6.15**	**7.90**	**4.87**	**6.56**	**8.70**	**7.40**	**6.22**

Table 2. Yield parameters, harvest index and protein content of *kharif* cowpea as influenced by different integrated nutrient management treatments

Treatments	Seed yield per plant (g)	Seed yield (kg ha-1)	Stover yield (kg ha-1)	Harvest index (%)	Days to physiological maturity	Protein content (%)
T_1-Absolute control	6.20	707	1367	34.16	78.25	18.41
T_2 -100% RDF	8.15	1037	1825	36.20	82.50	20.73
T_3-FYM @ 5.0 t ha-1	7.24	945	1733	35.36	82.75	20.11
T_4 -FYM @ 2.5 t ha-1 + R*hizobium* + PSB	8.61	1054	1840	36.34	84.75	21.52
T_5 -Vermicompost @ 2.0 t ha-1	6.91	901	1699	34.75	82.25	20.41
T_6-Vermicompost @ 1.0 t ha-1 + *Rhizobium* + PSB	8.15	1033	1813	36.36	84.75	20.66
T_7 -Castor cake @ 2.0 t ha-1	7.57	958	1721	35.84	82.75	20.30
T_8 -Castor cake @ 1.0 t ha-1 + *Rhizobium* + PSB	8.73	1109	1986	35.79	84.50	22.33
T_9 –*Ghan Jeevamrut* @ 250 kg ha-1 at sowing time + Seed treatment with *Beejamrut* @ 200 ml kg-1 seed+ *Jeevamrut* @ 500 lit ha-1 with irrigation at sowing and 30 DAS	6.80	891	1596	35.93	80.50	21.11
S.Em. ±	**0.31**	**50**	**88**	**1.38**	**2.22**	**0.56**
C.D. at 5 %	**0.90**	**146**	**257**	**NS**	**NS**	**1.65**
C.V. %	**8.08**	**10.41**	**10.18**	**7.72**	**5.38**	**5.48**

was the extent of 56.85 and 49.08 per cent and over T_2 (100% RDF) was the extent of 6.94 and 1.64 per cent, respectively. Seed yield was significantly higher with treatment castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) might be due to the fact that combined application of organic manure and Bio-fertilizer must have a produced excess of assimilates which are first stored in leaves and later translocate into seeds at the time of senescence, which might have ultimately led to higher seed yield. “Second reason for higher seed yield might be due to increase in photosynthetic activity of plant and root system and thus enabled plant to extract more water and nutrients from the soil depth, resulting into better development of plant growth, yield attributes and ultimately the higher seed yield. Third probable reason for increased seed yield under the INM may be the higher number of pods per plant and number of seeds per pod which gradually increased the seed yield under this treatment” [18].

3.3.7 Stover yield (kg ha-1)

A close surveillance of data presented in Table 2 showed that application of organic manure and bio-fertilizer manifest significant influence on Stover yield. Treatment T_8 (castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB) being at par with treatment100% RDF (T_2), FYM @ 5.0 t ha^{-1} (T_3), FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) and vermicompost @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_6) recorded significantly the higher stover yield (1986kg ha^{-1}). Whereas, absolute control (T_1) produced lower stover yield (1367kg ha^{-1}) among the different treatments. The magnitude of increase in stover yield due to castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB (T_8) and FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) over T_1 (absolute control) was to the tune of 45.28 and 34.60 per cent, respectively. Treatment T_8 i.e. application of castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB gave the highest Stover yield probably because of the fact that under this treatment the synthesis of photosynthates is more owing to adequate supply of nitrogen and phosphorus which increased the photosynthesis activity and production of more biomass, which ultimately resulted in higher yield of stover. Similar results in cowpea were given by [19].

3.4 Effect on Quality Parameters

3.4.1 Protein content in seed (%)

The set of data concerning to the protein content in seeds of cowpea which are provided in Table 2 indicates that the different treatments succeed in having their significant influence on protein content. Significantly higher protein content (22.33 %) was gained through the treatment T_8 (Castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB), which was at par with treatment100% RDF (T_2), FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB (T_4) and *Ghan Jeevamrut* @ 250 kg ha^{-1} at sowing time + Seed treatment with *Beejamrut* @ 200 ml kg^{-1} seed + *Jeevamrut* @ 500 lit ha^{-1} with irrigation at sowing and 30 DAS (T_9). Among all the treatments observed the lower protein content (18.41 %) was obtained under treatment T_1 (absolute control). As a whole, treatment T_8 (castor cake @ 1.0 t ha^{-1} + *Rhizobium* + PSB) and T_4 (FYM @ 2.5 t ha^{-1} + *Rhizobium* + PSB) were correspondingly increased of protein content was to the tune of 21.29 and 16.89 per cent over treatment T_1 (absolute control), respectively. “Increase in protein content in seed might be due to the fact that higher nitrogen content in seed is directly associated to higher availability of nitrogen to plants. Higher nitrogen is seeds are directly responsible for higher protein content because it is a primary component of amino acid which constitutes the basis of protein content. Another reason for increasing the protein content might be due to fact that cowpea is a leguminous crop and the application of bio-fertilizers must have activated the microbial population responsible for root nodulation and efficient nodulation which must have enhanced nitrogen fixation by the plant and ultimately increased the protein content” [20].

4. CONCLUSION

Based on field experimentation, it is concluded that higher yield from *kharif* cowpea could be obtained by applying either castor cake @ 1.0 t ha^{-1} or FYM @ 2.5 t ha^{-1} along with *Rhizobium* + PSB in loamy sand of North Gujarat Agro-climatic conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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