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Kolte Akshay Balasaheb
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

MO Naushad
Ph.D. Scholar, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Corresponding Author:
Kolte Akshay Balasaheb
M.Sc. Scholar, Department of
Agronomy, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Effect of biostimulants and plant growth regulators on growth and yield of *Zaid* Mungbean (*Vigna radiata* L.)

Kolte Akshay Balasaheb and MO Naushad

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Abstract

A field experiment was conducted during *Zaid* season 2024 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Sciences and Technology. To determine “Effect of Biostimulants and Plant Growth Regulators on growth and yield of *Zaid* Mungbean (*Vigna radiata* L.)” The soil of the experimental field was sandy loam in texture, slightly acidic in soil reaction (pH 6.9), low level of organic carbon (0.28%), available N (219kg/ha) P (15.3 kg/ha) and K (161.5 kg/ha). The result revealed that treatment 6 [Humic acid 2% + Benzyl adenine 20 PPM] recorded significant and higher plant height (55.69 cm), maximum number of nodules/plant (10.47), higher plant dry weight (7.63 g), maximum number of pods/plant (16.89), maximum number of seeds/pod (7.87), higher test weight (33.72 g), higher seed yield (1273.36 kg/ha) and higher stover yield (2296.17 kg/ha). Maximum gross return (INR 103016.65/ha), net return (INR 68492.65/ha) and B:C ratio (1.98) was recorded in treatment 6 [Humic acid 2% + Benzyl adenine 20 PPM] as compared to other treatments was found to be productive as well as economically feasible.

Keywords: Biostimulants, Benzyl adenine, growth, humic acid, plant growth regulators and yield

1. Introduction

Mungbean (*Vigna radiata* L.) is a short duration crop (60 - 70 days) and has wider adaptability it can be grown in *summer* as well as in *Kharif* season. It is an important pulse crop and an excellent source of high quality protein (20-25%). Green pods are cooked as peas whereas sprouts rich in amino acids and vitamins viz., Riboflavin, Thiamine and Vitamin C (Ascorbic acid). It can be used for both seed and forage since it produces a large amount of biomass and then recover after grazing to yield desirable seeds and can be used in broilers diets as a non-traditional feed stuff (Boopalaraja and Debbarma 2025)^[3].

In the global scenario, the total area under Mungbean production is 7.3 million ha. Total production of Mungbean is 5.3 million tonnes and average productivity is 721 kg/ha (FAO, 2024). India contributes more than 70% of world's Mungbean production. Totally, cultivated in an area of 51.13 lakh hectares with a production of 29.78 lakh tonnes and productivity of 583 kg/ha. In Uttar Pradesh, it is cultivated in an area of 0.94 lakh hectares with a production of 0.58 lakh tonnes and productivity of 377 kg/ha (GOI, 2024)^[10].

Biostimulants are substances other than fertilizers that have beneficial effects on plant growth and development. They work by influencing plant processes like nutrient uptake, root development, and overall plant metabolism. Unlike fertilizers, which directly provide nutrients, biostimulants stimulate the plant's natural processes Sharma *et al.* (2024)^[16]. Plant growth regulators (PGRs) are chemicals that modify plant growth by influencing physiological processes. They are classified into five main groups: auxins, gibberellins, cytokinins, ethylene, and abscisic acid. These hormones, and their synthetic analogs, play a crucial role in various aspects of plant growth, development (Duszka *et al.*, 2009)^[7].

Humic acid stimulates the plant growth consequently yield by enhancing the uptake of plant nutrients and also acting on various mechanisms such as cellular respiration, photosynthesis, protein synthesis and enzyme activities. This substance also regulates the plant growth hormones due to production of indole acetic acid or its precursors. Humic acid serves as an effective adsorption and retention complex for inorganic plant nutrients (Mayhew, 2004)^[14]. Humic acid

(HA) is when externally supplied was observed to increase crop growth and ultimately the yield. It improves the nutritional status of soil and plant system. Humic acid application has definite input on protein synthesis and nucleic acid synthesis. The high cation exchange capacity of humic acid prevents nutrient from leaching. Humic acid provided many binding sites for nutrient such as calcium, iron, potassium, and phosphorus. These nutrients are stored in humic acid molecules in a form readily available to plant, and are released when the plants require them. Humic acid increases the absorption and translocation of nutrients in plants and ultimately influences yield. Humic substances supply polyphenols that catalyze plant respiration and increases root growth (Deotale *et al.* 2014)^[6].

