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EFFECT OF BIOSTIMULANTS ON YIELD OF FIELD BEAN [*LABLAB PURPUREUS* (L.) SWEET] UNDER RAINFED CONDITION OF SOUTHERN TRANSITIONAL ZONE OF KARNATAKA, INDIA

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ABSTRACT

A field experiment was conducted at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Navile, Shivamogga during *kharif* 2024, to evaluate the effect of different biostimulants on yield and yield parameters of field bean. The experiment was laid out in Randomized Complete Block Design with eleven treatments and replicated thrice. Treatments comprised of foliar application of 2 per cent DAP, seaweed extract and humic acid at varying concentrations and time of application (30 and 45 DAS), along with recommended dose of fertilisers (RDF) and FYM (7.5 t ha^{-1}) were common for all treatments. Results revealed that the maximum values of yield parameters *viz.*, number of pods plant^{-1} (27.15), pod weight plant^{-1} (18.46 g), pod length (6.10 cm), number of seed pod^{-1} (4.38), test weight (14.65 g), seed yield (1191 kg ha^{-1}), haulm yield (2204 kg ha^{-1}) and highest economics such as gross returns (` 1,19,100 ha$^{-1}$), net returns (` 76,985 ha^{-1}) and B:C (2.83) were recorded under the treatment that received foliar application of DAP 2 % + humic acid 2 ml l^{-1}+ seaweed extract 2 ml l^{-1} at 30 and 45 DAS in along with RDF compared to all the treatment except treatment that received humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS along with RDF. The minimum values of all these characters were recorded under control.

Key words : Field bean, Biostimulants, Seaweed extract, Humic acid, DAP 2%, Yield.

Introduction

Field bean (*Lablab purpureus* (L.) Sweet) is bushy to spreading type and belongs to family Fabaceae with 2n=22. It is commonly known as Dolichos bean, Hyacinth bean, Indian bean, Egyptian bean, Sem, Avare etc., It is one of the most ancient crops among the cultivated legumes and is believed to be originated in India. Field bean is cultivated worldwide under diverse climatic conditions due to its high genetic diversity. It is grown for multiple purposes, including use as a vegetable, pulse grain, fodder, cover crop and green manure. In India, it is primarily cultivated in Karnataka and adjoining regions of Tamil Nadu, Andhra Pradesh, Gujarat and Maharashtra, both as an intercrop and a sole crop. In pure crop stands, the productivity of dry seed yield is 1.2 t ha^{-1} (raithamitra.co.in), while, it is 0.4 to 0.5 t ha^{-1} in inter cropping system (Shivashankar and Kulkarni, 1989). When it is grown for forage, it produces green fodder of 2.20 to 2.75 t ha^{-1} under rainfed conditions (Magoon *et al.*, 1974). In Karnataka, dolichos bean is grown in an area of 0.65 lakh hectares with a production of 0.73 lakh t and contributes nearly 90 per cent of both area and production in India (raithamitra.co.in). It requires high temperatures to grow (18-30°C). Field bean is a drought tolerant crop which has deep root system and can utilize available residual soil moisture. Field bean crop is sensitive to water logging soils of deep sandy to clay soils with good drainage are suited for cultivation. Optimum range of pH is from 5 to 7.5. Field bean crop is nutritionally rich in terms of pod and seed characteristics. It is a very good source of protein (20-25%), amino acids, vitamins (A, C & Riboflavin) and minerals like Ca, P, K, Fe and

