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Effect of Bio-stimulants on Biomass Production, Nutrient Content and uptake in Velvet Bean (*Mucuna pruriens* L.)

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ABSTRACT: Increasing the nutritional profile of legumes offers a desirable aim for reducing the global hunger caused by micronutrient deficiency. For decades, the use of inorganic/synthetic fertilizers has been common practice and accepted as an efficient means to alleviate these problems. However, the application of synthetic chemicals may cause a negative impact on the environment. In view of the increasing awareness of adverse effects of these chemicals and the recent paradigm shift towards 'green farming', the use of natural bio-stimulants is becoming popular globally. In this regard, an experiment was conducted at ICAR – Krishi Vigyan Kendra, Hadonahalli, Doddaballapura taluk, Bengaluru Rural District, Karnataka, during *rabi* 2020 - 2021, to assess the effect of bio-stimulants on biomass production, nutrient content and uptake in velvet bean. Experiment consisted of soil and foliar application of humic acid, amino acid, sea weed extract and microbial consortia based bio- stimulants. The experiment was carried out by adopting randomized complete block design (RCBD) consisting 9 treatments with three replications. Maximum fresh (90.46q/ha) and dry biomass yield (33.91q/ha) was found with RDF + Foliar application of humic acid based bio-stimulant. Whereas maximum nitrogen (2.82 %), phosphorus (0.15 %), potassium content in plant (1.45 %) and nutrient uptake of nitrogen (255.41kg ha^{-1}), phosphorus (13.17kg ha^{-1}), potassium (131.11kg ha^{-1}) and also increased nitrogen (234.92kg ha^{-1}), phosphorus (48.06kg ha^{-1}), potassium content in soil (171.60kg ha^{-1}), were recorded with RDF + Soil application of humic acid based bio-stimulant. Lower biomass production, nutrient content and uptake were found in control.

Keywords: Velvet bean, RDF, Bio-stimulants, biomass production, NPK.

INTRODUCTION

Velvet bean (*Mucuna pruriens*) is popularly known as mucuna belongs to the family fabaceae and called as Atmagupta in Sanskrit, cow itch or Kawaanch or kapikachhu or Alkushi are other names. It is native to tropical areas, particularly in Africa, India and the West Indies. It is considered as viable source of dietary proteins (Janardhanan *et al*., 2005) and due to its high protein concentration (23–35 %) in addition to its digestibility, which is comparable with other pulses such as soybean, rice bean, and lima bean (Pugalenthi *et al*., 2005). Velvet bean is a well-known herbal remedy utilized in the treatment of male infertility and nervous disorders, while also being recognized for its aphrodisiac properties. Extensive research has underscored the significant medicinal potential of its seeds. In ancient Indian medicine, Ayurveda, velvet bean was a traditional remedy for Parkinson's disease. The seeds of velvet bean exhibit anti-Parkinson and neuroprotective properties, which are likely associated with their potent antioxidant activity (Rai *et al*., 2020).

A novel, eco-friendly method involves utilizing natural plant bio-stimulants (PBs) to boost crop yields and improve quality. In recent years, plant bio-stimulants are being extensively used in farming due to their beneficial effects. The use of bio-stimulants is safe for both human being and for the environment and in particular for reducing chemicals in agriculture. Although we have yet to fully comprehend the mechanisms at play with bio-stimulants, rigorous research is currently underway (Sharma *et al*., 2014). Recognizing the significance of crops and bio-stimulants, this study was undertaken to evaluate how various bio-stimulants impact biomass production and nutrient characteristics.