Fulvic acid is a derivative of humic acid, but it has a smaller molecular size (Grenthe, 1997)^[12] and is less stable in soil due to its greater exposure to microbial degradation. It occurs naturally in soil, water and peat like humic acids, and it modifies the soil structure by binding to sand, silt and clay due to its colloidal characteristics (Mayhew, 2004)^[14]. Fulvic acid induces antioxidant enzyme activity and protects plants against oxidative damage. Humic substances include fulvic acids, humic acids and humans which play a role in increasing the vegetative growth and uptake of some mineral elements such as N, K, P, Ca, Fe, Zn and Mg. Biodegradation of lignin for the plant residuals increases the organic matter in soil and produces biostimulants such as a fulvic acid. The molecular weight for fulvic acid (FA) different than humic acid, which helps in mobilizing the minerals by forming fulvic complexes. In addition, foliar application of FA improves the metabolic process by transporting the trace minerals directly inside plant cells (Garcia *et al.* 2014)^[9].

In this respect, benzyl adenine is an important plant hormone that regulates various processes of plant growth and development including cell division and differentiation, enhancement of leaf expansion and nutrient mobilization, improve crop quality and management (Davies, 1995)^[5]. Also, benzyl adenine (BA) belongs to a group of plant hormones called cytokinins and its role is connected with the growth and development of plants. It is also implicated in the vascular development and synthesis of secondary metabolites like indols, alkaloids and anthocyanins. It influences chloroplast differentiation and chlorophyll (Chl) biosynthesis (Duszka *et al.*, 2009)^[7].

Keeping in view the above facts, the experiment was conducted to find out “Effect of Biostimulants and Plant Growth Regulators on growth and yield of *Zaid* Mungbean.

2. Materials and Methods

The experiment was conducted during *Zaid* season 2024 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, slightly acidic in soil reaction (pH 6.9), low level of organic carbon (0.28%), available N (219 kg/ha), P(15.3kg/ha) and K (161.5 kg/ha). The treatment consists of the various levels of humic acid, fulvic acid and benzyl adenine. The experiment was laid out in RBD with 9 treatments each replicated thrice. The treatment combinations are T₁- Humic acid 1% + Benzyl adenine 10 ppm, T₂- Humic acid 2% + Benzyl adenine 10 ppm, T₃- Fulvic acid 1% + Benzyl adenine 10 ppm, T₄- Fulvic acid 2% + Benzyl adenine 10 ppm, T₅- Humic acid 1% + Benzyl adenine 20 ppm, T₆- Humic acid 2% + Benzyl adenine 20 ppm, T₇- Fulvic acid 1% + Benzyl adenine 20 ppm, T₈- Fulvic acid 2% + Benzyl adenine 20 ppm, T₉- Control/ RDF 20:40:20 (N: P:

K kg/ha). Data recorded on different aspects of crop, viz., growth, yield attributes and yield were subjected to statistically analysed by analysis of variance method as described by Gomez and Gomez (1976).

3. Result and Discussion

3.1 Growth Attributes

3.1.1 Plant height (cm)

The data revealed that Significant and higher plant height (55.69 cm) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

The Significant and higher plant height was observed with the application of humic acid 2% might be due to the improved nutrient uptake, improved photosynthetic activity, stimulating root development, and providing Stress tolerance by increasing the plant's ability to retain water. Foliar application of humic acid increase chlorophyll content in leaves, leading to improved light absorption and enhanced photosynthetic activity. Similar results were also reported by (Deotale *et al.* 2014)^[6]. Further, the application of benzyl adenine is Synthetic cytokinin's that enhanced the growth of the plants. Benzyl adenine is a plant hormone that regulates Physiological processes in Plants. Benzyl adenine played a key role in cell division, cell expansion which help in higher growth attributes. Similar results were also reported by (Ananthi *et al.* 2012)^[2].

3.1.2 Number of nodules/plant

The data revealed that significant and maximum number of nodules/plant (10.47) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

The significant and higher number of nodules/plant was observed with the application of humic acid 2% might be due to better proliferation of roots and increased nodulation due to enhancing nutrient uptake, improving photosynthetic activity, stimulating root development which leads to higher Plant growth. Similar results were also reported by Ali *et al.* (2019)^[1]. Further, the application of Benzyl adenine 20 ppm promoted the nodule increment due to direct involvement in cell division, cell expansion. Benzyl adenine is a synthetic plant growth regulator that regulates Physiological Processes in plants which help in higher growth attributes. Similar results were also reported by Borges *et al.* (2014)^[4].

3.1.3 Plant dry weight (g)

The data revealed that significant and higher plant dry weight (7.63 g) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6. Significantly higher plant dry weight (g) was influenced by application of humic acid 2% with benzyl adenine 20 ppm. This might be due to enhancing nutrient uptake, improving photosynthetic activity, stimulating root development, regulating Plant hormones to increased dry weight of the plants. Similar results were also reported by El-Hak *et al.* (2012)^[3]. The maximum dry weight of crop was also influenced by Benzyl adenine that increased cell division in plants, leading to increased shoot growth, flower formation and Stimulating the development of new plant tissues and delaying senescence of leaves. Similar results were also reported by Zewail (2019)^[19].