Zn (Deka and Sarkar, 1990). Moreover, green pods and seeds are rich in dietary fiber, low carbohydrates and lipids. However, seeds to some extent also have antinutritional factors like other pulses. Field bean being a legume crop fixes nitrogen biologically, improves nutrient status of soil. It's bushy stature and deep root system enhances soil stability and reduces the adverse effects of soil erosion in dry land conditions. Being multi-purpose crop and grown under diverse conditions, its importance as pulse grain crop is often ignored. Despite with wide range of adaptability and diversity, it remains as an underutilized crop, as evidenced by low area under cultivation. However, it's potential as pulse, vegetable, forage, green manure and cover crops makes it suitable for tropical condition. However, it can contribute to food and nutritional security, increase income of rural poor, ecosystem stability and cultural diversity associated with local food habits (Ramesh and Byregowda, 2016). This crop has good demand in market, yet it is cultivated in limited area due to its low productivity. One of the greatest challenge of today's agriculture is the fast growing population which is mounting tremendous pressure in food production. Modern agricultural practices purely depend on chemical fertilizers to increase crop production which adversely affects the soil efficiency and also have huge impacts on human health (Rengasamy *et al*., 2015). Use of chemical fertilizers along with growth enhancing biostimulants increases the productivity of the crop as well as enhances the soil fertility and reduces the cost of production. In this context, liquid seaweed extract has gained popularity in the world where marked increase is observed in the commercial utilization of seaweed extract. Seaweed extract exhibit growth stimulating property, as they contain macro nutrients, trace elemets, organic substances like amino acids and plant growth regulators such as auxin, cytokinin and gibberellins (Spinelli *et al.*, 2010). Humic acid improves soil nutrient dynamics by chelating micronutrients and enhancing root architecture, thereby increasing nutrient use efficiency, abiotic stress tolerance (Ampong, 2022). Foliar application of DAP at 2 % concentration provides a rapid and efficient supply of nitrogen and phosphorus during the critical reproductive phase of field bean. Nitrogen promotes chlorophyll synthesis and vegetative growth, while phosphorus enhances root development, nodulation and energy metabolism. Hence, a field experiment was undertaken to examine the interactive effect of biostimulants in combination with 2% DAP foliar application and the recommended dose of fertilizers (RDF) on the yield and yield parameters of field bean (*Lablab purpureus* (L.) Sweet).

Materials and Methods

A field experiment was conducted at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Navile, Shivamogga during *kharif* 2024. The research station situated in the Southern Transition Zone (Zone 7) of Karnataka state that lies under 13º 58' N latitude, 75º 34' E longitude with an altitude of 650 m above the mean sea level. The soil of experimental site was sandy loam in texture with slightly acidic in pH (6.26), electric conductivity of 0.22 dS m^{-1} and organic content was 3.62 (g kg^{-1}). The soil was low in available nitrogen and high in phosphorus and medium in potassium availability. The experiment was laid out in Randomized Complete Block Design with eleven treatments and replicated thrice. The recommended spacing is 45 cm × 15 cm and dose of fertilizer (RDF) was 25:50:20 kg NPK ha^{-1} and FYM (7.5 t ha^{-1}) is common for all treatment. The treatments comprised of T_1: Control (RDF), T_2: DAP 2 %, T_3: Humic acid 2 ml l^{-1}, T_4: Humic acid 4 ml l^{-1}, T_5: Seaweed extract 2 ml l^{-1}, T_6: Seaweed extract 4 ml l^{-1}, T_7: Humic acid 2 ml l^{-1} + Seaweed extract 2 ml l^{-1}, T_8: Humic acid 2 ml l^{-1} + Seaweed extract 4 ml l^{-1}, T_9: Humic acid 4 ml l^{-1} + Seaweed extract 2 ml l^{-1}, T_{10}: Humic acid 4 ml l^{-1} + Seaweed extract 4 ml l^{-1}, T_{11}: DAP 2 % + Humic acid 2 ml l^{-1} + Seaweed extract 2 ml l^{-1}. Foliar application of biostimulants was applied during two stages, *i.e.*, 30th and 45th from treatment (T_2) to treatment (T_{11}). The field was initially ploughed with disc plough followed by secondary tillage with rotavator at optimum condition and obtained weed free fine tilth. The experimental unit was differentiated as per layout into individual treatment plots of uniform shape and size by raising bunds. Individual plots were levelled thoroughly in all replications. Treatment combinations are randomly allocated to respective individual plots. FYM was applied as per recommendations four weeks before sowing. Field bean seeds of Hebbel Avare-5 variety was used for sowing. It is a derivative of HA 4 × GL 153 and a leading variety developed by University of Agricultural Sciences, Bangalore. Plants are photo insensitive, non-viny, compact with Semi-determinate growth habit. It matures in 95-100 days. Green pods can be harvested in 65-70 days for vegetable purpose. Pods are constricted and also have the characteristic odour (Sogadu). Seed yield is about 1300-1500 kg ha^{-1}. Weeding was done by passing bullock drawn harrow at 25 DAS. This was followed by manual hand weeding at 45 DAS to keep the experimental plots free from weeds. The observation recorded for yield attributes includes, number of pods $plant^{-1}$, pod weight $plant^{-1}$ (g), pod length (cm), number of seeds pod^{-1}, test weight (g), seed yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index. The data obtained was subjected to statistical analysis by analysis of variance (ANOVA) to test the significance of difference among the treatments by "F" test and a conclusion was drawn at 5 per cent probability level.

