Original Research Article

RESPONSE OF SUMMER COWPEA (*Vigna unguiculata* L.) TO INORGANIC FERTILIZERS AND FOLIAR APPLICATION OF BIO-ENHANCERS

ABSTRACT

A field experiment on "Response of summer cowpea (*Vigna unguiculata* L.) to inorganic fertilizers and foliar application of bio-enhancers" was carried out during summer 2022 on loamy sand soil of Agronomy Instructional Farm, C. P. College of Agriculture, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar. The experiment was laid out in RBD with factorial concept with threereplications. The result revealed that significantly higher plant height, Number of pods per plant, number of root nodules per plant, fresh and dry weight of root nodules, seed yield, stover yield and protein content, were recorded with 100% RDF. It also gave the higher net return and B:C ratio. Significantly higher number of pods per plant, root nodules/plant, fresh and dry weight of root nodules, seed yield and stover yield with an application of panchagavya as foliar spray @ 3% at 30 and 45 DAS. The same bio-enhancer application recorded maximum net return as well as B:C ratio.

Keywords:Cowpea, Inorganic fertilizer, Bio-enhancers, Pod, Yield, Quality

1. Introduction

Cowpea belongs to family *Papilionaceae* and sub family *Fabaceae* with a chromosome number of 2n=2x=22. Its primary center of origin is in Africa. It is a warm season, annual and herbaceous legume. Cowpea is consumed as whole grain as well as dal or to make flour in variety of ways for table purposes. Green tender pods are used as vegetable. Cowpea (row seeds) contain 60.03 g carbohydrates, 23.52 g protein and 1.26 g fat, 5.68 mg vitamins, 1857.64 mg minerals, 11.95 g water, 336 kcal energy. Moreover, cowpea seeds are rich source of phosphorus, calcium and iron. The common names of cowpea are 'Black-eye-pea', 'Southern pea', 'China pea' and 'Marble pea'. In Gujarati languages, the famous name is 'chola' or 'chowli'.The important cowpea growing countries are Africa, Brazil, India, Myanmar, Srilanka, Australia and Bosnia. In India, major cowpea growing states are Maharashtra, Karnataka, Tamilnadu, Gujarat, Madhya Pradesh and Andhra Pradesh. In Gujarat, it is mainly grown in Sabarkantha, Banaskantha, Mehsana, Patan, Ahmedabad, Kheda and Anand districts. In Gujarat, kharif cowpea is cultivated in 520 ha area with an annual production of 290 tonnes leading to average productivity of 550 kg per hectare (DOA, 2021).Pulses are second most important group of crops after cereals. In India, pulses are grown nearly 28.83 million hectares with the annual production of 25.72 million tonnes and an average productivity of 892 kg/ha (DA & FW 2021). In Gujarat, pulses crops are grown over an area of 17.61 lakh hectares with an annual production of 26.88 lakh metric tonnes and productivity of 1526 kg/ha (DOA, 2021).

Cowpea is highly responsive to fertilizer application. Nitrogen plays important role in various metabolic process of the plant growth. Nitrogen is an essential constituent of protein and chlorophyll (Meena and Chand, 2014). Although cowpea is a legume and capable of fixing atmospheric nitrogen, still it responds to small quantity of nitrogenous fertilizers applied as starter dose. Application of 15-20 kg N/ha has been found optimum to get better response. The positive effect of supplying legume plants with supplementary nitrogen was found to be beneficial effect on increasing seed yield. Application of higher dose of nitrogen may reduce nodule number and nodule growth and thus adversely affects the nitrogen fixation capacity (Singh and Nair, 1995). In addition, nitrogen and phosphorus have a stimulating effect on root activity and rooting pattern of the crop. Phosphorus is an essential constituent of nucleic acids such as ribonucleic acid (RNA), deoxyribonucleic acid (DNA), adenosine diphosphate (ADP) and adenosine triphosphate (ATP), nucleoproteins amino acids, proteins,

phosphatides, phytin and several co - enzymes. It has been established that there is a positive correlation between fertilizer use and crop production. Among various agronomical factors responsible for increasing productivity of crop, fertilizer management plays a vital role for harvesting potential production of crop in different agro - climatic conditions.
Beside this, foliar application of bio-enhancers exploiting genetic potential of crop. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating uptake of nutrients by the plant. Since, foliar nutrients usually penetrate through the leaf cuticles or stomata and enters the cell facilitating easy and rapid utilization of nutrients. So foliar nutrition on cowpea helps in achieving the optimum grain yield of summer cowpea.Among the different foliar applications, panchagavya, jivamrut, vermiwash, cow urine and novel are very important for the production of crops.

