

Effect of organic manures and bio-fertilizers on growth, yield and quality of *kharif* cowpea [*Vigna unguiculata* (L.)]

ABSTRACT

A field experiment was conducted at Agronomy Instructional Farm of SDAU, Sardarkrushinagar, Gujarat, Indiaduring *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 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

42 the nutrients”[4].FYM play an important role for improving soil physical property. Organic
43 fertilizer is considered as an important source of humus, macro and micro element carrier,
44 and at the same time it increases the activity of the useful microorganisms [19,20].Use of
45 biofertilizer can have a greater importance in increasing fertilizer use efficiency.
46

47 2. MATERIALS AND METHODS

48 A field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel
49 College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University,
50 Sardarkrushinagar, Gujarat, India to study the “Effect of organic manures and bio-fertilizers
51 on growth and yield of *kharif* cowpea [*Vigna unguiculata* (L.)]” during *kharif* season of 2020-
52 2021.Geographically, Sardarkrushinagar is situated at 24° 19' North latitude and 72° 19' East
53 longitude with an elevation of 154.52 meter above the mean sea level and situated in the
54 North Gujarat Agro-climatic region. Climate of this region is sub-tropical monsoon type and
55 falls under semi-arid region. The soil of experimental field was loamy sand in texture with
56 low in organic carbon (1.8 g kg⁻¹) and available nitrogen (138.0 kg ha⁻¹), medium in available
57 phosphorus (38.6 kg ha⁻¹) and high in available potassium (215.2 kg ha⁻¹) having pH value of
58 7.56. The experiment consisting nine treatments viz., T₁-Absolute control, T₂-100% RDF (20
59 kg N + 40 kg P₂O₅ ha⁻¹), T₃- FYM @ 5.0 t ha⁻¹, T₄-FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB, T₅-
60 vermicompost @ 2.0 t ha⁻¹, T₆-vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB, T₇-castor
61 cake @ 2.0 t ha⁻¹, T₈-castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB, T₉-*Ghan Jeevamrut* @ 250
62 kg ha⁻¹ at sowing time + Seed treatment with *Beejamrut* @ 200 ml kg⁻¹ seed+ *Jeevamrut* @
63 500 lit ha⁻¹ with irrigation at sowing and 30 DAS were tested in randomized block design
64 with four replications. Cowpea variety GC 4 was used as a test crop. The required quantity of
65 healthy cowpea seeds of cultivar GC 4 was inoculated with *rhizobium* and PSB @ 20 ml kg⁻¹
66 seeds and required quantity of seeds inoculated with *beejamrut* @ 200 ml kg⁻¹ seeds as per
67 treatments.“The biometric observations were recorded from five randomly selected plants
68 tagged earlier in each plot for the following parameters at grand growth and at harvest. The
69 details of various growth parameters, yield attributes, quality and chemical parameters
70 studied. The data recorded for various parameters during the course of investigation were
71 statistically analysed”[5] The significance of difference was tested by “F” test at 5 per cent
72 level. The critical difference was calculated when the differences among treatments were

73 found significant under “F” test. In remaining cases, only standard error of mean was worked
74 out.

75 3. RESULTS AND DISCUSSION

76 3.1 1 Effect of organic manures and bio-fertilizers on plant population

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

81 3.2 Effect organic manures and bio-fertilizers on growth parameters

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

85 3.2.1 Plant height (cm)