Results and Discussion

Number of pods per plant and Pod length (cm)

Number of pods plant^{-1} and pod length at harvest as influenced by different biostimulants are interpreted in the Table 1. Analysis of data revealed that at harvest, the number of pods plant^{-1} and a pod length were significantly influenced by the application of different biostimulants. The higher number of pods plant^{-1} (27.15) and pod length (6.10 cm) was recorded with RDF in combination with foliar sprays of DAP 2% + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} at 30 and 45 DAS. This treatment found to be statistically comparable with RDF along with foliar spray of humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS, which produced 27.05 pods plant^{-1} and a pod length of 5.99 cm. The lowest number of pods plant^{-1} (18.28) and pod length (4.05 cm) were observed in the RDF alone. The beneficial effect of biostimulants on pod set and elongation may be attributed to multiple physiological and biochemical mechanisms. Seaweed extracts contain phytohormone-like compounds such as auxins, cytokinins and gibberellins, which stimulate floral initiation, pod setting and cell elongation. These findings are supported by the work of Khan *et al.* (2009), Spinelli *et al.* (2010) and Battacharyya *et al.* (2015). In addition, seaweed-derived bioactive substances like polysaccharides, amino acids, phenolics and vitamins enhance photosynthetic efficiency, assimilate production and their partitioning towards reproductive organs, thereby supporting both pod number and pod length (Elansary *et al.*, 2016; Rengasamy *et al.*, 2015 and Kocira *et al.*, 2019). The humic acid plays a pivotal role in nutrient dynamics by chelating micronutrients and stimulating root growth, thereby enhancing nutrient use efficiency and reproductive development. Consistent outcomes were noted by Trevisan *et al.* (2010), Canellas *et al.* (2015) and Monda *et al.* (2021). The contribution of foliar DAP may also be linked to phosphorus availability, which is crucial for flowering, energy transfer and seed formation in legumes. Similar results were also reported by Marschner (2012) and Singh *et al.* (2015). Thus, the synergistic action of seaweed extract (hormonal and metabolic regulation), humic acid (nutrient dynamics and root stimulation) and foliar DAP (readily available N and P) created a favorable physiological environment for flower initiation, pod set and pod elongation. This explains the superior performance of integrated biostimulant treatments over RDF alone, a trend that has also been reported in legumes by Calvo *et al.* (2014), Colla *et al.* (2015) and Halpern *et al.* (2015).

Pod weight plant^{-1}(g)

The data relating to pod weight plant^{-1} of field bean as influenced by different biostimulants is represented in Table 1. At the time of harvest, the pod weight plant^{-1} of field bean was significantly affected by the application of different biostimulant treatments. The maximum pod weight (18.46 g plant^{-1}) was obtained with RDF in combination with foliar application of DAP 2 % + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} applied at 30 and 45 DAS. This treatment remained statistically on par with RDF supplemented with foliar application of humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS, which produced 18.12 g of pod weight plant^{-1}. On the other hand, the minimum pod weight (11.69 g plant^{-1}) was recorded in the treatment that received RDF alone, without any foliar application of biostimulants. The higher pod weight plant^{-1} in treatments receiving DAP, humic acid and seaweed extract along with RDF may be attributed to their role in enhancing nutrient availability, photosynthetic efficiency and assimilate translocation. Foliar-applied DAP supplied readily available nitrogen and phosphorus, which increased chlorophyll content, energy transfer and sink activity. The above results are in conformity with findings of Deka and Sarkar (1990). Humic acid improved root growth, nutrient uptake and enzymatic activity, thereby facilitating greater biomass accumulation and efficient mobilization of assimilates towards developing pods (Nardi *et al*., 2002 and Ampong, 2022). Seaweed extracts, being rich in natural phytohormones such as cytokinins, auxins and gibberellins, as well as amino acids and polysaccharides, stimulated cell division, pod set, and grain filling processes. These results are in accordance with results from Kocira *et al.* (2019) and Rengasamy *et al*. (2015). The combined effect of these biostimulants resulted in improved source-sink relationship and effective partitioning of photosynthates, ultimately leading to higher pod weight compared to RDF alone.