2. Material and Methods

The experiment was carried out during summer season of 2022 on Plot No. C-6 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar, Gujarat. The data of soil analysis indicated that the soil of the experimental plot was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus and medium in available potassium status. EC was very low showing that the soil was free from salinity hazard. The experiment was laid out in a randomized block design with factorial concept with three replications. The treatments were assigned randomly to each plot in the replication.There were fourteen treatments comprising two Inorganic fertilizer levels (F_1: 75% RDF, F_2: 100% RDF) and seven levels of bio-enhancer (Foliar application) (B_1: Panchagavya @ 3%,B_2: Jivamrut @ 5%,B_3: Vermiwash @ 10%,B_4: Cow urine @ 5%, B_5: Novel @ 1%, B_6: Water spray, B_7:Control (no spray)).The experimental field was prepared by tractor drawn cultivator followed by harrowing and planking to obtain fine tilth. Cowpea variety Gujarat cowpea 6 was selected for present investigation. The seeds were sown manually to a depth of 3 to 4 cm in previously opened furrows using recommended seed rate of 17.5 kg/ha under dry condition by maintaining row spacing of 45 cm and covered with the soil immediately.The recommended dose of nitrogen and phosphorus (20:40:00 kg NPK/ha) as a basal application was applied in furrow of each plot in the form of urea and DAP, respectively just before sowing.The required quantity of healthy cowpea seeds of cultivar GC 6 was inoculated uniformly with rhizobium @ 5 ml/kg seeds and were dried in the shade before sowing.Foliar application of bio-enhancers was sprayed at 30 DAS and 45 DAS as per treatments. The spray volume of water used for foliar spray was 400 l/ha at 30 and 45 days after sowing.Gap filling were carried out after 10 days of sowing to maintain optimum plant population in the experimental plots.The interculturing and hand weeding operation were carried out in cowpea crop to keep the plots weed free and to eliminate the early crop weed competition and better soil aeration.The biometric observations were recorded from five randomly selected tagged plants within each net plot for all parameters *viz*., plant height, pods/plant, root nodules/plant, fresh and dry weight of root nodules, seed yield, stover yield and protein content, gross return, net return and BCR.The data recorded for various parameters during the course of investigation were statistically analysed by a producer appropriate to the design of experiment as described by Panse and Sukhatme (1985). The significance of difference was tested by “F” test at 5 per cent level.

3. Result and discussion

3.1 Growth parameters

3.1.1 Plant height (cm)

The data outlined in Table 1 indicated application of 100% recommended dose of fertilizer recorded significantly highest plant height at harvest (57.39 cm). The difference in plant height might be due to acceleration of various metabolic process, internodes elongation and synthesis of higher photosynthates due to adequate supply of nitrogen and phosphorus through chemical fertilizers. These results are in closed conformity with results of Keshwa*et al.* (2009), Pargi*et al*. (2018) and Sakpal *et al*. (2021).Numerically higher plant height (57.60 cm) were recorded by foliar spray of panchagavya @ 3% at harvest.

3.1.2 Number of branches per plant

The data presented in Table 1 indicated that the number of branches per plant at harvest were not significantly influenced by different levels of inorganic fertilizer, which indicated that there was no significant effect of inorganic fertilizer on number of branches per plant. However, numerically higher number of branches per plant (7.55) was recorded by the application of 100% recommended dose of fertilizer (F_2).However, numerically higher number of branches per plant (7.57) was recorded by the foliar spray of *panchagavya* @ 3% at 30 and 45 DAS (B_1).

3.2Yield attributes

3.2.1 Number of pods per plant

The results presented in Table 1 indicated that significantly higher number of pods per plant (19.08) was recorded by the application of 100% recommended dose of fertilizer (F_2). The increase in number of pods per plant might be due to better translocation of photosynthates from source to sink by the application of 100% recommended dose of fertilizer. The better availability of nutrients to the plants from basal application of nitrogen and phosphorus from fertilizers which enable plants to produce higher number of pods per plant. These findings are in close agreement with the results of Subbarayappa*et al*. (2009), Dongare*et al*. (2016), Pargi*et al*. (2018) and Sakpal *et al*. (2021). Application of panchagavya as foliar spray @ 3% at 30 and 45 DAS (B1) recorded significantly higher number of pods per plant at harvest (20.03), which was remained at par with foliar spray of novel @ 1% (B_5) (19.57), jivamrut @ 5% (B_2) (19.23) and vermiwash @ 10% (B_3) (17.97), respectively.The higher number of pods per plant might be due to foliar spray of panchagavya enhanced the growth of plant since it contains the favourable macro and micro nutrients and growth hormones in liquid formulation. It resulted in stimuli in the plant system and turn to increase the production of growth regulator in the cell system favouring cell division and elongation which ultimately increased the number pods per plant. Also, application of panchagavya stimulates the production of auxins. Auxins are plant hormones that promotes plant growth leading to more number of pods per plant. These findings are in close agreement with the results of Patel *et al*. (2013) and Sutar *et al*. (2019) and Sakpal *et al*. (2021).

3.2.2Pod length (cm)

The data presented in Table 1 revealed that the pod length was not differ significantly due to different levels of inorganic fertilizer. However, numerically higher pod length (10.87 cm) was recorded by the application of 100% recommended dose of fertilizer (F_2). These results are in closed conformity with Patel (2020) and Chaudhary (2021).The perusal of data given in Table 1 showed that the length of pod was found to be non-significant by the application of different bio-enhancers. However, numerically higher pod length (11.20 cm) was recorded by foliar spray of panchagavya @ 3% at 30 and 45 DAS (B_1). These results are in closed conformity with results of Charamata (2022).The result of Charamata (2022) showed that the pod length of mothbean did not differ significantly due to application of different bio-enhancers.