3.1.4 Crop Growth Rate (g/m²/day)

The data revealed that During 45-60 DAS, treatment 3 [Fulvic acid 1% + Benzyl adenine 10 ppm] recorded highest crop growth rate (5.59 g/m²/day), though there was no significant difference among the treatments.

3.1.5 Relative Growth Rate (g/g/day)

The data revealed that During 45-60 DAS, treatment 3 [Fulvic acid 1% + Benzyl adenine 10 ppm] recorded highest Relative Growth Rate (0.034 g/g/day), though there was no significant difference among the treatments.

3.2 Yield and Yield Parameters

3.2.1 Number of pods/plant

The data revealed that significant and maximum number of pods/plant (16.89) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

The significant number of pods/plant with the application of humic acid 2%. Humic acid played a significant role in increasing the number of pods produced by a plants, acting as a plant growth stimulant by improving nutrient uptake, root development, and overall plant health, which ultimately leads to higher number of pods/plant. Similar results were also reported by (Ananthi *et al.* 2012) ^[2]. Further, the application of benzyl adenine 20 ppm. Benzyl adenine acts as plant growth regulator, primarily by stimulating cell division, which can lead to an increased number of pods/plant by promoting the development of more flower buds and ultimately more pods. Similar results were also reported by (Silva *et al.* 2019) ^[17].

3.2.2 Number of seeds/pods

The data revealed that significant and maximum number of seeds/pods (7.87) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

The maximum number of seeds/pods with application of humic acid 2% might be due the promoting nutrient uptake, leading to more flowers and pods development on plants, ultimately resulting in higher number of seeds/pods. Similar results were also reported by Vinod *et al.* (2014) ^[18]. Further the increase in seeds/pods with the application of Benzyl adenine might be due to stimulating cell division and promoting flower and seed development. Similar results were also reported by Borges *et al.* (2014) ^[4].

3.2.3 Test weight (g)

The data revealed that significant and higher test weight (33.72 g) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

3.2.4 Seed yield (kg/ha)

The data revealed that significant and higher seed yield (1273.36 kg /ha) was recorded in Treatment 6 [Humic acid 2% + Benzyl

adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

The significant increase in seed yield of Mungbean was obtained due to humic acid 2% with Benzyl adenine 20 ppm. Similar results were also reported by Ananthi *et al.* (2012) ^[2] found that humic acid played a significant role in enhancing the seed yield of Mungbean by improving nutrient availability, promoting root development, increasing photosynthetic activity. Benzyl adenine played a significant role in enhancing seed yield by promoting cell division, delaying leaf senescence, improving source-sink relationships. Similar results were also reported by Mangena, (2022) ^[13].

3.2.5 Stover yield (kg/ha)

The data revealed that significant and higher stover yield. (2296.17 kg/ha) was recorded in Treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] However, treatment 8 [Fulvic acid 2% + Benzyl adenine 20 ppm] was found to be statistically at par with treatment 6.

The maximum stover yield was obtained with the application of humic acid 2% might be due to increase in photosynthetic activities of plant system. This might be due to greater photosynthetic accumulation in vegetative components leading to superior vegetative development such as plant height, dry matter accumulation hence the stover yield got increased. Similar results were also reported by El-Hak *et al.* (2012) ^[3]. Benzyl adenine played a significant role in increasing the plants stover yield might be due to promoting cell division, delaying leaf senescence, increase branching, improves stomata uptake efficiency. Similar results were also reported by Silva *et al.* (2019) ^[17].

3.2.6 Harvest index (%)

The data revealed that highest harvest index (36.80%) was recorded in treatment 3 [Fulvic acid 1% + Benzyl adenine 10 ppm]. There was no significant difference among the treatments.

3.3 Economics

The result showed that Maximum gross return (INR 103016.65/ha), Maximum net return (68492.65 INR/ha) and maximum benefit cost ratio (1.98) was recorded in treatment 6 [Humic acid 2% + Benzyl adenine 20 ppm] as compared to other treatments.

Higher gross return, net return and benefit cost ratio was recorded with the application of humic acid 2% might be due to higher growth and yield attributes resulting in more seed and stover yield. These results might be due to highest seed and stover yields in the same treatment because of enhanced availability of essential nutrients for plants by improving nutrient uptake, promoting root development, increasing photosynthetic activity. Similar results were also reported by Ananthi *et al.* (2012) ^[2]. Benzyl adenine acts as a synthetic plant hormone that stimulates cell division and growth of plants, leading to increased plant size and formation of healthier flowers, pods. Therefore, yield became higher and profitable. Similar results were also reported by Zewail (2019) ^[19].