86 The data on plant height of cowpea recorded at the time of 30 DAS, 60DAS and at harvest are
87 presented in Table 1 clearly indicated that the plant height was increased progressively and linearly
88 up to the harvest with the advancement of crop growth and also significantly affected by the different
89 integrated nutrient management treatments. The mean data on plant height presented in Table 1
90 indicated that different treatments had significant influence on plant height at 30 DAS. Significantly
91 higher plant height (21.58 cm) was recorded by the application of 100 % RDF (T₂), but it was at par
92 with FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄) and vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB
93 (T₆). At 60 DAS and at harvest, plant height was significantly influenced by different integrated
94 nutrient management treatments. Significantly higher plant height at 60 DAS (48.07 cm) and at
95 harvest (52.26 cm) was recorded by the application of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* +
96 PSB (T₈), but it was at par with 100% RDF (T₂), FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB
97 (T₄), vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₆) and castor cake @ 2.0 t ha⁻¹ (T₇) at the time
98 of 60 DAS and FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄), vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* +
99 PSB (T₆) at the time of harvest. Significantly the lower plant height at 30 DAS (17.08 cm), 60
100 DAS (36.68 cm) and at harvest (44.97 cm) was observed by the absolute control (T₁). The probable
101 reason might be positive effect of nutrient on growth character due to augment of cell division and
102 cell expansion [6]. The increase in the plant growth in terms of plant height under treatment T₈ (Castor
103 cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB) is the combined use of organic manure and bio-fertilizer might
104 be increased the fertilizer use efficiency and also nutrient availability leading to the higher growth of
105 plant in terms of plant height by higher cell multiplication and cell elongation. “Moreover, organic
106 manures also contain almost all essential elements in variable quantities, which had synergistic effect
107 with other essential elements for their availability” [7].

108 4.3.2 Number of branches per plant

109 “Maximum number of branches per plant with castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈) might
110 be due to the integrated use of organic manures and bio fertilizers offers more balanced nutrition and
111 favourable soil conditions for better growth of the plant. Moreover, higher availability of nutrients
112 might be reflected on higher number of branches per plant”[8,9].

113 3.2.3 Number of root nodules per plant

114 An appraisal of data presented in Table 1 indicated that the number of root nodules per plant was
115 significantly influenced by different integrated nutrient management treatments. An application
116 of FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄) to cowpea crop recorded significantly higher number of
117 root nodules per plant (25.00), but it was at par with vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB
118 (T₆), Castor cake @ 2.0 t ha⁻¹ (T₇) and Castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈). Significantly a
119 smaller number of root nodules per plant (18.32) was noted under absolute control (T₁). Improvement
120 in number of root nodules per plant could be attributed due to favorable aeration and moisture regime
121 with the integration of organic manures with bio-fertilizers. Moreover, seed inoculation of bio-
122 fertilizers (*Rhizobium* + PSB) may be provided more conducive environment for better root growth
123 and respiration along with higher soil biological activity. “The PSB liquid bio-fertilizer might also
124 have enhanced the availability of phosphorus to plants which must have utilized in greater root
125 development and nodulation”[10].

126 3.2.4 Dry matter accumulation per plant (g)

127 The mean data on dry matter accumulation of cowpea presented in Table 1 indicated that different
128 treatments had significant influence on dry matter accumulation at 30 DAS. Treatment T₂ (100% RDF)
129 registered significantly higher dry matter per plant (37.30 g) which was at par with FYM @ 5.0 t ha⁻¹
130 (T₃), FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄), vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* +
131 PSB (T₆), castor cake @ 2.0 t ha⁻¹ (T₇) and castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈). Data
132 presented in Table 1. Showed that significantly higher dry matter per plant at 60 DAS (63.44 g) and at
133 harvest (92.02 g) was observed with treatment T₈ (castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB) which
134 was at par with treatment 100% RDF (T₂), FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄), vermicompost @
135 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₆) and castor cake @ 2.0 t ha⁻¹ (T₇). Significantly the lower dry matter
136 accumulation at 30 DAS (30.43 g), 60 DAS (47.85 g) and at harvest (60.14 g) was observed by the
137 absolute control (T₁). Adequate major nutrients might have helped in harvesting of solar energy as
138 reflected by increased dry matter accumulation. The beneficial effect of organic manures and bio-
139 fertilizers in growth attributes are close agreement with the findings reported by Pargiet *al.* [11].

140 3.2.5 Fresh and dry root nodules weight per plant (mg) at 45 DAS

141 Results presented in Table 1 indicated that the fresh and dry root nodules weight per plant was
142 significantly influenced by different integrated nutrient management treatments. Significantly
143 maximum fresh nodules weight per plant (69.80 mg) and dry nodules weight per plant (26.77 mg)
144 was recorded with treatment T₄ (FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB), but it was at par with castor
145 cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈). Significantly the minimum fresh nodules weight per plant
146 (53.71 mg) and dry nodules weight per plant (15.99 mg) was registered under the treatment of absolute
147 control (T₁). Improvement in fresh and dry root nodules weight per plant could be attributed due to
148 favorable aeration and moisture regime with the integration of organic manures with bio-fertilizers.

