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Nutrient Uptake and Yield Potential of Bhendi as Influenced by Humic Acid, Micronutrients Mixture and Plant Growth Regulators

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Abstract

An experiment was carried out to study the effect of humic acid, micronutrient mixture and growth regulators on yield attributes, yield and nutrient uptake of bhendi variety Arka anamika at Guddampatti village near Errabaiyahalli taluk, Dharmapuri district, Tamil Nadu. The experimental soil was sandy loam in texture. The field experiment was laid out in randomized block design consisting of nine treatments and replicated thrice. The treatments included with humic acid, micronutrients mixture and plant growth regulators along with recommended dose of fertilizers. A uniform NPK dose of 80:40:40 kg ha^{-1} was applied to all the plots through urea, SSP, MOP respectively. The results of the experiment revealed that application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_1$ (Gibberellic acid @ 50 ppm) (T_7) recorded maximum nitrogen uptake (375.18 kg ha^{-1}), phosphorus uptake (22.80 kg ha^{-1}), potassium uptake (285.32 kg ha^{-1}), calcium uptake (20.46 kg ha^{-1}), magnesium uptake (10.93 kg ha^{-1}), sulphur uptake (18.76 kg ha^{-1}), copper uptake (111.61 g ha^{-1}), zinc uptake (674.71 g ha^{-1}), iron uptake (1061.03 g ha^{-1}), manganese uptake (311.95 g ha^{-1}) and yield attributes and yield viz., number of fruits plant^{-1} (23), fruit length (20.35 cm) and fruit length (22.50 g), fruit yield (28.98 t ha^{-1}) and stover yield (11.74 t ha^{-1}). The minimum nutrient uptake, yield attributes and yield were recorded in control treatment (T_1).

***Key words*:** Bhendi, Humic acid, Micronutrient mixture, Plant growth regulators, Yield, Nutrient uptake

Bhendi (*Abelmoschus esculentus* L.) is an herbaceous annual crop and belongs to the family Malvaceae. It is an economically important vegetable crop grown in tropical and sub-tropical regions of the world. Africa is the centre of origin of bhendi and it is otherwise called as a queen of vegetables. It is commonly cultivated in warmer parts of temperate regions of Asia, Southern Europe, Northern Africa, the United States, and in all parts of the tropics. Bhendi plays an important role in the diet by supplying carbohydrate, protein, minerals, vitamins and fat that are usually deficient in the stable food. It has good nutritional value as 100 g consumable unripe fruit contains moisture 89.6 g, carbohydrates 6.4 g, protein 1.9 g, fat 0.2 g, fibre 1.2 g, minerals 0.7 g, vitamin A 88 IU, thiamine 0.07 mg, riboflavin 0.10 mg, nicotinic acid 0.60 mg and vitamin C 13 mg [1]. Bhendi crop requires large quantities of macro and micro nutrients for required economic yield. In India it is widely grown as spring summer and rainy season crop. India produces about 64.16 lakh tonnes of bhendi from 5.23 lakh ha area. In Tamil Nadu, it produces about 2.04 lakh tonnes of bhendi from 22.88 thousand ha area [2]. The input includes humic acid, micronutrient mixture and plant growth regulators.

Humic acid can increase plant growth and yield by promoting the bioavailability of essential nutrients through reform of the soil environment at the roots. It is main source of macro and micro nutrients, which had advantageous effects on improve yield and nutrient uptake [3]. The application of micronutrients mixture facilitates the wide range of plant nutrients in the proportion and to suit the specific requirements of nutrients on different stages of crop growth [4]. The application of plant growth regulators depends upon the amount of particular compound absorbed by the plant and ability of plant to respond to the stimulus of the chemical applied. It is however, believed that the mechanism of action of a growth regulator in plant through same fundamental process involving the activities of the cell and the enzyme concerned in the process [5]. In view of scarcity of information pertaining to role of humic acid, micronutrient mixture and plant growth regulators in augmenting yield and nutrient uptake of bhendi, the present study was conducted.

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MATERIALS AND METHODS

A field investigation was carried out at Guddampatti village near Errabaiyahalli taluk, Dharmapuri district, Tamil Nadu to study the effect of humic acid, micronutrients mixture and growth regulators on bhendi variety Arka anamika. The experimental soil was sandy loam in texture (Typic Usticfluvents). The experimental design adopted in the study was randomized block design with the following nine treatments and three replications. The treatments consisted of T_1- Control (recommended dose of NPK) (80:40:40), T_2- Humic acid @ 30 kg soil application, T_3- Humic acid + Micronutrients mixture (Cu, Zn, Mn, Fe, Mo, B) @ 50 ppm, T_4- Humic acid + Growth regulator$_1$ (Gibberellic acid @ 50 ppm), T_5- Humic acid + Growth regulator$_2$ (Indole-3 Butyric acid @ 50 ppm), T_6- Humic acid + Growth regulator$_3$ (Naphthalene acetic acid @ 50 ppm), T_7- Humic acid + Micronutrients mixture @ 50 ppm + Growth regulator$_1$ (Gibberellic acid @ 50 ppm), T_8- Humic acid + Micronutrients mixture @ 50 ppm+ Growth regulator$_2$ (Indole-3 Butyric acid @ 50 ppm), T_9- Humic acid + Micronutrients mixture @ 50 ppm + Growth regulator$_3$ (Naphthalene acetic acid @ 50 ppm). The recommended NPK dose of 80:40:40 kg ha^{-1} was supplied through urea, single super phosphate and muriate of potash, respectively. The yield attributes and yield were recorded after harvest of crop and nutrient uptake was calculated by using nutrient content and dry matter production at harvest. The data was analysed statistically at 5% significance level.