MATERIAL AND METHODS

The field experiment was conducted during *rabi*, 2021 at ICAR –Krishi Vigyan Kendra, Hadonahalli, Doddaballapur Taluk, Bengaluru Rural District, Karnataka which is situated under the Eastern dry zone of Karnataka at 12°58′ North latitude and 77°35′ East longitude with an altitude of 896 m above mean sea level. The soil of the experimental site was red soil with medium fertility level. The experiment included 9 treatments laid out in randomized complete block design with three replication. Treatments involved soil and foliar application of bio-stimulants. The velvet bean variety Arka Dhanwantari seeds were sown in lines at the rate of 30kg/ha with a depth of 2cm, maintaining 60 cm row to row and 60 cm plant to plant spacing. The soil was fertilized with 100: 80: 40 kg N:P:K/ ha and 15t/ ha FYM before sowing. The different bio-stimulants *viz.,* Humic acid @ 3 ml/l, Amino acid @ 3 ml/l, Sea weed extract @ 1 ml/l, Arka microbial consortia @10 ml/ l were applied to the crop at 30 and 60 days after sowing, maintaining the quantity of 1500 l/ ha for soil application and 750 l/ha for foliar application.

RESULTS AND DISCUSSION

A. Biomass production

Effect of different bio-stimulant treatments on fresh weight of leaves, stem, root and total biomass per hectare in velvet bean during *rabi* is tabulated in Table 1. Among different treatments, maximum fresh weight of leaves (41.54 q), stem (44.04 q), root (4.89 q) and total biomass (90.46 q) was found in plants supplied with RDF + Foliar application of humic acid based bio-stimulant, which is *on par* with RDF + Foliar application of sea weed extract based bio-stimulant. Whereas, lower fresh weight of leaves (23.70 q), stem (26.03 q), root (3.01 q) and total biomass (52.75 q) was registered in untreated.

The data pertaining to dry weight of leaves, stem, root and total biomass per hectare as influenced by soil and foliar application of bio-stimulants were shown in Table 2. The treatment comprising of RDF+ Foliar application of humic acid based bio-stimulant registered significantly maximum dry weight of leaves, stem, root and total biomass per hectare (14.59 q, 16.51 q, 2.81 qand33.91 q, respectively), which is followed by RDF+ Foliar application of sea weed extract based bio-stimulant. While, minimum dry weight of leaves, stem, root and total biomass per hectare (6.77 q, 7.44 q, 1.75 q and 15.96 q, respectively) was registered in untreated plants.

Table 1: Influence of bio-stimulants on fresh biomass yield in velvet bean during *rabi* season.

Treatment	Fresh weight (q/ha)			
	Leaves	Stem	Root	Total fresh Biomass
T_1 – Control	23.70^{e}	26.03^{e}	3.01^{d}	52.75^{e}
T_2 - RDF+ Soil application of Humic acid based bio-stimulant	32.44^{bc}	34.57^{cd}	3.67^{bcd}	70.68^{bc}
T_3 - RDF+ Foliar application of Humic acid based bio-stimulant	41.54^{a}	44.04^{a}	4.89^{a}	90.46^{a}
T_4 - RDF+ Soil application of Amino acid based bio-stimulant	29.68^{cd}	31.72^{cde}	3.39^{cd}	64.79^{cd}
T_5 - RDF+ Foliar application of Amino acid based bio-stimulant	34.30^{b}	38.28^{abc}	3.99^{bc}	76.57^{b}
T_6 - RDF+ Soil application of Sea weed extract based bio-stimulant	31.84^{bc}	33.27^{cde}	3.52^{bcd}	68.63^{bcd}
T_7 - RDF+ Foliar application of Sea weed extract based bio-stimulant	39.52^{a}	42.74^{ab}	4.34^{ab}	86.60^{a}
T_8 - RDF+ Soil application of Microbial based bio-stimulant	27.75^{de}	29.80^{de}	3.29^{cd}	60.85^{de}
T_9- RDF+ Foliar application of Microbial based bio-stimulant	33.20^{bc}	36.69^{bcd}	3.85^{bcd}	73.73^{b}
S.Em. ±	1.29	2.18	0.26	2.59
CD @ 5%	3.87	6.54	0.77	7.76

Table 2: Effect of bio-stimulants on dry biomass yield in velvet bean during *rabi* season.