149 Moreover, seed inoculation of bio-fertilizers (*Rhizobium* + PSB) may be provided more conducive
150 environment for better root growth and respiration along with higher soil biological activity. The
151 positive response of organic manures and bio fertilizer to increase the nodulation might be due to the
152 organic matter provides energy for nodulation. “The PSB liquid bio-fertilizer might also have
153 enhanced the availability of phosphorus to plants which must have utilized in greater root
154 development and nodulation”[12].

155 **3.3Effect on yield and yield attributes**

156 **3.3.1 Number of pods per plant**

157 The set of data furnished in Table 1 confirms that the number of pods per plant was influenced
158 significantly by different treatments. Significantly the greater number of pods per plant (12.80) was
159 recorded under the application of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈). Treatment 100%
160 RDF(T₂)and FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄) remained at par with treatment T₈. The
161 increment in number of pods per plant under T₈and T₄ was to the tune of 55.15 and 51.51 per cent
162 higher than treatment T₁ (absolute control), respectively. Significantly the smaller number of pods per
163 plant (8.25) was recorded under the treatment T₁ (absolute control). The data in Table 1 displayed that
164 the application of treatment T₈ of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB on number of pods per
165 plant was found significant over rest of the treatments except treatment 100% RDF (T₂) and FYM @
166 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄). More number of pods plant⁻¹ might be due to more survival of
167 flowers under high supply of photosynthates under treatment castor cake @ 1.0 t ha⁻¹ + *Rhizobium* +
168 PSB(T₈) as compared to other treatments. Higher number of pods per plant might be owing to better
169 vegetative growth and photosynthetic activity ascribed by larger uptake of nutrients and water from
170 the soil by well-developed root system and profuse nodulation which caused an increase in nitrogen
171 supply from symbiotically fixed nitrogen in root nodules [11].

172 **3.3.2 Number of seeds per pod**

173 The data presented in Table 1 disclosed that the number of seeds per pod was significantly influenced
174 by application of different treatments. Significantly the higher number of seeds per pod (10.39) was
175 obtained under treatment T₈ i.e. application of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB which
176 remained at par with treatment FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄), 100% RDF (T₂),
177 vermicompost @ 2.0 t ha⁻¹ (T₅), vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₆) and castor cake
178 @ 2.0 t ha⁻¹ (T₇). Significantly the lower number of seeds per pod (8.61) was gained under absolute
179 control (T₁). The increment in number of seeds per pod under T₈ and T₄ was to the tune of 20.67 and
180 18.93 per cent higher than treatment T₁ (absolute control), respectively. “The highest number of seeds
181 per pod was obtained with application of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB probably due to
182 the fact that supplying of ample amount of nutrients in form of organic manure and bio-fertilizer must
183 have increased carbohydrate accumulation and their remobilization to reproductive parts of the plant,
184 being closest sink and hence, resulted into increased flowering, fruiting and seed formation and thus a
185 greater number of seeds per pod”[13].

186 **3.3.3 Length of pod (cm)**

187 The results from Table 1 revealed that different treatments including organic manure and bio-fertilizer
188 significantly influenced on length of pod of cowpea. Significantly higher length of pod (11.56 cm)
189 was obtained through the application of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈). Treatment
190 100% RDF (T₂), FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄), vermicompost @ 1.0 t ha⁻¹ + *Rhizobium*
191 + PSB (T₆) and castor cake @ 2.0 t ha⁻¹ (T₇) remained at par with treatment castor cake @ 1.0 t ha⁻¹ +
192 *Rhizobium* + PSB (T₈) and the lower value of pod length (9.78 cm) was obtained by absolute control.
193 The length of pod measured under castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈) and FYM @ 2.5 t
194 ha⁻¹ + *Rhizobium* + PSB (T₄) was 18.20 and 17.58 per cent higher than treatment T₁ (absolute control),
195 respectively. The length of cowpea pod was significantly influenced by different organic manures as
196 well as bio fertilizers (Table 2). Lengthier pods were observed with application of castor cake @ 1.0 t
197 ha⁻¹ + *Rhizobium* + PSB probably due to the fact that increased supply of N and P and their higher
198 uptake by plants might have stimulated the rate of various physiological processes in plant and
199 resulted in increased pod length. “The increase in pod length might be due to better partitioning of
200 assimilates from source to sink. Resultant utilization of accumulated photosynthates influenced the
201 growth and development of yield attributes” [14].

