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EFFECT OF ORGANIC MANURES AND NATURAL GROWTH STIMULANTS ON THE GROWTH AND QUALITY CHARACTERS OF BHENDI

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ABSTRACT
Ten treatments were replicated thrice using randomized block design. The treatments details are T_1- control (no treatment), T_2- 100% recommended dose of NPK, T_3- FYM @ 40 t ha^{-1}, T_4- pressmud@ 40 t ha^{-1}, T_5- FYM @ 40 t ha^{-1} + foliar application of panchagavya (3%), T_6- FYM @ 40 t ha^{-1} + foliar application of vermiwash (10%), T_7- FYM @ 40 t ha^{-1} + foliar application of humic acid (0.3%), T_8- pressmud@ 40 t ha^{-1} + foliar application of panchagavya (3%), T9- pressmud@ 40 t ha^{-1} + foliar application of vermiwash (10%) and T_{10}- pressmud@ 40 t ha^{-1} + foliar application of humic acid (0.3%). Soil application of pressmud @ 40 t ha^{-1} along with foliar application of humic acid (T_{10}-), recorded significantly highest value in both growth and quality characters like plant height (116.3 cm), number of leaves plant^{-1} (32.6), number of branches plant^{-1} (6.0), stem grith (3.72), leaf area index (6.92) and chlorophyll content (3.10 mg g^{-1}), relative water content (85.4 per cent), ascorbic acid (15.42 mg 100g^{-1}), crude protein (1.65 per cent), total soluble solids (5.23 brix percent), titrable acidity (0.15 per cent) and low fiber content (9.85 per cent). The results of the field experiment proved that the application of bulky organic manures (FYM and Pressmud) at higher dose (40 t ha^{-1}) significantly increased both the growth and quality characters. The untreated control (T1) treatment registered the least values.

INTRODUCTION

Bhendi (*Abelmoschus esculentus* L) is native of tropical Africa. Out of 34 species of Abelmoschus, only the species, Abelmoschus esculentus is known to be cultivated extensively as commercial vegetable. Bhendi (*Abelmoschus esculentus*) is one of the popular vegetable in India. It is a fast growing annual which has captured a prominent position among the vegetables in India. It is a multiple use crop, grown in all agro-ecological zones of India mainly for its immature fruits which are eaten as cooked vegetable. It is widely cultivated in India in the states of Uttar Pradesh, Assam, Bihar, Orissa, Maharastra, West Bengal, Karnataka, Tamilnadu and Andhra Pradesh. Bhendi, being a short duration vegetable crop, its growth, yield and quality are largely influenced by the application of nutrient through different sources. It requires proper and sufficient supply of all essential plant nutrients for regular fruiting and subsequent pickings (Premsekhar and Rajashree, 2009). Farming with organic manures gains potential importance because it is claimed that the crops grown with organics are free from pesticides and chemical residues, taste well and are morenutritious, thereby increasing export potential (Prabhu *et al*., 2003). Manures are usually applied at higher rates, relative to inorganic fertilizers, and they give residual effects on the growth and yield of succeeding crops (Makinde and Ayoola, 2012).

Organic manures constitute a source of macro and micro nutrients and are helpful in improving physical, chemical and biological health of soil, reduces nutrient losses, increases nutrient availability and uptake, produces harmful residues free produce, improve the quality of vegetables (Acharya and Mandal, 2000) and (Tiamiyu *et al*., 2012). Farm Yard Manure is a bulky organic manure, as well as a good soil conditioner it is probably the best and safest of all manures, natural or artificial. The quantities of farmyard manure necessary to keep a soil in a fertile condition vary according to the soil and its nature. Farmyard manure has been used as a soil conditioner since ancient times and its benefit have not been fully harnessed due to large quantities required in order to satisfy the nutritional needs to crops (Makinde *et al*., 2007). Incessant land application of pressmud cake to farming crops for 5–6 years is likely to improve soil health by adding sulfur (S) and organic matter to soil (Razzaq, 2001). Pressmud is reported to be a valuable resource of plant nutrients and may therefore improve physical, chemical and biological properties of a soil (Rangaraj *et al*., 2007). Interestingly, panchagavya had the highest population of total bacteria, actinomycetes, phosphate solubilizers, fluorescent pseudomonas and nitrifiers. In addition, dehydrogenase activity and microbial biomass carbon were also found to be higher in panchagavya (Amalraj *et al*., 2013). Vermiwash contains 0.5% N, 0.39% P and 0.46% K (Jasmin, 1999). The assessment of vermiwash indicated the presence of micronutrients in significant quantity (Ismail, 2005).