Number of seeds per pod

The data on number of seeds pod^{-1}, as influenced by the application of different biostimulants, were recorded at the time of harvest are presented in the Table 1. The effect of different biostimulants on the number of seeds pod^{-1} was found to be non-significant. The numerically maximum number of seeds pod^{-1} (4.38) was obtained with the application of RDF in combination with foliar

Table 1 : Number of pods plant^{-1}, pod weight plant^{-1} (g), pod length(cm), number of seeds pod^{-1} and test weight (g) of field bean as influenced by the application of different biostimulants.

Treatments	Pods plant^{-1}	Pod weight plant^{-1} (g)	Pod length (cm)	Seeds pod^{-1}	Test weight(g)
T_1: Control (RDF)	18.28	11.69	4.05	3.92	13.04
T_2: DAP 2 % at 30 and 45 DAS	20.42	13.06	4.50	3.95	13.36
T_3: Humic acid 2 ml l^{-1} at 30 and 45 DAS	20.50	13.12	4.52	4.04	13.43
T_4: Humic acid 4 ml l^{-1} at 30 and 45 DAS	22.71	14.53	4.98	4.08	13.84
T_5: Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	20.58	13.17	4.55	4.05	13.65
T_6: Seaweed extract 4 ml l^{-1} at 30 and 45 DAS	22.73	14.77	5.02	4.12	13.91
T_7: Humic acid 2 ml l^{-1} + Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	24.85	16.15	5.47	4.14	14.06
T_8: Humic acid 2 ml l^{-1} + Seaweed extract 4 ml l^{-1} at 30 and 45 DAS	24.91	16.44	5.50	4.16	14.11
T_9: Humic acid 4 ml l^{-1} + Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	24.95	16.71	5.55	4.24	14.25
T_{10}: Humic acid 4 ml l^{-1} + Seaweed extract 4 ml l^{-1} at 30 and 45 DAS	27.05	18.12	5.99	4.30	14.59
T_{11}: DAP 2 % + Humic acid 2 ml l^{-1} + Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	27.15	18.46	6.10	4.38	14.65
S.Em. ±	**0.68**	**0.45**	**0.14**	**0.11**	**0.41**
C.D @ 5 %	**2.01**	**1.32**	**0.41**	**NS**	**NS**

NS- Non significant at 5 % C.D. value DAS – Days after sowing.

sprays of DAP 2% + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} at 30 and 45 DAS. Followed by application of RDF along with foliar sprays of humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS, which recorded 4.30 seeds pod^{-1}. The minimum number of seeds pod^{-1} (3.92) was observed in the RDF alone treatment. Although these differences were statistically non-significant, a numerical trend suggests a slight positive effect of combined biostimulant application on seed setting. Similar numerical trends, without significant differences, were reported by Kocira *et al.* (2019) in legumes, where foliar application of seaweed extract and humic acid improved seed and pod parameters. Elansary *et al.* (2016) also observed enhanced reproductive growth in legumes with seaweed extract, though the increase in seeds per pod was sometimes non-significant. These findings indicate that combined biostimulants may improve plant physiological activity and nutrient utilization, which could contribute to a higher number of seeds per pod, even if the effect is subtle.

Test weight (g)

The results pertaining to test weight, expressed as the weight of 100 seeds (g), as influenced by the application of different biostimulants, are presented in Table 1. The analysis of data revealed that the effect of different treatments on test weight was found to be non-significant. Nevertheless, numerical differences were observed among the treatments. The maximum test weight (14.65 g) was recorded with the application of RDF in combination with foliar sprays of DAP 2% + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} at 30 and 45 DAS, which was closely followed by the treatment comprising RDF along with foliar sprays of humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS, registered a test weight of 14.59 g and the minimum test weight (13.04 g) was noted under the RDF alone treatment. Although the differences were not statistically significant, the numerical increase may be associated with the combined effects of biostimulants enhancing nutrient translocation, photosynthetic efficiency, and seed filling processes. These results are similar with findings of Kocira *et al.* (2019), Trevisan *et al.* (2010) and Ampong (2022).