202 3.3.4 Seed yield per plant (g)

203 An appraisal of data presented in Table 2 clearly indicated that seed yield per plant of *kharif* cowpea
204 was differed significantly due to various integrated nutrient management treatments. Significantly
205 higher seed yield per plant (8.73 g) was obtained under treatment castor cake @ 1.0 t ha⁻¹ +
206 *Rhizobium* + PSB (T₈), but it remained at par with treatment of 100% RDF (T₂), FYM @ 2.5 t ha⁻¹ +
207 *Rhizobium* + PSB (T₄) and vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₆). The magnitude of
208 increase in seed yield per plant due to castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈) and FYM @
209 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄) over T₁ (absolute control) was to the tune of 40.80 and 38.87 per
210 cent, respectively. Significantly the lower seed yield per plant (6.20 g) was noted under treatment
211 absolute control (T₁). Castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈) recorded higher seed yield per
212 plant than other treatments. The seed yield per plant was higher due to higher pod length, seeds per
213 pod, number of pods per plant and also higher test weight due to better growth of plant. This result is
214 in conformity with the findings of Vikrant *et al.* [15].

215 3.3.5 Seed index (g)

216 The data presented in Table 2 disclosed that seed index was not varied significantly due to different
217 treatments. However, marginally higher seed index was observed in treatment castor cake @ 1.0 t ha⁻¹ +
218 *Rhizobium* + PSB (T₈) (9.98 g) than rest of treatments.

219 3.3.6 Seed yield (kg ha⁻¹)

220 A close examination of result indicated that application of organic manure and bio-fertilizer manifest
221 significant influence on seed yield. Significantly the higher seed yield (1109 kg ha⁻¹) was recorded
222 under the treatment T₈ (castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB) which was at par with
223 treatment 100% RDF (T₂), FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄) and vermicompost @ 1.0 t ha⁻¹
224 + *Rhizobium* + PSB (T₆). Whereas, absolute control (T₁) gave the lower seed yield (707 kg ha⁻¹)
225 among the treatments. The magnitude of increase in seed yield of cowpea due to castor cake @ 1.0 t
226 ha⁻¹ + *Rhizobium* + PSB (T₈) and FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄) over T₁ (absolute

227 control) was the extent of 56.85 and 49.08 per cent and over T₂ (100% RDF) was the extent of 6.94
228 and 1.64 per cent, respectively. Seed yield was significantly higher with treatment castor cake @ 1.0 t
229 ha⁻¹ + *Rhizobium* + PSB (T₈) might be due to the fact that combined application of organic manure
230 and Bio-fertilizer must have produced excess of assimilates which are first stored in leaves and later
231 translocate into seeds at the time of senescence, which might have ultimately led to higher seed yield.
232 “Second reason for higher seed yield might be due to increase in photosynthetic activity of plant and
233 root system and thus enabled plant to extract more water and nutrients from the soil depth, resulting
234 into better development of plant growth, yield attributes and ultimately the higher seed yield. Third
235 probable reason for increased seed yield under the INM may be the higher number of pods per plant
236 and number of seeds per pod which gradually increased the seed yield under this treatment” [16].