Application of vermicompost and vermiwash along with recommended dose of NPK inorganic fertilizers or alone

improves the yield and yield contributing parameters of bhendi (Kulkarni *et al*., 2004 and Paramasivan *et al*., 2006), due to its growth promoting activity (Rajan and Murugesan, 2012 and Nath and Singh, 2012). Researchers explained the beneficial effects of humic acid such as increasing cell membrane permeability (Sial *et al*., 2007). The significance of humic acid is not limited to their hormone like activity it also improves stress tolerance (Yildirim, 2007), with this background.

The present work was conducted to establish the effect of organic manures and natural growth stimulants on the growth and quality characters of bhendi. Whether native nutrients of the organic manures and stimulants create any impact on bhendi was core objective. The growth characters includes plant height, number of leaves plant^{-1}, number of branches plant^{-1}, stem girth and leaf area index, the quality characters include relative water content, ascorbic acid, crude protein, total soluble solids, titrable acidity and low fiber content

MATERIALS AND METHODS

The experimental soil was sandy loam in texture with pH (Jackson, 1973) of 7.40, electrical conductivity (Jackson, 1973) of 0.14 d Sm^{-1} and organic carbon (Walkley and Black, 1934) 4.82 kg ha^{-1}. The available nitrogen (Subbiah and Asija, 1956), phosphorus (Watanable and Olsen, 1965) and potassium (Standford and English, 1949) content of the soil were 174.8, 18.7 and 93.6 kg ha^{-1} respectively. The exchangeable calcium, magnesium content (Jackson, 1973) was 7.5, 3.2 c mol (p+) kg^{-1} and available sulfur content (Chesnin and Yien, 1951) of the soil was 7.4 mg kg^{-1}. The DTPA extractable Zn, Cu, Mn and Fe (Lindsay and Norvell, 1978) was 0.398, 1.15, 1.09 and 4.85 mg kg^{-1}, respectively. The field experiment was conducted in Randomized Block Design with ten treatments. Each treatment was replicated thrice. The treatments details are, T_1- Control (no treatment), T_2 - 100% Recommended dose of NPK, T_3- FYM @ 40 t ha^{-1}, T_4 - Pressmud@ 40 t ha^{-1},T_5 - FYM @ 40 t ha^{-1} + foliar application of Panchagavya (3%), T_6 - FYM @ 40 t ha^{-1} + foliar application of Vermiwash (10%), T_7 - FYM @ 40 t ha^{-1} + foliar application of Humic acid (0.3%), T_8 - Pressmud@ 40 t ha^{-1} + foliar application of Panchagavya (3%), T_9 - Pressmud@ 40 t ha^{-1} + foliar application of Vermiwash (10%), T_{10} - Pressmud@ 40 t ha^{-1} + foliar application of Humic acid (0.3%).