RESULTS AND DISCUSSION

Nutrient uptake

Application of humic acid, micronutrients mixture and growth regulators had a significant difference in the nutrient uptake of bhendi. Soil application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_1$ (Gibberellic acid @ 50 ppm) presented the best. The influence of treatment of humic acid, micronutrients mixture and growth regulators analysed for NPK and micronutrients uptake and listed in (Table 1-2).

Table 1 Effect of humic acid, micronutrient mixture and plant growth regulators on macronutrients uptake of bhendi

Treatments	N uptake	P uptake	K uptake	Ca uptake	Mg uptake	S uptake
	(Kg ha^{-1})					
T_1	84.42	13.82	270.43	14.40	6.03	13.80
T_2	101.50	16.23	276.42	15.92	7.42	14.72
T_3	131.77	18.64	279.30	16.33	8.56	15.46
T_4	244.51	20.83	281.06	18.14	9.72	17.94
T_5	166.94	18.96	278.23	17.32	9.03	16.01
T_6	204.80	19.42	280.96	17.94	9.24	16.75
T_7	375.18	22.80	285.32	20.46	10.93	18.76
T_8	296.35	21.26	283.45	19.73	10.11	17.24
T_9	373.32	22.43	285.26	20.45	10.92	18.75
SEd	0.94	0.30	0.22	0.19	0.23	0.23
CD (p=0.05)	1.89	0.65	0.47	0.42	0.50	0.50

Table 2 Effect of humic acid, micronutrient mixture and plant growth regulators on micronutrients uptake of bhendi

Treatments	Cu uptake	Zn uptake	Fe uptake	Mn uptake
	(g ha^{-1})			
T_1	26.04	226.16	331.32	99.29
T_2	35.67	291.50	433.31	131.41
T_3	46.48	335.48	511.19	154.83
T_4	72.90	496.52	777.75	244.51
T_5	54.46	388.20	578.73	187.87
T_6	64.08	439.91	701.73	223.80
T_7	111.61	674.71	1061.03	311.95
T_8	83.07	561.73	902.45	269.18
T_9	111.38	674.13	1060.21	311.59
SEd	0.34	0.29	0.47	0.27
CD (p=0.05)	0.72	0.61	0.94	0.58

The highest amount of nitrogen uptake (375.18 kg ha^{-1}), phosphorus uptake (22.80 kg ha^{-1}), potassium uptake (285.32 kg ha^{-1}), calcium uptake (20.46 kg ha^{-1}), magnesium uptake (10.93 kg ha^{-1}), sulphur uptake (18.76 kg ha^{-1}), copper uptake (111.61 g ha^{-1}), zinc uptake (674.71 g ha^{-1}), iron uptake (1061.03 g ha^{-1}) and manganese uptake (311.95 g ha^{-1}) of bhendi fruit was noticed in T_7 treatment with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_1$ (Gibberellic acid @ 50 ppm). This was followed by T_9. However, the T_7 and T_9 were not significantly different from each other. The control plot (only recommended dose of NPK) was noticed to be lowest fruit nutrient uptake of macro and micronutrients compared to other treatments tried. This increased uptake might be due to maximum production of dry matter and availability of nutrients from different sources. Application of humic acid stimulate the uptake of macro and micronutrients and also promote growth, increased yield and quality in a number of plant species, at least partially through increasing nutrient uptake by chelation and complexion reaction of humic acid with nutrients [6]. Application of humic acid @ 30 kg ha^{-1} significantly influenced the uptake of nutrients. The plants take more mineral elements due to better-developed root systems. In addition, the stimulation of ions uptake in the applications of humic materials led many investigators to proposing that these materials affect membrane permeability. This is related to the surface activity of humic substances resulting from the presence of both hydrophilic and hydrophobic sites. Therefore, the humic substances may

interact with the phospholipids structures of the cell membranes and react as carriers of nutrients through them [7]. The increased uptake of nutrients with the application of micronutrients mixture @ 50 ppm was mainly due to the fact that the nutrients are readily absorbed by leaves and translocated within the plant when they are dissolved in water and sprayed on them resulting in higher dry matter production [8]. Plant growth regulators help in efficient uptake of water and nutrients from the soil by maintaining high osmatic pressure inside the cell resulting in increases in nutrient uptake [9].