3.2.3Number of seeds per pod

The data outlined in Table 1 revealed that the number of seeds per pod was not significantly influenced by different levels of inorganic fertilizer. However, numerically higher number of seeds per pod (10.54) was recorded by the application of 100% recommended dose of fertilizer (F_2). These results are in closed conformity with result of Patel (2020) and Chaudhary (2021). The result of Chaudhary (2021) showed that the number of seeds per pod of cowpea did not differ significantly due to application of 100% recommended dose of fertilizer.The perusal of data given in Table 1 indicated that the number of seeds per pod was found to be non-significant by the application of different bio-enhancers. However, numerically higher number of seeds per pod (10.87) was recorded by the foliar spray of panchagavya @ 3% at 30 and 45 DAS (B_1).These findings are in close agreement with the result of Charamata (2022). The result of Charamata (2022) showed that the number of seeds per pod of mothbean did not differ significantly due to application of different bio-enhancers.

3.2.4Number of root nodules per plant

The data outlined in Table 1 revealed that significantly higher number root nodules per plant (21.73) of summer cowpea was recorded by the application of 100% recommended dose of fertilizer (F_2).The remarkable increase in number of root nodules per plant of cowpea might be due to supply of adequate phosphorus to plant with the application of 100% dose of phosphorus through inorganic fertilizer attributed to better nodulation in roots of cowpea as phosphorus basically involved in several energy transformation processes and biochemical reactions including nitrogen fixation. Moreover, phosphorus also needed relatively in large amounts for growth (particularly root development) and nitrogen fixation which ultimately promote biomass yield, nodule formation and nodule mass. These findings are in close agreement with the results of Joshi *et al*. (2018) and Pargi*et al.* (2018).The perusal of data given in Table 1 indicated that the number of root nodules per plant of summer cowpea was significantly influenced by foliar application of bio-enhancers. Application of panchagavya as foliar spray @ 3% at 30 and 45 DAS (B_1) recorded significantly higher number of root nodules per plant at harvest (22.83), which was remained at par with foliar spray of novel @ 1% (B_5) (22.23), jivamrut @ 5% (B_2) (21.77) and vermiwash @ 10% (B_3) (21.30), respectively.The increase in number of root nodules per plant by the foliar spray of bio-enhancers might be due to application of panchagavya contains favorable macro and micro nutrients, growth hormones and microorganism viz., Azo*spirillium, Azotobacter, Phosphobacter, Pseudomonas* in liquid formulation which plays an important role in root development and proliferation resulting in better nodule formation and nitrogen fixation by supplying assimilates to the roots and better environment in rhizosphere for growth and development. These results are in close vicinity with the findings of Patel *et al*. (2013) and Sutar*et al*. (2019) and Chaudhary *et al.* (2014). Patel *et al*. (2013) showed that the significantly the highest number of root nodules per plant of cowpea was recorded by the application of panchagavya as foliar spray @ 3% at 20 and 40 days after sowing.

3.2.5 Fresh and dry weight of root nodules (mg/plant)

The data outlined in Table 1 revealed that different levels of inorganic fertilizer exert significant effect on fresh and dry weight of root nodules per plant of summer cowpea. Among two different levels of inorganic fertilizer, significantly the higher fresh and dry weight root nodules of per plant (80.20 and 45.96 mg, respectively) were recorded by the application of 100% recommended dose of fertilizer (F_2). The increase in fresh and dry weight of root nodules per plant of cowpea with application of 100% recommended dose of fertilizer might be due to better root development and profuse nodulation on account of increase in rhizobial activity in the rhizosphere under increased fertilizer level especially due to increased phosphorus availability. These results are supported by Choudhary and Yadav (2011) and Meena *et al*. (2015). The result of Choudhary and Yadav (2011) showed that the significantly higher fresh and dry weight of root nodules of chickpea was recorded by the application of 100% recommended dose of fertilizer.The perusal of data given in Table 1 indicated that the fresh and dry weight of root nodules per plant of summer cowpea was significantly influenced by foliar application of bio-enhancers. Application of panchagavya as foliar spray @ 3% at 30 and 45 DAS (B_1) recorded significantly higher fresh and dry weight of root nodules (83.69 and 47.81 mg, respectively), which was remained at par with foliar spray of novel @ 1% (B_5) (82.03 and 46.98 mg), jivamrut @ 5% (B_2) (81.14 and 46.80 mg) and vermiwash @ 10% (B_3) (78.25 and 45.42 mg), respectively. The increase in fresh and dry weight of root nodules per plant might be due to foliar application of panchagavya may have indirectly contributes to overall plant growth and root formation by providing some essential nutrients and growth promoting substances which leads to increase the population of desired microbes in the rhizosphere during the early stage of infection. The foliar spray of panchagavya is also might be increase plant growth and translocation of carbohydrate to developing nodules. These findings are in agreement with those reported by Panchal *et al*. (2017) and Sutar *et al.* (2019). The result of Panchal *et al*. (2017) showed that the significantly higher fresh and dry weight of root nodules per plant of cowpea was recorded by the application of 100% of recommended dose of fertilizer.

