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Full Length Research Article

Evaluation of Humic Acid, Micronutrients Mixture and Plant Growth Regulators on Growth and Quality of Bhendi

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Abstract

A field experiment was conducted to study the effect of humic acid, micronutrients and growth regulators on bhendi at Guddampatti village near Errabaiyahalli taluk, Dharmapuri district, Tamil Nadu. Bhendi variety Arka anamika was grown as test crop. 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 details contain combined application of recommended dose of fertilizers, humic acid, micronutrients mixture and plant growth regulators. 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 the maximum values of growth attributes viz., plant height, number of leaves $plant^{-1}$, leaf area index, stem girth, chlorophyll content, number of branches $plant^{-1}$, dry matter production, minimum days to first flowering and maximum values of quality attributes *viz,* ascorbic acid content, total soluble solids, titrable acidity, crude protein and minimum crude fibre were recorded in the treatment with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators1 (Gibberellic acid @ 50 ppm) (T_7), which was on par with the treatment with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_3$ (Naphthalene acetic acid @ 50 ppm) (T_9). The minimum values were recorded in control treatment (T_1).

***Key words*:** Bhendi, Humic acid, Micronutrients mixture, Plant growth regulators, Growth, Fruit quality

Bhendi (*Abelmoshus esculentus* L.) belongs to the family Malvaceae family. It is probably originated from Ethiopian region of Africa. It is a self-pollinated crop, but occasionally up to 20% cross pollination happens by insects. The commonly called as ladies finger. It is otherwise known as a queen of vegetables. It is an imperative vegetable crop in the tropical and subtropical area. It is suitable for both kitchens gardening as well as on large scale for commercial purpose [1]. Bhendi is a good source of carbohydrate, protein, fats, vitamins and minerals [2]. It contains vitamins A, B, C and some amount of calcium, iron, and niacin. Mature fruit and stem containing crude fibres are used in the paper industry; root and stem are used for clarification of sugar cane juice in preparation of Jaggary.

In India it is widely grown as spring summer and rainy season crop in states like Bihar, West Bengal, Odisha, Gujarat, Jharkhand, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Haryana and Assam. India produces about 64.16 lakh tonnes of okra from 5.23 lakh ha area. In Tamil Nadu, it produces about 2.04 lakh tonnes of okra from 22.88 thousand ha area [3]. It has an enormous potential as one of the foreign exchange earner crops and accounts for 70 per cent of the export of fresh vegetables.

Humic acid is the one of the most important components of bio-liquid complex. Because of its molecular structure, it provide numerous to crop production. Humic acid may play a major role in the plant growth under different soil condition. The application of humic acid enhanced nutrient uptake, plant development, yield and quality in a number of plant species [4]. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants Swarup [5]. It also plays direct role or indirect role in plant growth and development. Plant absorbs these elements in minor quantity but they are essential for proper growth of the plant. The requirement of micronutrients (boron, iron, copper, zinc, manganese, chloride and molybdenum) is only in traces, which is partly met from the soil or through chemical fertilizer or through other sources.

Plant growth regulators are organic compounds, which in small amounts modify physiological process of plants. The used compounds of similar nature, produced by plants, are designated as plant hormones or phytohormones. There are six

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recognized categories of natural plant growth hormones. They are auxins, gibberellins, cytokinins, ethylene, abscisic acid and brassinosteroids. Among the several growth substances, gibberellic acid (GA_3) and IBA are found very promising and these are being used in fruit and vegetable crops. Pruning which involves the removal of apical buds will in-turn increase the number of fruiting branches per plant. Therefore, the combination of pruning and plant growth regulators is essential to improve yield and quality of okra. Auxin IBA plays important role in cell elongation and encourages cell division. GA_3 or gibberellic acid is the most popular available form. GA_3 has many effects on plant growth such as enhance stem and internodes elongation, produce seed germination, the mobilization of endosperm storage reserves, shoot growth, flowering, floral development, enzyme production during germination, fruit setting and growth [6]. Naphthalene acetic acid (NAA) is a synthetic auxin and it stimulates cell elongation and used for flowering. NAA increases ethylene formation in plants, which facilitates the efficient translocation of photosynthetes from source to sink. Higher physiological efficiency including photosynthetic ability of plants can be induced by application of NAA. For growth and quality improvement of bhendi, a research was conducted on growth and quality of bhendi by using humic acid, micronutrient mixture and plant growth regulators.