Seed yield (kg ha^{-1}) and Haulm yield (kg ha^{-1})

Seed yield and haulm yield of field bean as influenced by application of different biostimulants is presented in the Table 2. The highest seed yield (1191 kg ha^{-1}) and haulm yield (2204 kg ha^{-1}) was obtained with the treatment comprised RDF along with foliar sprays of DAP 2% + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} applied at 30 and 45 DAS. This treatment was statistically on par with RDF supplemented with foliar sprays of humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS, which produced a seed yield of 1182 kg ha^{-1} and a haulm

Table 2 : Seed yield, haulm yield and harvest index of field bean as influenced by the application of different biostimulants.

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest Index (%)
T_1: Control (RDF)	879	1494	0.370
T_2: DAP 2% at 30 and 45 DAS	948	1662	0.363
T_3: Humic acid 2 ml l^{-1} at 30 and 45 DAS	957	1675	0.363
T_4: Humic acid 4 ml l^{-1} at 30 and 45 DAS	1027	1848	0.357
T_5: Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	961	1682	0.363
T_6: Seaweed extract 4 ml l^{-1} at 30 and 45 DAS	1032	1858	0.357
T_7: Humic acid 2 ml l^{-1} + Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	1100	2025	0.352
T_8: Humic acid 2 ml l^{-1} + Seaweed extract 4 ml l^{-1} at 30 and 45 DAS	1108	2030	0.353
T_9: Humic acid 4 ml l^{-1} + Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	1115	2032	0.354
T_{10}: Humic acid 4 ml l^{-1} + Seaweed extract 4 ml l^{-1} at 30 and 45 DAS	1182	2199	0.349
T_{11}: DAP 2 % + Humic acid 2 ml l^{-1} + Seaweed extract 2 ml l^{-1} at 30 and 45 DAS	1191	2204	0.350
S.Em. ±	**21.93**	**55.52**	**0.01**
C.D @ 5 %	**64.68**	**163.80**	**NS**

NS- Non significant at 5% C.D. value DAS – Days after sowing

yield of 2199 kg ha^{-1}. However, significantly lower seed yield (879 kg ha^{-1}) and haulm yield (1494 kg ha^{-1}) was recorded under the RDF alone treatment, which did not receive any biostimulants application. The increase in seed and haulm yields with biostimulant application may be attributed to the synergistic effects of humic acid, seaweed extract and DAP. Humic acid improves root architecture, nutrient uptake, soil enzymatic activity and overall plant vigour. Similar with the findings of Trevisan *et al.* (2010), Monda *et al.* (2021) and Ampong (2022). Seaweed extracts, rich in phytohormones such as auxins, cytokinins and gibberellins, as well as bioactive compounds including polysaccharides, amino acids and vitamins, stimulate cell division, elongation, floral initiation, pod set and seed filling, thereby enhancing both vegetative and reproductive growth**.** The above results were in line with findings of Booth (1965), Challen and Hemingway (1965), Khan *et al.* (2009), Spinelli *et al.* (2010), Battacharyya *et al.* (2015), Elansary *et al.* (2016), Kocira *et al.* (2019), Chatterjee and Thirumdasu (2014) and Divya *et al.* (2015). Foliar application of DAP (2 %) supplies readily available nitrogen and phosphorus, which are essential for chlorophyll synthesis, protein formation, energy metabolism and reproductive development, leading to improved pod elongation and seed formation. Similar results were reported by Deka and Sarkar (1990), Marschner (2012), Ramesh *et al.* (2017) and Singh *et al.* (2015). Thus, the integration of humic acid, seaweed extract and DAP with RDF created a favorable physiological and nutritional environment that enhanced photosynthetic efficiency, assimilate partitioning and biomass accumulation, ultimately resulting in significantly higher seed and haulm yields in field bean.