Yield attributes

Soil application of humic acid, micronutrients mixture and growth regulators has significantly increased the yield characters (number of fruit plant^{-1}, fruit length and fruit weight) of bhendi. The data from the (Table 3), the combined application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators1 (Gibberellic acid @ 50 ppm) (T_7) recorded the maximum number of fruits plant^{-1} (23), fruit length (20.35 cm) and fruit length (22.50 g) when compared with all other treatments. This treatment was on par with the treatment (T_9) with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_3$ (Naphthalene acetic acid @ 50 ppm). The minimum number of fruits plant^{-1}(11), fruit length (16.02 cm) and fruit weight (10.95 g) were found in control (T_1). The results showed that appropriate amounts of humic acid, micronutrients mixture and growth regulators could be used as growth enhancement for bhendi. This increase in yield attributes of bhendi could be explained on the fact that the application of recommended dose of mineral fertilizers with humic acid, micronutrient mixture and plant growth regulators as foliar spray increased the uptake of nutrients by plants and consequently increased growth rate. The beneficial interaction effects of those fertilizers could be attributed to the enhanced nutrient release into soil solution and to encourage their penetration through plant roots, as well as to develop antagonistic impacts towards pests and plant diseases [10]. This makes crops much green and leads to more accumulation to dry matter and subsequently increase the crop yield [11-12]. The increased yield attributes with the foliar feeding of micronutrients @ 50 ppm was due to the fact that, improvement in photosynthesis and carbohydrate metabolism resulting into greater formation of photosynthetic and metabolites in source and later on translocated in the newly formed sinks which ultimately increased the yield parameters [13]. The yield is an end product, which obviously depends upon the total dry matter production at different stages of crop growth and its partitioning into reproductive parts for higher production.

Fruit yield and stover yield

The fruit yield and stover yield of bhendi was noticed and it was influenced significantly by the application of different level of humic acid, micronutrients mixture and growth regulators. The data pertaining to the effect of humic acid, micronutrients mixture and growth regulators is furnished in (Table 3). In the application of humic acid alone, the fruit and stover yield were noticed in T_2 with humic acid 30 kg ha^{-1}. Along with the humic acid and growth regulators treatments experimented, the humic acid @ 30 kg ha^{-1} + growth regulators$_1$ (Gibberellic acid @ 50 ppm) (T_4) recorded the highest fruit and stover yield. This was followed by (T_6) with humic acid @ 30 kg ha^{-1} + growth regulators$_3$ (Naphthalene acetic acid @ 50 ppm). Though all the treatments were efficient, the combined effect duo to the soil application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_1$ (Gibberellic acid @ 50 ppm) (T_7) recorded the highest fruit yield of 28.98 t ha^{-1} and stover yield of 11.74 t ha^{-1}. This treatment was on par with the treatment with application humic acid @ 30 kg ha-1 + micronutrients mixture @ 50 ppm + growth regulators$_3$ (Naphthalene acetic acid @ 50 ppm) (T_9). The lowest fruit yield of 19.56 t ha^{-1}) and stover yield of 5.07 t ha^{-1} were registered in T_1 (control). The yield increase of Bhendi in T_7 and T_9 is due to increased yield attributing characters of Bhendi. Furthermore, the increases might be due to micronutrients application is attributed to that, activation of various enzymes and increased basic metabolic rate in plants facilitated the synthesis of nucleic acids and hormones, which in turn enhanced the yield due to greater availability of nutrients and increased photosynthesis. It also involved in synthesis of ATP and translocation of sugars which help in more flowering and fruiting ultimately responsible for greater yield [14-15]. Increased production of dry matter and its efficient translocation to the economic parts ultimately reflected on the final yield of the crop.

Table 3 Effect of humic acid, micronutrient mixture and plant growth regulators on yield attributes and yield of bhendi

Treatments	Number of fruits plant^{-1}	Fruit length (cm)	Fruit weight (g)	Fruit yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	11	16.02	10.95	19.56	5.07
T_2	13	16.23	12.65	21.32	6.34
T_3	15	16.94	14.34	22.43	7.59
T_4	20	18.52	19.33	25.21	10.98
T_5	17	17.02	16.02	23.63	8.75
T_6	18	17.78	17.68	24.72	9.87
T_7	23	20.35	22.50	28.98	11.74
T_8	21	19.83	20.81	26.82	11.49
T_9	22	20.34	22.49	28.63	11.73
SEd	0.17	0.23	0.08	0.28	0.09
CD (p=0.05)	0.36	0.50	0.17	0.61	0.20

CONCLUSION

Bhendi crop was significantly responded to application of humic acid along micronutrient mixture and PGR. In conclusion, the effect of humic acid along micronutrient mixture and PGR application are safe and as a result, it is effective and easily adopted by farmers. The nutrient uptake of fruit, yield attributes and fruit yield were increased in the treatment which received humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_1$ (Gibberellic acid @ 50 ppm) along with recommended dose of NPK fertilizers.

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