3.2.6 Seed index (g)

The data outlined in Table 1 clearly indicated that the seed index of summer cowpea was not significantly influenced by different levels of inorganic fertilizer. However, numerically the higher seed index (8.54) was recorded by the application of 100% recommended dose of fertilizer (F_2).The perusal of data given in Table 1 indicated that the seed index of summer cowpea was found to be non-

significant by application of different bio-enhancers. However, numerically higher seed index (8.59 g) was recorded by the foliar spray ofpanchagavya @ 3% at 30 and 45 DAS (B_1).

3.2.7 Seed yield (kg/ha)

The data outlined in Table 2 indicated that seed yield of summer cowpea was significantly influenced by different levels of inorganic fertilizer. Significantly higher seed yield (1114 kg/ha) was recorded by the application of 100% recommended dose of fertilizer (F_2). whereas lower seed yield (1031 kg/ha) was recorded by application of 75% recommended dose of fertilizer (F_1). The percent increase in seed yield of 100% recommended dose of fertilizer was to the tune of 8.05% than that of 75% recommended dose of fertilizer.The application of 100% recommended dose of fertilizer (F_2) recorded significantly higher seed yield of summer cowpea might be due to significant improvement in number of pods per plant and number of root nodules per plant. Moreover, higher application of nitrogen and phosphorus which is involved in energy transformation, activation of enzymes in carbohydrate metabolism and consequently greater translocation of photosynthates towards vegetative and reproductive parts led to overall improvement of growth and yield attributes which ultimately reflected on seed yield.Nitrogen encourages formation of new cells, promote plant vigour and hastens leaf development and phosphorus plays vital role in root development and also in simulation of growth and formation of seed. These findings are corroborated by Subbarayappa*et al*. (2009), Dekhane*et al*. (2011), Pargi*et al*. (2018) and Sakpal *et al.* (2021). The result of Dekhane*et al.* (2011) showed that the application of 100% recommended dose of fertilizer recorded higher seed yield of cowpea crop.Appraisal of data given in Table 2 indicated that the seed yield of summer cowpea was significantly influenced by the foliar application of bio-enhancers. Among the different bio-enhancer, application of panchagavya as foliar spray @ 3% at 30 and 45 DAS (B_1) recorded significantly higher seed yield (1183 kg/ha), which was remained at par with foliar spray of novel @ 1% (B_5) (1157 kg/ha), jivamrut @ 5% (B_2) (1124 kg/ha) and vermiwash @ 10% (B_3) (1055 kg/ha), respectively. Significantly lower seed yield (970 kg/ha) was recorded with control treatment (B7). The percent increase in seed yield by foliar spray of panchagavya @ 3% at 30 and 45 DAS was in the tune of 21.96% over no foliar spray.This increase in seed yield might be due to presence of IAA and GA in panchagavya could create stimuli in the plant system and increased the production of growth regulator in cell system and the action of growth regulators in plant system stimulated the necessary growth and development of plant leading to better yield of crop. Panchagavya application lead to enhancement in the biological efficiency of crop plants as well as easy and ready transfer of nutrients to the plants through foliar spray might be resulted in enhancement of yield and yield attributes. The maximum biological yield with bio-enhancer source might be associated with increased yield attributes due to concomitant increase in dry matter accumulation and supply of all the plant nutrients from source to sink. These findings are corroborated by Swaminathan *et al.* (2007), Patel *et al*. (2013), Shariff *et al.* (2017) and Sutar *et al*. (2019b). Patel *et al*. (2013) showed that the significantly the highest seed yield of cowpea was recorded by the application of panchagavya as foliar spray @ 3% at 20 and 40 days after sowing.

3.2.8 Stover yield (kg/ha)

The data presented in Table 2 indicated that stover yield of summer cowpea was significantly influenced by different levels of inorganic fertilizer. Significantly higher stover yield (2282 kg/ha) was recorded by the application of 100% recommended dose of fertilizer (F_2), whereas lower seed yield (2053 kg/ha) was recorded by the application of 75% recommended dose of fertilizer (F_1). The percent increase in stover yield by the application of 100% recommended dose of fertilizer was to the tune of 11.15% than that of 75% recommended dose of fertilizer.The application of 100% recommended dose of fertilizer (F_2) recorded significantly higher stover yield might be due to increase in the level of recommended dose of fertilizer. The stover yield advantage might be contributed to enhancement of plant height number of branches per plant and number of pods per plant with the application of 100% recommended dose of fertilizer and also more uptake of nutrients i.e. nitrogen and phosphorus due to better utilization of plant nutrients and also phased released of nutrients as per requirement of crop. They also help to increase photosynthesis, by which plants convert light energy to chemical energy. This chemical energy is then used to fuel plant growth and development and ultimately stover yield. These results are in close conformity with the results of Subbarayappa*et al*. (2009), Dekhane *et al*. (2011), Pargi*et al*. (2018) and Sakpal *et al.* (2021). The result of Sakpal *et al.* (2021) showed that the application of 100% recommended dose of fertilizer recorded significantly higher stover yield of cowpea crop. A critical analysis of data revealed that the stover yield of summer cowpea was significantly influenced by the foliar application of bio-enhancers. Among the different bio-enhancer, application of panchagavya as foliar spray @ 3% at 30 and 45 DAS (B_1) recorded