Treatment	Dry weight(q/ha)			
	Leaves	Stem	Root	Total Biomass
T_1 – Control	6.77^{f}	7.44^{e}	1.75^{c}	15.96^{g}
T_2 - RDF+ Soil application of Humic acid based bio-stimulant	10.81^{c}	11.52^{bc}	2.14^{bc}	24.48^{cd}
T_3 - RDF+ Foliar application of Humic acid based bio-stimulant	14.59^{a}	16.51^{a}	2.81^{a}	33.91^{a}
T_4 - RDF+ Soil application of Amino acid based bio-stimulant	9.28^{de}	9.91^{cde}	1.98^{bc}	21.17^{ef}
T_5 - RDF+ Foliar application of Amino acid based bio-stimulant	10.91^{c}	12.82^{b}	2.31^{abc}	26.04^{c}
T_6 - RDF+ Soil application of Sea weed extract based bio-stimulant	10.29^{cd}	10.73^{bcd}	2.04^{bc}	23.07^{de}
T_7 - RDF+ Foliar application of Sea weed extract based bio-stimulant	13.17^{b}	15.25^{a}	2.54^{ab}	30.96^{b}
T_8 - RDF+ Soil application of Microbial based bio-stimulant	8.41^{e}	9.03^{de}	1.89^{c}	19.33^{f}
T_9- RDF+ Foliar application of Microbial based bio-stimulant	10.71^{c}	11.83^{bc}	2.23^{abc}	24.78^{cd}
S.Em. ±	0.42	0.74	0.15	0.84
CD @ 5%	1.27	2.22	0.44	2.52

Higher total biomass in the treatments which receives bio-stimulants both through soil and foliar application might be due to balanced availability of macro and micro nutrients at all stages of crop growth by preventing their fixation and precipitation, there by improved nutrient use efficiency and better availability of nutrients in soil. The considerable significant increase in leaf, shoot and root fresh weight and dry weight could be due to the combined effect of both bio-stimulants along with balanced nutrition and increasing nutrients use efficiency (Barone *et al*., 2019).

Furthermore, humic acid increases the porosity of soil and improve growth of root system which leads to increase the shoot system (Garcia *et al.,* 2008). Photosynthesis process in plant fixes atmospheric CO_2 to carbohydrates and chlorophyll is essential for the process. Higher the chlorophyll content more efficient is the photosynthesis which resulting in greater CO_2

fixation and total biomass production. These results are in accordance with the findings of Savitha and Girijesh (2019) in soybean and Safaei *et al*. (2014) in black cumin.

B. Nutrient concentration of plants

The plants response to soil and foliar application of bio-stimulant treatment with reference to nitrogen, phosphorus and potassium concentration is presented in Table 3.Nitrogen, phosphorus and potassium content was maximum (2.82 %, 0.15 % and1.45 %, respectively) with RDF+ Foliar application of humic acid based bio-stimulant, which is *at par* with RDF+ Foliar application of amino acid based bio-stimulant, RDF+ Foliar application of sea weed extract based bio-stimulant, RDF+ Foliar application of microbial based bio-stimulant and also with RDF+ Soil application of humic acid based bio-stimulant. While, minimum nitrogen, phosphorus and potassium concentration was noted in control (2.23 %, 0.08 % and 1.0% respectively).

Rhizodeposition affects the activity and composition of microbial communities associated with plants. These microorganisms play a fundamental role in plant feedback. The intensification of root exudation of organic acids was reported due to the application of bio-stimulants. These organic acids, in addition to assisting in the availability of poorly soluble nutrients, constitute one of the primary sources of carbon for soil microorganisms and changes in the pattern of root exudation by humic acid can lead to an increase in the chemotaxis of these microorganisms to the plant. Apart from this carboxylates can change the arrangement of humic substances releasing bioactive molecules that generate root modifications and providing entry routes for the colonization of these microorganisms in plants (Olivares *et al*., 2017; Nardi *et al*., 2021). Ammonifiers and nitrifiers with increased microbial activity produce a steady stream of nitrogen, which improves dry matter accumulation and the nutrient content due to humic compounds. Therefore, addition of RDF with bio-stimulants has an advantage over soil-dwelling microorganisms, changes in the exudates pattern may contribute to increased soil diversity, recruiting microorganisms that act to improve plant nutrition. These findings are similar with Rasouli *et al*. (2022) in coriander, Taha *et al*. (2016) in lettuce and Seif *et al*. (2016) in snap bean.