Economics

Gross returns, net return and benefit-cost ratio of field bean production were influenced by application of different biostimulants presented in Fig. 1. Higher gross returns, net return and benefit-cost ratio (` 1,19,100, 76,985 and 2.83 ha^{-1}) of field bean were recorded with application of RDF + foliar sprays of DAP 2 % + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} at 30 and 45 DAS, followed by treatment that received RDF + foliar Sprays of humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS (` 1,18,200, 74,225 and 2.69 ha$^{-1}$). The lowest gross returns, net return and benefit-cost ratio (` 87,900, 49,445 and 2.29 ha^{-1}) were recorded in RDF alone treatment. The increase in economic returns can be attributed to the enhancement of yield attributes such as number of pods plant^{-1}, pod weight plant^{-1}, pod length, number of seeds pod^{-1} and test weight, which collectively contributed to higher grain and haulm yield. The findings are similar with Gokul and Senthilkumar (2019) in finger millet and Singh *et al.* (2018) in pulses, who observed that foliar application of biostimulants significantly improved economic returns by enhancing yield and nutrient use efficiency. Cost benefit of farmers was greatest when biostimulants was used as a growth promoter and proved as the cheapest along with higher net returns. Application

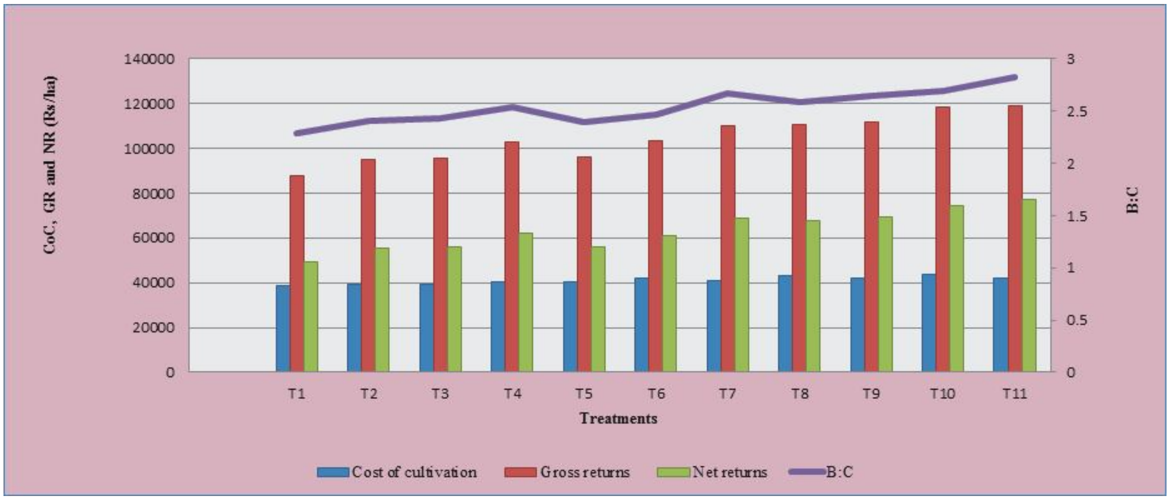

Fig. 1 : Cost of cultivation, Gross return, Net return and B:C of field bean influenced by application of different biostimulants.

of seaweed extract increased the overall growth as well as the yield characters due to the various active compounds present in them. It may be concluded that the results strongly emphasis the role played by seaweed extract and other biostimulants in enhancing the yield and net returns of field bean. With abundant distribution, great regeneration potential and easy mass cultivation, the seaweed and humic biostimulant seems to be a feasible substitute to synthetic fertilizers. Apart from this, DAP 2% can also be further recommended to farmers for increasing the yield and enhancing the productivity of the crop thereby improving the livelihood of farmers.

Conclusion

The present investigation clearly demonstrates that the combined foliar application of DAP 2% + humic acid 2 ml l^{-1} + seaweed extract 2 ml l^{-1} at 30 and 45 DAS, along with RDF, significantly enhanced growth, yield attributes, seed yield, haulm yield and economic returns of field bean compared to RDF alone. This integrated treatment consistently recorded the highest number of pods per plant, pod weight, pod length and seed yield, while remaining statistically comparable with the treatment comprising RDF + humic acid 4 ml l^{-1} + seaweed extract 4 ml l^{-1} at 30 and 45 DAS. The beneficial effects can be attributed to the synergistic action of seaweed extracts (rich in phytohormones, amino acids and bioactive compounds), humic acid (improving nutrient uptake and root growth) and DAP (supplying readily available phosphorus for reproductive development), which together enhanced photosynthetic efficiency, assimilate partitioning and seed filling.

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