significantly higher stover yield (2407 kg/ha), which was remained at par with foliar spray of novel @ 1% (B_5) (2285 kg/ha) and jivamrut @ 5% (B_2) (2246 kg/ha), respectively. Significantly lower stover yield (1975 kg/ha) was recorded by control treatment (B_7). The percentage increase in stover yield by foliar spray of panchagavya @ 3% at 30 and 45 DAS was to the tune of 21.87% over no foliar spray.This increase in stover yield might be due to favourable effect of Panchagavya on vegetative growth viz., number of branches per plant and reproductive growth viz., number of pods per plant and pod length which might have positive correlation with stover yield. These results are in close conformity with the results of Kumaravelu and Kadamban(2009), Patel *et al.* (2013), and Sutar *et al.* (2019). Patel *et al.* (2013) showed that the significantly the highest stover yield of cowpea was recorded by the application of panchagavya as foliar spray @ 3% at 20 and 40 days after sowing.

3.3 Quality parameters

3.3.1 Protein content (%)

The data presented in Table 2 indicated that protein content of summer cowpea was significantly influenced by different levels of inorganic fertilizer. Significantly higher protein content (20.75%) was recorded by the application of 100% recommended dose of fertilizer (F_2).This increase in protein content might be due to higher nitrogen content in seed which is integral part of protein synthesis. Increase in protein content has positive correlation with nitrogen content in seed. These results are in close conformity with the results of Subbarayappa*et al*. (2009), Dekhane*et al*. (2011), Namdeo*et al.* (2015) and Dongare*et al*. (2016). The result of Dekhane*et al*. (2011) showed that the application of 100% recommended dose of fertilizer recorded significantly highest protein content in cowpea crop.It is inferred from the data furnished in Table 2 that the protein content of summer cowpea was found to be non-significant by application of different bio-enhancers. However, numerically higher protein content (20.90%) was recorded by foliar spray of panchagavya @ 3% at 30 and 45 DAS (B_1).

3.4 Economics

Data presented in Table 2 showed that the maximum gross return (75968 ₹/ha), net return (41483 ₹/ha) and benefit cost ratio (2.20) was noted with the application of 100% recommended dose of fertilizer (F_2). The minimum net return (36163 ₹/ha) and benefit cost ratio (2.07) was noted with the application of 75% recommended dose of fertilizer (F_1). The higher net return was recorded by higher seed and stover yield of summer cowpea. These results are in close conformity with the results of Subbarayappa*et al*. (2009), Namdeo (2015) and Patel *et al*. (2015). The result of Subbarayappa*et al*. (2009) showed that the application of 100% recommended dose of fertilizer recorded maximum net return and benefit cost ratio (BCR) of cowpea crop.Data presented in Table 2, it could be seen that the maximum gross return (80608 ₹/ha), net return (45319 ₹/ha) and benefit cost ratio (2.29) were noted with the application of *panchagavya* as foliar spray @ 3% at 30 and 45 DAS (B_1). The minimum net return (33216 ₹/ha) were noted with the control treatment (B_7). However, numerically lower benefit cost ratio (2.00) was recorded with the water spray (B_6). These results are in close conformity with the results of Swaminathan *et al*. (2007), Patel *et al.* (2013) and Panchal *et al*. (2017). The result of Swaminathan *et al.* (2007) showed that the application of panchagavya @ 3% recorded maximum net return and benefit cost ratio (BCR).

4. Conclusion

Based on result of the experiment, it can be concluded that the summer cowpea should be fertilized with 100% recommended dose of fertilizer (20-40-00 N-P_2O_5-K_2O kg/ha) and foliar spray of panchagavya @ 3% or novel @ 1% or jivamrut @ 5% at 30 and 45 days after sowing for obtaining higher yield and net return.

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Table 1: Effect of inorganic fertilizer and bio-enhancerson growth and yield attributes of summer cowpea