Table 3: Impact of bio-stimulants on nutrient concentration in velvet bean during *rabi* season.

Treatment	N content (%)	P content (%)	K content (%)
T_1 – Control	2.23^{d}	0.08^{a}	1.0^{d}
T_2 - RDF+ Soil application of Humic acid based bio-stimulant	2.67^{abc}	0.11^{a}	1.24^{abc}
T_3 - RDF+ Foliar application of Humic acid based bio-stimulant	2.82^{a}	0.15^{a}	1.45^{a}
T_4 - RDF+ Soil application of Amino acid based bio-stimulant	2.50^{c}	0.09^{a}	1.13^{bcd}
T_5 - RDF+ Foliar application of Amino acid based bio-stimulant	2.74^{ab}	0.12^{a}	1.32^{ab}
T_6 - RDF+ Soil application of Sea weed extract based bio-stimulant	2.59^{bc}	0.10^{a}	1.20^{bcd}
T_7 - RDF+ Foliar application of Sea weed extract based bio-stimulant	2.79^{ab}	0.13^{a}	1.42^{a}
T_8 - RDF+ Soil application of Microbial based bio-stimulant	2.48^{c}	0.09^{a}	1.07^{cd}
T_9- RDF+ Foliar application of Microbial based bio-stimulant	2.71^{ab}	0.11^{a}	1.30^{ab}
S.Em. ±	0.07	0.01	0.07
CD @ 5%	0.20	0.03	0.21

C. Nutrient uptake by plants

Results obtained for nitrogen, phosphorus and potassium uptake in plants as impacted by bio-stimulant treatment are presented in Table 4.

Among different bio-stimulant treatments, maximum nitrogen, phosphorus and potassium uptake (255.41, 13.17 and 131.11 kg ha^{-1} respectively) was noticed in plants which received RDF + Foliar application of humic acid based bio-stimulant. Meanwhile, least nitrogen, phosphorus and potassium uptake was observed in control plants (117.62, 4.38 and 52.54 kg ha^{-1}, respectively).

The availability of nutrients was increased since humic acid is also a source of nitrogen (Phelps, 2000). It might be because more lateral roots emerged, which led to the creation of secondary roots that were smaller but more ramified and improved mineral nutrition. The results are similar with the findings of Eyheraguibel *et al*. (2008). And also, the presence of humic acid may have increased the permeability of plant membranes, resulting in higher metabolic activity and improved soil characteristics. Humic acid is also known to encourage good soil structure and moisture retention, which in turn promotes plant nutrient uptake (Piccolo *et al*., 1993). Because bacteria are multiplying rapidly and actively, especially in the rhizosphere, favourable circumstances were created for nitrogen fixation and phosphorus solubilization at faster rates, which makes it available to the plants and increases nutrient and water uptake. In addition, the priming action of solubilizing native fixed and non-exchangeable forms of potassium, humic compounds chelating capacity plays a crucial role in liberating fixed potassium. By lowering potassium fixation in the soil and promoting the dissolution of fixed K, the increased microbial activity brought on by the application of humic acid would have also opened the way for increased potassium availability (Schnitzer and Khan 1972). These findings are in line with Mahmood *et al*. (2019) in cauliflower, Noroozisharaf and Kaviani (2018) in garden thyme and Rathore *et al*. (2009) in soybean.

Table 4: Effect of bio-stimulants on major nutrient uptake by velvet bean during *rabi* season.