The calculated quantity of fertilizer was applied to the treatment (T_2) through urea, single super phosphate and muriate of potash. Half dose of (50 percent) N and full dose of P and K were applied basally and remaining 50 percent of N was applied at first weeding. The Bhendi hybrid siva was grown as test crop. Seeds were dibbled with spacing of 45 × 30 cm. The foliar application of natural growth stimulants *viz*., humic acid (0.3%), vermiwash (10%) and panchagavya (3%) were applied thrice on 30, 60 and 90 DAS. Usual cultural operations were followed and crop was allowed to grow up to harvest. Five plants were selected from each plot to record the biometric observations of growth characters (plant height, number of leaves plant^{-1}, number of branches plant^{-1} stem girth and leaf area index) and the quality characters (highest relative water content, ascorbic acid by titrimetric method A.O.A.C, 1975, crude protein by micro kjeldahl method Piper, 1966, total soluble solids, titrable acidity by titrimetric method and low fiber content by the method suggested Sadasivam and Manickam, 1996).

RESULTS AND DISCUSSION

Growth characters

Plant height

The soil application of pressmud @ 40 t ha^{-1} and foliar application of humic acid (0.3%) [T10] recorded the highest plant height of 116.3 cm. However, the treatment [T10] was found to be on par with [T_9 - pressmud @ 40 t ha^{-1} and foliar application of vermiwash] and [T_8 - pressmud @ 40 t ha^{-1} and foliar application of panchagavya] (Table 1). The results of the study clearly indicated that bhendi responded well for soil application of organic manures and foliar application of growth stimulants. The primary goal of organic farming is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people (Yuda *et al*., 2016). The growth components of bhendi were significantly increased by application of organic manures (Damse *et al*., 2014). Moreover, the humic acid acts as growth regulators and by retard the activity of IAA oxidase in the plant system and pro long the persistence of IAA in plants increased the cell division and cell enlargement which led to increased plant height (Dhanasekaran *et al*., 2007).

Number of branches plant^{-1}

The soil application of pressmud @ 40 t ha^{-1} along with humic

Table 1: Effect of organic manures and foliar fertilization of natural growth stimulants on growth characters of bhendi

Treatment details	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Stem grith (cm)	Leaf area index	Chlorophyll content (mg g^{-1})
T_1 – Control	79	3	24	2.49	4.51	1.61
T_2 - NPK alone	84.4	3.3	25.4	2.71	4.98	2.11
T_3 - FYM 40 t ha^{-1}	90.6	3.5	26.8	2.9	5.34	2.26
T_4 - Pressmud 40 t ha^{-1}	105.2	4.9	30.2	3.41	6.32	2.82
T_5 - FYM 40 t ha^{-1} + Panchagavya	96.2	3.7	28.2	3.08	5.66	2.47
T_6 - FYM 40 t ha^{-1} + Vermiwash	97.6	4.2	28.5	3.12	5.71	2.51
T_7 - FYM 40 t ha^{-1} + Humic acid	98.4	4.7	29	3.2	5.92	2.57
T_8 - Pressmud 40 t ha^{-1} + Panchagavya	111.9	5.1	31.5	3.6	6.66	3.03
T_9 - Pressmud 40 t ha^{-1} + Vermiwash	113.7	5.4	32	3.62	6.8	3.05
T_{10} - Pressmud 40 t ha^{-1} + Humic acid	116.3	6	32.6	3.72	6.92	3.1
SEd	2.55	0.08	0.55	0.076	0.142	0.052
CD (p=0.05)	5.36	0.17	1.16	0.16	0.3	0.11

Table 2 : Effect of organic manures and foliar fertilization of natural growth stimulants on quality characters of bhendi