Treatment	Plant height (cm)	Number of branches per plant	Number of pods/plant	Pod length (cm)	Number of seeds per pod	Number of root nodules per plant	Weight of root nodules (mg/plant)		Seed index (g)
							Fresh	Dry	
Inorganic fertilizer levels (F)									
F_1: 75% RDF	54.40	7.21	17.55	10.41	10.20	20.52	75.62	43.39	8.24
F_2: 100% RDF	57.39	7.55	19.08	10.87	10.54	21.73	80.20	45.96	8.54
S.Em.±	0.98	0.14	0.40	0.19	0.18	0.39	1.37	0.88	0.12
C.D. at 5%	2.85	NS	1.16	NS	NS	1.14	3.99	2.55	NS
Bio-enhancer (B)									
B_1: Panchagavya @ 3%	57.60	7.57	20.03	11.20	10.87	22.83	83.69	47.81	8.59
B_2: Jivamrut @ 5%	56.33	7.43	19.23	10.75	10.50	21.77	81.14	46.80	8.47
B_3: Vermiwash @ 10%	55.77	7.40	17.97	10.63	10.40	21.30	78.25	45.42	8.40
B_4: Cow urine @ 5%	55.20	7.37	17.73	10.46	10.33	20.67	76.08	43.02	8.32
B_5: Novel @ 1%	56.87	7.47	19.57	10.89	10.77	22.23	82.03	46.98	8.51
B_6: Water spray	54.87	7.23	16.87	10.31	9.90	19.60	72.52	41.89	8.24
B_7: Control (no spray)	54.63	7.20	16.80	10.23	9.83	19.50	71.69	40.81	8.20
S.Em.±	1.83	0.25	0.75	0.35	0.33	0.73	2.57	1.64	0.22
C.D. at 5%	NS	NS	2.17	NS	NS	2.12	7.46	4.77	NS
Interaction (F × B)									
S.Em.±	2.59	0.36	1.06	0.50	0.47	1.03	3.63	2.32	0.31
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.04	8.42	10.00	8.14	7.84	8.47	8.06	9.00	6.43

Table 2:Effect of inorganic fertilizer and bio-enhancerson yield, quality and economics of summer cowpea

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Protein content (%)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net returns (₹/ha)	B: C ratio
Inorganic fertilizer levels (F)							
F_1: 75% RDF	1031	2053	20.13	33909	70072	36163	2.07
F_2: 100% RDF	1114	2282	20.75	34485	75968	41483	2.20
S.Em.±	27.43	44.53	0.19	-	-	-	-
C.D. at 5%	80	129	0.54	-	-	-	-
Bio-enhancer (B)							
B_1: Panchagavya @ 3%	1183	2407	20.90	35289	80608	45319	2.29
B_2: Jivamrut @ 5%	1124	2246	20.67	33743	76424	42681	2.26
B_3: Vermiwash @ 10%	1055	2158	20.51	35332	71932	36600	2.04
B_4: Cow urine @ 5%	1031	2105	20.33	34044	70280	36236	2.06
B_5: Novel @ 1%	1157	2285	20.78	34473	78560	44087	2.28
B_6: Water spray	989	2000	19.98	33614	67340	33726	2.00
B_7: Control (no spray)	970	1975	19.92	32884	66100	33216	2.01
S.Em.±	51.32	83.31	0.35	-	-	-	-
C.D. at 5%	149	242	NS	-	-	-	-
Interaction (F × B)							
S.Em.±	72.57	117.81	0.49	-	-	-	-
C.D. at 5%	NS	NS	NS	-	-	-	-
C.V. %	11.72	9.41	4.17	-	-	-	-

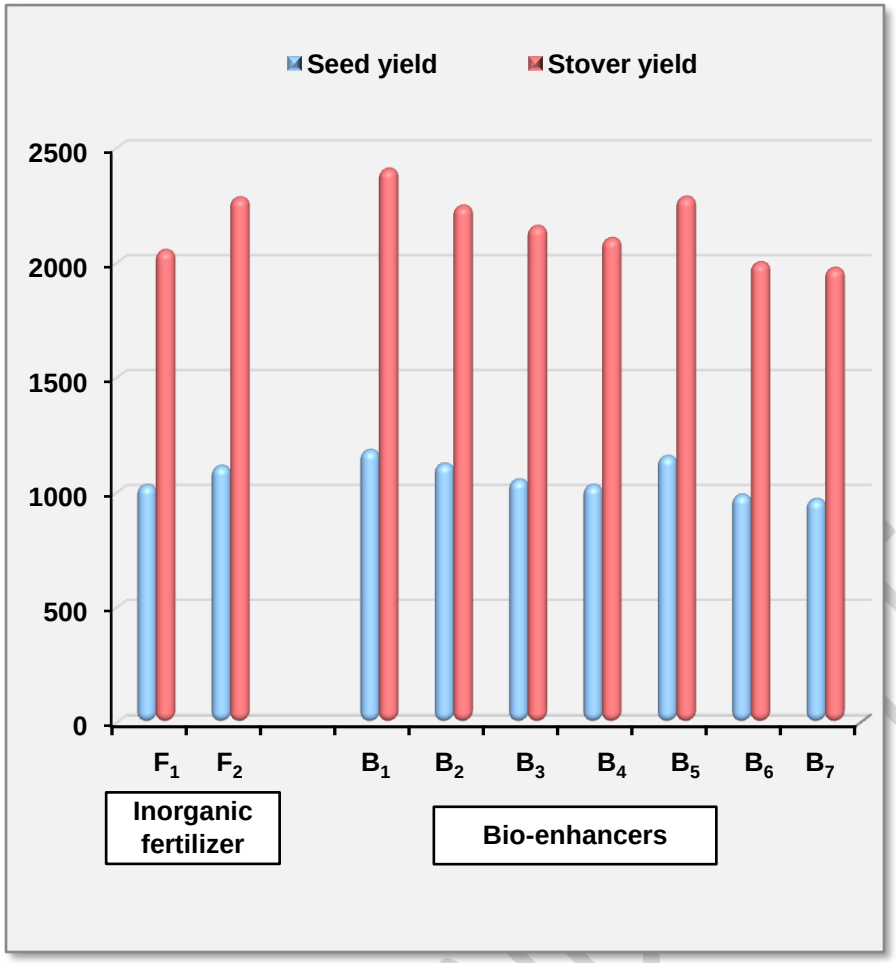

Figure 3: Effect of inorganic fertilizer and bio-enhancers on yield of summer cowpea