MATERIALS AND METHODS

A field experiment was conducted to study the effect of humic acid, micronutrients and growth regulators on bhendi at Guddampatti village near Errabaiyahalli taluk, Dharmapuri district, Tamil Nadu. The experimental soil was sandy loam in texture with pH 8.21 and EC 0.36 dS m^{-1}. The experimental design adopted in the study was randomized block design with the following nine treatments, viz., 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). Each treatment was replicated thrice. The recommended NPK dose of 80:40:40 kg ha^{-1} was supplied through urea, single super phosphate and muriate of potash, respectively. The growth attributes were recorded at 30, 60 and 90 DAS and quality of fruit was analysed after harvest of the fruit. The statistical data was analysed at 5% significance level.

RESULTS AND DISCUSSION

Growth attributes

The growth attributes were influenced by the application of same levels of humic acid, micronutrients mixture and growth regulators. The data pertaining to the effect of humic acid, micronutrients and growth regulators is furnished in (Table 1-2).

Table 1 Effect of humic acid, micronutrient mixture and plant growth regulators on plant height, number of leaves $plant^{-1}$, leaf area index of bhendi

Treatments	Plant height (cm)			Number of leaves $plant^{-1}$			LAI		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	46.3	67.7	104.4	9.57	15.10	22.4	2.01	3.75	4.87
T_2	47.8	75.8	108.5	9.88	17.5	24.3	2.31	4.07	5.18
T_3	49.4	79.2	112.7	10.15	19.6	26.1	2.60	4.38	5.47
T_4	54.3	90.4	126.5	10.79	24.7	30.9	3.35	5.16	6.24
T_5	50.8	82.5	117.2	10.39	21.5	27.8	2.87	4.66	5.75
T_6	52.6	86.2	122.4	10.60	23.2	29.4	3.12	4.92	6.01
T_7	57.7	97.3	138.8	11.13	26.2	33.9	3.72	5.61	6.71
T_8	55.9	93.6	133.1	10.95	25.9	32.3	3.53	5.38	6.46
T_9	57.2	96.8	137.2	11.11	26.1	33.6	3.69	5.59	6.69
SEd	0.57	1.49	1.69	0.07	0.08	0.60	0.07	0.08	0.10
CD (p=0.05)	1.22	3.15	3.59	0.15	0.18	1.29	0.15	0.18	0.21

Table 2 Effect of humic acid, micronutrient mixture and plant growth regulators on stem girth, chlorophyll content, number of branches $plant^{-1}$, day taken to first flowering and dry matter production of bhendi

Treatments	Stem girth (cm)			Chlorophyll content of leaves (mg g^{-1} fresh weight)			No. of branches $plant^{-1}$	Days taken to first flowering	DMP (t ha^{-1})
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
T_1	0.70	1.39	2.06	1.48	1.68	1.16	1.41	47	8.04
T_2	0.96	1.76	2.48	1.26	1.97	1.43	1.69	46	9.72
T_3	1.21	2.12	2.89	1.06	2.25	1.70	1.96	45	10.54
T_4	1.90	3.14	4.03	2.54	3.03	2.56	2.71	43	13.16
T_5	1.45	2.47	3.28	2.02	2.52	1.98	2.22	45	11.54
T_6	1.68	2.81	3.66	2.27	2.78	2.27	2.47	44	12.42
T_7	2.32	3.78	4.43	2.95	3.51	3.09	3.16	40	16.13
T_8	2.11	3.46	4.24	2.75	3.27	2.83	2.94	41	14.25
T_9	2.31	3.77	4.42	2.94	3.50	3.08	3.15	40	16.12
SEd	0.06	0.04	0.05	0.08	0.10	0.11	0.06	0.22	0.33
CD (p=0.05)	0.13	0.08	0.12	0.18	0.21	0.24	0.14	0.46	0.70