237 3.3.7 Stover yield (kg ha⁻¹)

238 A close surveillance of data presented in Table 2 showed that application of organic manure and bio-
239 fertilizer manifest significant influence on Stover yield. Treatment T₈ (castor cake @ 1.0 t ha⁻¹ +
240 *Rhizobium* + PSB) being at par with treatment 100% RDF (T₂), FYM @ 5.0 t ha⁻¹ (T₃), FYM @ 2.5 t
241 ha⁻¹ + *Rhizobium* + PSB (T₄) and vermicompost @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₆) recorded
242 significantly the higher stover yield (1986 kg ha⁻¹). Whereas, absolute control (T₁) produced lower
243 stover yield (1367 kg ha⁻¹) among the different treatments. The magnitude of increase in stover yield
244 due to castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB (T₈) and FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₄)
245 over T₁ (absolute control) was to the tune of 45.28 and 34.60 per cent, respectively. Treatment T₈ i.e.
246 application of castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB gave the highest Stover yield probably
247 because of the fact that under this treatment the synthesis of photosynthates is more owing to
248 adequate supply of nitrogen and phosphorus which increased the photosynthesis activity and
249 production of more biomass, which ultimately resulted in higher yield of stover. Similar results in
250 cowpea were given by [17].

251 4.5 Effect on quality parameters

252 4.5.1 Protein content in seed (%)

253 The set of data concerning to the protein content in seeds of cowpea which are provided in Table 2
254 indicates that the different treatments succeed in having their significant influence on protein content.
255 Significantly higher protein content (22.33 %) was gained through the treatment T₈ (Castor cake @
256 1.0 t ha⁻¹ + *Rhizobium* + PSB), which was at par with treatment 100% RDF (T₂), FYM @ 2.5 t ha⁻¹ +
257 *Rhizobium* + PSB (T₄) and *GhanJeevamrut* @ 250 kg ha⁻¹ at sowing time + Seed treatment with
258 *Beejamrut* @ 200 ml kg⁻¹ seed + *Jeevamrut* @ 500 lit ha⁻¹ with irrigation at sowing and 30 DAS (T₉).
259 Among all the treatments observed the lower protein content (18.41 %) was obtained under treatment
260 T₁ (absolute control). As a whole, treatment T₈ (castor cake @ 1.0 t ha⁻¹ + *Rhizobium* + PSB) and T₄
261 (FYM @ 2.5 t ha⁻¹ + *Rhizobium* + PSB) were correspondingly increased of protein content was to the
262 tune of 21.29 and 16.89 per cent over treatment T₁ (absolute control), respectively. “Increase in protein
263 content in seed might be due to the fact that higher nitrogen content in seed is directly associated to
264 higher availability of nitrogen to plants. Higher nitrogen in seeds are directly responsible for higher
265 protein content because it is a primary component of amino acid which constitutes the basis of protein
266 content. Another reason for increasing the protein content might be due to fact that cowpea is a
267 leguminous crop and the application of bio-fertilizers must have activated the microbial population

268 responsible for root nodulation and efficient nodulation which must have enhanced nitrogen fixation
269 by the plant and ultimately increased the protein content”[18].

270 4. CONCLUSION

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

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339 **Table: 1. Effect of different integrated nutrient sources on plant population, plant height,**
340 **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 45D AS	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 D A S	At harvest	30 D AS	60 D AS	At harvest			30 D AS	60 D AS	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%	8.7	8.13	21.	44.	46.9	5.36	19.8	37.	59.	83.3	62.2	21.6	11.4	10.1	11.2

RDF	7		58	18	7		2	30	30	2	0	7	5	2	8
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 + <i>Rhizobium</i> + 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 + <i>Rhizobium</i> + 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 + <i>Rhizobium</i> + 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 - <i>GhanJeevamrut</i> @ 250 kg ha-1 at sowing time + Seed treatment with <i>Beejamrut</i> @ 200 ml kg-1 seed + <i>Jeevamrut</i> @ 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

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

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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 + <i>Rhizobium</i> + 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 + <i>Rhizobium</i> + 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 + <i>Rhizobium</i> + PSB	8.73	1109	1986	35.79	84.50	22.33
T ₉ - <i>Ghan Jeevamrut</i> @ 250 kg ha-1 at sowing time + Seed treatment with <i>Beejamrut</i> @ 200 ml kg-1 seed+ <i>Jeevamrut</i> @ 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

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