Treatment	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})
T_1 – Control	117.62^{f}	4.38^{f}	52.54^{e}
T_2 - RDF+ Soil application of Humic acid based bio-stimulant	188.61^{bc}	7.5^{cde}	88.36^{bc}
T_3 - RDF+ Foliar application of Humic acid based bio-stimulant	255.41^{a}	13.17^{a}	131.11^{a}
T_4 - RDF+ Soil application of Amino acid based bio-stimulant	161.96^{de}	5.62^{def}	73.5^{cd}
T_5 - RDF+ Foliar application of Amino acid based bio-stimulant	209.33^{b}	9.18^{bc}	100.96^{b}
T_6 - RDF+ Soil application of Sea weed extract based bio-stimulant	177.64^{cd}	6.86^{de}	82.3^{bcd}
T_7 - RDF+ Foliar application of Sea weed extract based bio-stimulant	241.42^{a}	10.98^{b}	122.8^{a}
T_8 - RDF+ Soil application of Microbial based bio-stimulant	151.37^{e}	5.29^{ef}	63.23^{de}
T_9- RDF+ Foliar application of Microbial based bio-stimulant	199.71^{bc}	7.86^{cd}	95.92^{b}
S.Em. ±	8.24	0.71	6.08
CD @ 5%	24.69	2.13	18.24

D. Available nutrients in soil

Soil response to bio-stimulant treatments with respect to available nitrogen, phosphorus and potassium in soil is given in Table 5.

RDF + soil application of humic acid based bio-stimulant registered maximum available nitrogen (234.92), phosphorus (48.06) and potassium (171.60) which is *on par* with all other bio-stimulant treatments. While, lower available nitrogen (216.18), phosphorus (35.42) and potassium (154.02) was noted in control. Such increase in N, P and K as a result of bio-stimulants may be attributed to the improving in soil nutrients retention and enhancing soil microbial activity which works to convert the organic from of nutrients to mineral form. And also, may be due to humic substances or micronutrients led to increase the root system and solubilisation of nutrient elements which helped in higher absorption which increased available nutrients in the soil after the harvesting and decomposition of the roots. Above findings are in line with the output of Mahmoud *et al*. (2011) in soybean and Atia and El-Saady (2009) in faba bean.

Table 5: Impact of bio-stimulants on major nutrient content in soil after harvest of velvet bean.

Treatment	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
T_1 – Control	216.18^{c}	35.42^{b}	154.02^{b}
T_2 - RDF+ Soil application of Humic acid based bio-stimulant	234.92^{a}	48.06^{a}	171.60^{a}
T_3 - RDF+ Foliar application of Humic acid based bio-stimulant	230.62^{ab}	46.11^{a}	168.80^{a}
T_4 - RDF+ Soil application of Amino acid based bio-stimulant	228.12^{b}	44.53^{a}	165.60^{a}
T_5 - RDF+ Foliar application of Amino acid based bio-stimulant	227.96^{b}	45.12^{a}	166.80^{a}
T_6 - RDF+ Soil application of Sea weed extract based bio-stimulant	231.09^{ab}	47.08^{a}	169.12^{a}
T_7 - RDF+ Foliar application of Sea weed extract based bio-stimulant	229.68^{ab}	45.12^{a}	165.99^{a}
T_8 - RDF+ Soil application of Microbial based bio-stimulant	228.12^{b}	44.09^{a}	166.12^{a}
T_9- RDF+ Foliar application of Microbial based bio-stimulant	226.09^{b}	45.72^{a}	165.09^{a}
Initial value	195.80	35.70	148.06
S.Em. ±	1.98	1.32	2.39
CD @ 5%	5.93	3.96	7.16

Plate 1. General view of the experimental plot.

CONCLUSIONS

Humic acid based bio-stimulant stimulate natural processes to enhance nutrient content and nutrient use efficiency in turn resulted in better nutrient uptake and maximum biomass production.

FUTURE SCOPE

The combination of different bio-stimulants can be experimented to know their synergistic effect on growth, yield and quality of the crop.

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