Table 1: Effect of Biostimulants and Plant Growth Regulators on growth parameters of Mungbean.

S. No	Treatment combinations	At 60 DAS			AT 45-60 DAS	
		Plant height (cm)	Number of nodules /plant	Plant Dry weight (g/plant)	CGR (g/m ² /day)	RGR (g/g/day)
1	Humic acid 1% + Benzyl adenine 10 ppm	46.77	8.40	6.39	4.28	0.024
2	Humic acid 2% + Benzyl adenine 10 ppm	49.92	8.93	5.90	3.92	0.023
3	Fulvic acid 1% + Benzyl adenine 10 ppm	49.95	8.00	6.36	5.59	0.034
4	Fulvic acid 2% + Benzyl adenine 10 ppm	48.70	8.20	6.53	5.02	0.028
5	Humic acid 1% + Benzyl adenine 20 ppm	47.09	8.67	6.40	5.13	0.030
6	Humic acid 2% + Benzyl adenine 20 ppm	55.69	10.47	7.63	5.44	0.026
7	Fulvic acid 1% + Benzyl adenine 20 ppm	46.17	8.60	6.33	5.50	0.033
8	Fulvic acid 2% + Benzyl adenine 20 ppm	53.47	9.93	6.83	4.55	0.023
9	Control/ RDF 20:40:20 (N: P: K)	40.90	7.00	5.33	4.74	0.034
	F-test	S	S	S	NS	NS
	SEm(±)	1.51	0.41	0.28	0.78	0.004
	C.D (p=0.05)	4.53	1.23	0.85	-	-

Table 2: Effect of Biostimulants and Plant Growth Regulators on yield parameters of Mungbean.

S. No	Treatments	Number of pods/plant	Number of Seeds/pod	Test Weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
1.	Humic acid 1% + Benzyl adenine 10 ppm	16.80	6.47	33.17	1172.05	2062.05	36.29
2.	Humic acid 2% + Benzyl adenine 10 ppm	15.40	6.45	32.57	1062.75	1985.33	34.94
3.	Fulvic acid 1% + Benzyl adenine 10 ppm	16.80	6.37	33.71	1172.67	2013.19	36.80
4.	Fulvic acid 2% + Benzyl adenine 10 ppm	16.87	6.20	33.45	1096.15	2063.66	34.79
5.	Humic acid 1% + Benzyl adenine 20 ppm	16.00	6.33	32.25	1040.46	1925.63	35.11
6.	Humic acid 2% + Benzyl adenine 20 ppm	16.89	7.87	33.72	1273.36	2296.17	35.68
7.	Fulvic acid 1% + Benzyl adenine 20 ppm	16.80	6.39	33.69	1177.68	2067.27	36.32
8.	Fulvic acid 2% + Benzyl adenine 20 ppm	16.88	7.82	33.71	1224.25	2224.26	35.49
9.	Control/ RDF 20:40:20 (N: P: K)	15.10	6.39	32.25	999.78	1775.78	36.02
	F test	S	S	S	S	S	NS
	S. Em (±)	0.30	0.38	0.34	28.42	75.55	1.08
	C.D (p=0.05)	0.89	1.15	1.03	85.20	226.50	-

Table 3: Effect of Biostimulants and Plant Growth Regulators on Economics of different treatments in Mungbean.

S. No	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
1	Humic acid 1% + Benzyl adenine 10 ppm	34374.00	94794.88	60420.88	1.76
2	Humic acid 2% + Benzyl adenine 10 ppm	34474.00	86012.82	51538.82	1.50
3	Fulvic acid 1% + Benzyl adenine 10 ppm	34524.00	94820.54	60296.54	1.75
4	Fulvic acid 2% + Benzyl adenine 10 ppm	34774.00	88723.65	53949.65	1.55
5	Humic acid 1% + Benzyl adenine 20 ppm	34424.00	84199.44	49775.44	1.45
6	Humic acid 2% + Benzyl adenine 20 ppm	34524.00	103016.65	68492.65	1.98
7	Fulvic acid 1% + Benzyl adenine 20 ppm	34574.00	95247.81	60673.81	1.75
8	Fulvic acid 2% + Benzyl adenine 20 ppm	34824.00	99051.77	64227.77	1.84
9	Control/ RDF 20:40:20 (N: P: K)	34224.00	80870.65	46646.65	1.36

4. Conclusion

It is concluded that in Mungbean (treatment 6) with the application of [Humic acid 2% + Benzyl adenine 20 ppm] was observed higher seed yield and benefit cost ratio.

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