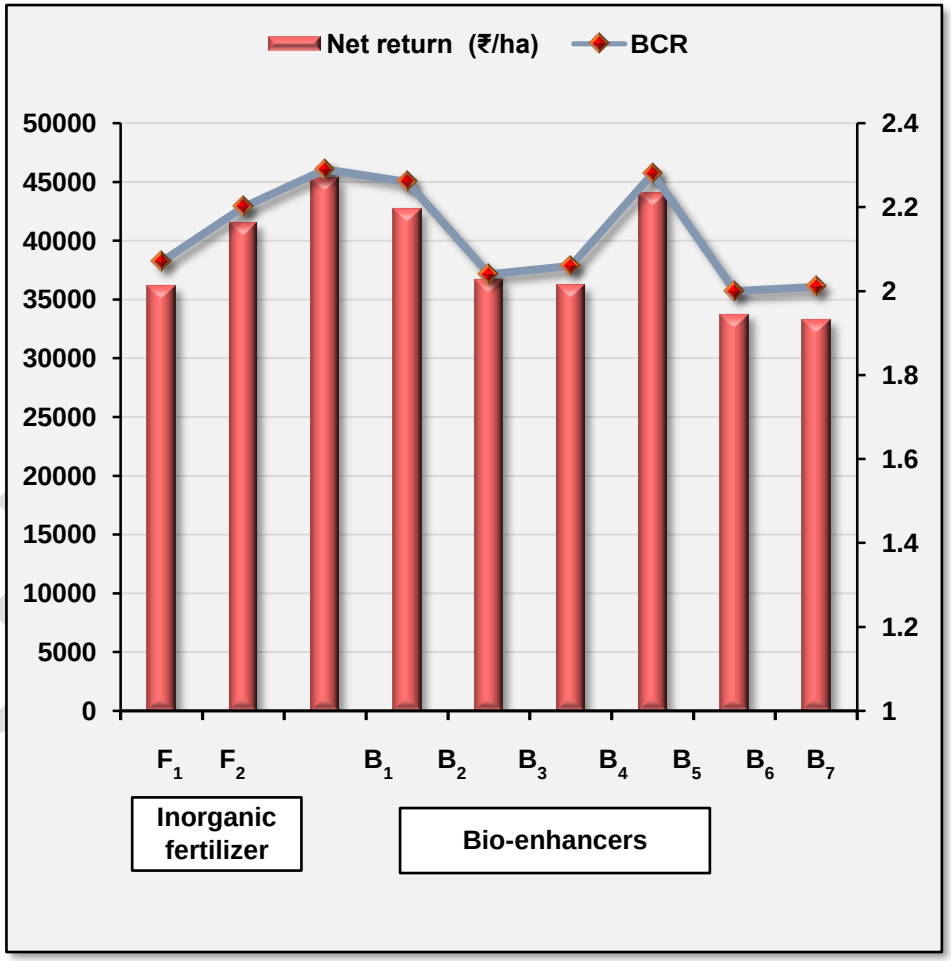

Figure 4: Effect of inorganic fertilizer and bio-enhancers on economics of summer cowpea