Significant variations were recorded between the treatments. The highest plant height (57.7, 97.3, 138.8 cm at 30, 60 and 90 days, respectively), number of leaves plant^{-1} (11.13, 26.2, 33.9 at 30, 60 and 90 days, respectively), leaf area index (3.72, 5.61, 6.71 at 30, 60 and 90 days, respectively), stem girth (2.32, 3.78, 4.43 cm at 30, 60 and 90 days, respectively), leaf chlorophyll content (2.95, 3.51, 3.01 mg g^{-1} fresh weight at 30, 60 and 90 days, respectively), number of branches plant^{-1}, (3.16), dry matter production (16.13 t ha^{-1}) and minimum days taken to first flowering (40) were catalogued in the treatment with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_1$ (Gibberellic acid @ 50 ppm) (T_7) which was on par with the treatment with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators$_3$ (Naphthalene acetic acid @ 50 ppm) (T_9). The trend of increasing growth parameters with the application of humic acid in bhendi was reported earlier by Nadeem Haider *et al.* [7] and concluded that humates enhance nutrient uptake, improve soil structure and increase the growth and quality of various vegetable crops. Researchers also found that lower dose of humic acid equally effective to their higher levels in increasing plant growth and enhancing the nutrient uptake [8]. Humic acid influences plant growth both in direct and indirect ways. Indirectly, it improves physical, chemical and biological conditions of soil, while directly, it increases chlorophyll content, accelerates plant respiration and hormonal growth responses, increases penetration in plant membranes, etc. These effects of humic acid operate singly or in integration. Humic acid sources extend their influence on foliar transport in number of ways. The foliar application enhances the absorption of nutrients by the leaf at site of application [9]. The morphological character of crop differs due to foliar application of micronutrient mixture. The significant effect of foliar application micronutrient mixture was reported earlier by Polara *et al.* [10] which could be due to their role in fundamental processes involved in the cellular mechanism and respiration and it takes part in active photosynthesis [11] and also enhances the transport of sugar from source to sink during flowering and fruit stage, synthesis of ATP thus helped in improving the growth attributes of the bhendi plant [12]. The increase in DMP might be due to the significant improvement in nodulation and N fixation with the Zn and B application. Zinc enhanced the plant growth through auxin production and activation of several enzyme systems as evidenced by Elayaraja and Singaravel [13]. Increase in growth characters by application of PGR might be due to fact that gibberellins promote the vegetative growth of plant because it involves in the process of rapid cell division and cell elongation these helps in increasing the growth attributes of the plant reported by Ravat and Makani [14]. The application GA, IBA, NAA in bhendi reduced days of first flowering. The earliness in flowering observed in foliar application of GA might be due to fact that GA has character of reducing the anthesis time by promoting early bud formation. Application of GA might increase the endogenous level of gibberellins which ultimately reduced the days taken to first flowering [15].

Quality attributes

The quality parameters of the okra viz., ascorbic acid, total soluble solids, titrable acidity, crude protein and crude fibre were significantly improved with the humic acid, micronutrients mixture and growth regulators. The results of quality attributes of bhendi are presented in (Table 3). Among the combined levels of treatments applied, the humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators @ 50 ppm exceeded all the other treatments. Along with the treatments with application of humic acid and growth regulators, application of humic acid @ 30 kg ha^{-1} + growth regulators @ 50 ppm (T_4) was enhanced the quality attributes followed by humic acid @ 30 kg ha^{-1} + growth regulators$_3$ (Naphthalene acetic acid @ 50 ppm) (T_6) 10.56 mg 100 g fruit^{-1}. Among the combined treatments, the highest ascorbic acid content (13.73 mg 100 g fruit^{-1}), total soluble solids (5.05% brix), titrable acidity (0.73%), crude protein (15.31%) and lowest crude fibre (8.15%) were recorded in the treatment with application of humic acid @ 30 kg ha^{-1}+ micronutrients mixture @ 50 ppm + growth regulators1 (Gibberellic acid @ 50 ppm) (T_7). The treatments T_7 was on par with application of humic acid @ 30 kg ha^{-1} + micronutrients mixture @ 50 ppm + growth regulators (Naphthalene acetic acid @ 50 ppm). The lowest values of quality attributes were noticed in control except crude fibre (T_1). The improvement in quality attributes might be due to addition of humic acid improved quality parameters viz., titrable acidity, ascorbic acid, crude fibre, crude protein and TSS of bhendi crop. The combine application of humic acid and micronutrient mixture showed significant effect on quality parameters of bhendi. This increase can be attributed to chelate property of elements such as Na, K, Mg, Ca, Zn, Fe, Cu and other elements which compensate nutrient deficiency and as a result promote quality and production [16].

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

Treatments	Ascorbic acid (mg 100 g fruit^{-1})	Total soluble solids (% brix)	Titrable acidity (%)	Crude protein (%)	Crude fibre (%)
T_1	8.42	3.14	0.51	6.56	13.56
T_2	9.12	3.31	0.54	7.81	12.93
T_3	9.43	3.49	0.56	9.00	12.24
T_4	11.15	4.01	0.67	12.56	9.94
T_5	10.12	3.68	0.62	10.12	11.51
T_6	10.56	3.82	0.65	11.31	10.75
T_7	13.73	5.05	0.73	15.31	8.15
T_8	12.21	4.71	0.69	13.87	9.07
T_9	13.52	5.02	0.72	15.25	8.16
SEd	0.23	0.23	0.01	0.02	0.07
CD (p=0.05)	0.50	0.50	0.03	0.46	0.14

CONCLUSION

The results of this study showed that application of humic acid @ 30 kg ha^{-1} along with micronutrients mixture @ 50 ppm and GA3 @ 50 ppm have a great potential to increase the growth, mineral contents, quality and yield of bhendi crop, also addition of humic acid @ 30 kg ha^{-1} along with Micronutrients mixture @ 50 ppm and Naphthalene acetic acid @ 50 ppm is recommended to bhendi crop due to its comparable performance.

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