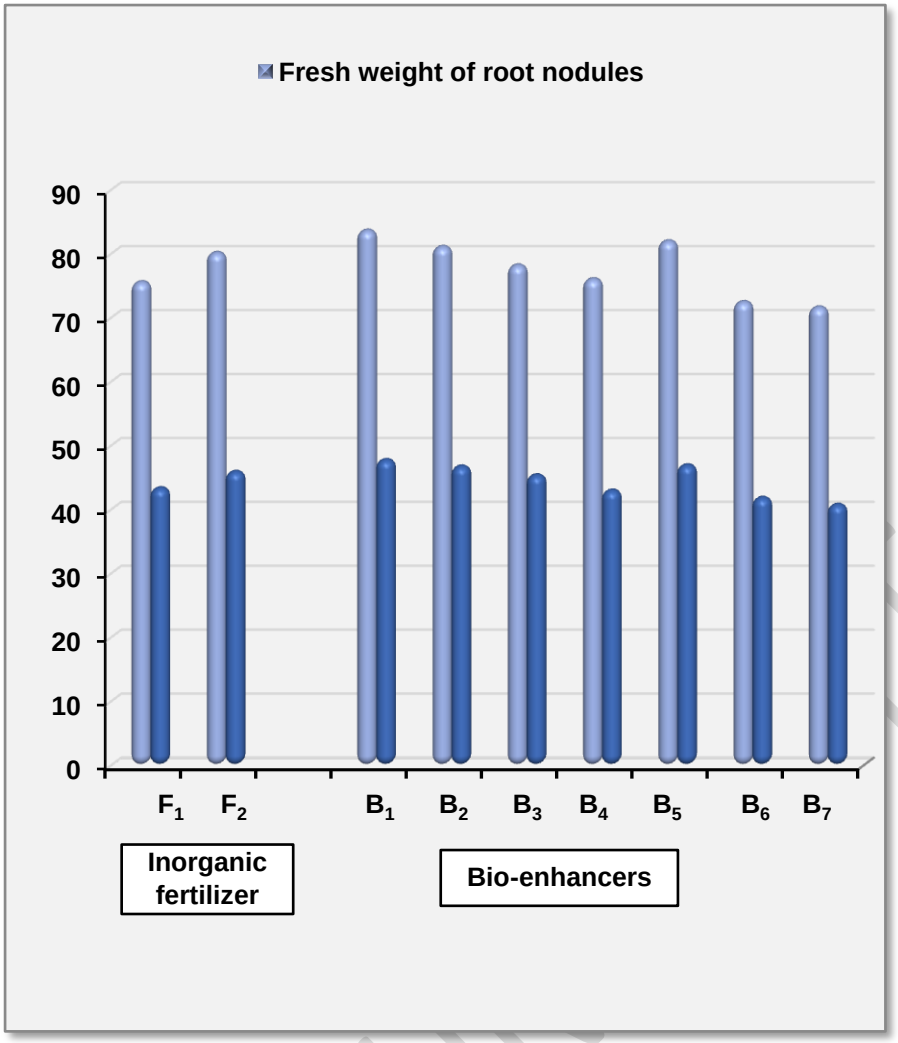

Figure 1: Effect of inorganic fertilizer and bio-enhancers on fresh and dry weight of root nodules of summer cowpea

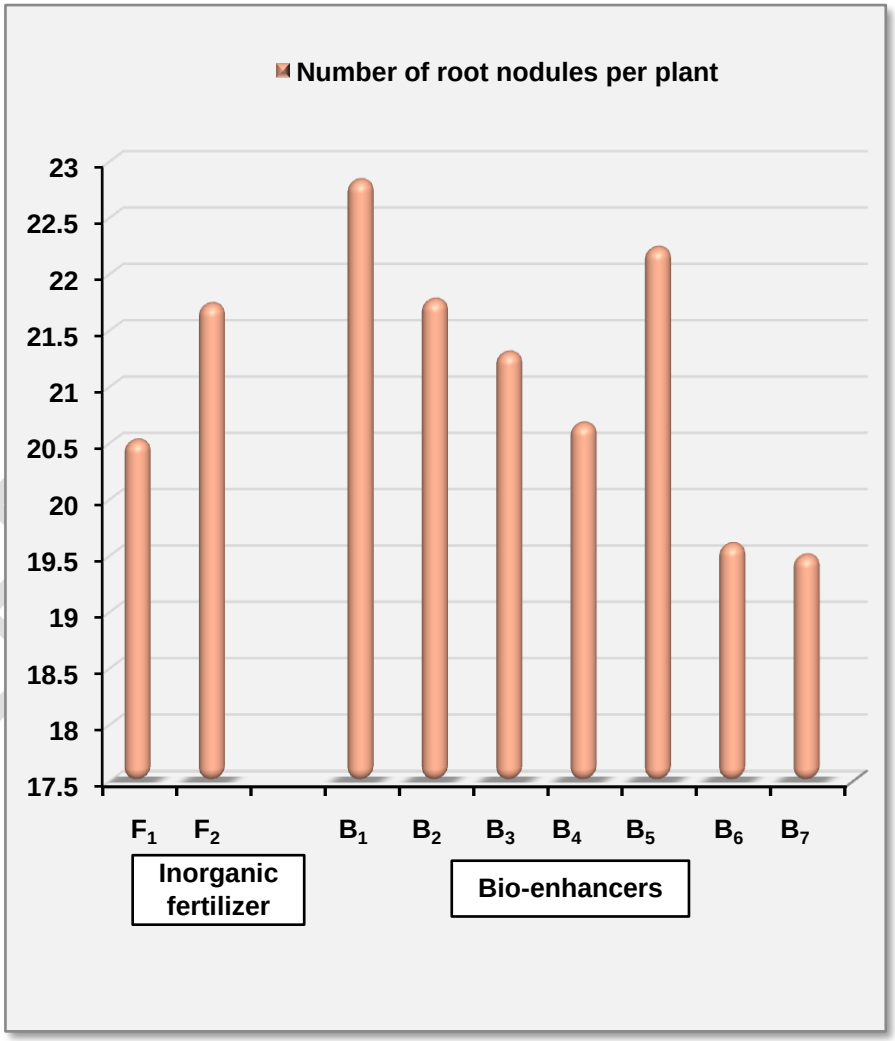

Figure 2: Effect of inorganic fertilizer and bio-enhancers on number of root nodules per plant