Treatment details	Relative water content (%)	Total soluble solids (% Brix)	Ascorbic acid content (mg 100 g^{-1})	Crude protein (%)	Crude fibre (%)	Titrable acidity (%)
T_1 – Control	63	3.34	10.12	9.3	13.92	0.31
T_2 - NPK alone	66.8	3.71	11.1	10	13.17	0.28
T_3 - FYM 40 t ha^{-1}	70.4	4.1	11.82	10.6	12.52	0.25
T_4 - Pressmud 40 t ha^{-1}	79.3	4.82	13.97	13	10.89	0.19
T_5 - FYM 40 t ha^{-1} + Panchagavya	74.1	4.39	12.59	11.6	11.9	0.23
T_6 - FYM 40 t ha^{-1} + Vermiwash	74.9	4.46	12.7	11.8	11.75	0.22
T_7 - FYM 40 t ha-1 + Humic acid	75.5	4.51	13.22	12.1	11.63	0.22
T_8 - Pressmud 40 t ha^{-1} + Panchagavya	83.6	5.13	14.75	14.1	10.17	0.16
T_9 - Pressmud 40 t ha^{-1} + Vermiwash	84.7	5.18	15.21	14.3	9.95	0.15
T_{10} - Pressmud 40 t ha^{-1} + Humic acid	85.4	5.23	15.42	14.5	9.85	0.15
SEd	1.51	0.104	0.33	0.33	0.29	0.0095
CD (p = 0.05)	3.61	0.22	0.71	0.7	0.62	0.0201

acid at 0.3% [T_{10}] recorded the highest number of branches $plant^{-1}$ (5.98). This was followed by the treatment applied with pressmud @ 40 t ha^{-1} along with vermiwash at 10% [T_9] (5.46) and pressmud @ 40 t ha^{-1} along with panchagavya at 3% [T_8] (5.18) (Table 1). However, the treatment T10 was found to be on par with T_9 and T_8. The results clearly showed that application of growth stimulants along with press mud recorded significantly higher number of branches as compared to the treatment supplied with T_4 pressmud @ 40 t ha^{-1} alone. The increased number of branches $plant^{-1}$ in bhendi due to the supply of nutrients through organic sources was reported by Suchithra and Manivannan (2012). Similar results were obtained by Muhammad and Khattak (2009).

No. of leaves $plant^{-1}$

Among the three growth stimulants tried with pressmud, foliar feeding of humic acid to pressmud [T_{10}] applied plant excelled the other two treatments T_8 [pressmud @ 40 t ha^{-1} and foliar application of panchagavya] and T_9 [pressmud @ 40 t ha^{-1} and foliar application of vermiwash] by recording the higher number of leaves $plant^{-1}$ of 32.6 (Table 1). However, the treatment T_8 and T_9 was found to be on par with T_{10}, similar trend was noticed with FYM also. The enlargement in cell size and cell division by increasing nutrients from FYM might have helped in growth parameters like plant height and number of leaves. These results are in agreement with those reports of Anburani and Manivannan (2002). Humic acid applied through foliage appeared to behave like a plant growth regulator and helped to produce more number of leaves $plant^{1}$. Similar results were also given by Thapa *et al*. (2014) and Abed (2016).

Stem girth

Soil application of pressmud @ 40 t ha^{-1} and foliar feeding of humic acid recorded the highest stem girth of 3.72 cm (Table 1). Soil application of pressmud increased the availability of N in soil. Nitrogen plays an important role in the synthesis of chlorophyll and amino acid which contributes to build units of protein and thus growth of plants. Further, the growth and development of plant mostly depends upon differentiation and expansion of cell component. Increase in shoot girth with vermiwash treated plants might be due to supplementation of essential nutrients through foliar application of vermiwash (Rajan and Murugesan, 2012).

Leaf area index

Among the three growth stimulants tried with pressmud, T_{10} humic acid by recording the highest leaf area index of 6.92 (Table 1). However, the treatments T_8 and T_9 were found on par with T_{10}. Photosynthetic capacity of plants is a function of photosynthetically active leaf area which is indicated by LAI. Patil *et al*., 2004 reported that the leaf area index was significantly higher with application of FYM, which might be due to production of more capsicum leaf area through higher nutrients uptake of both macro and micronutrients resulting in balanced nutrition. Increased leaf area implies higher light interception and dry matter production which invariably promotes the plant growth (Chen *et al*., 2004).The increased production of auxin and growth substances by humic acid at early phase of growth would have increased the leaf area in bhendi (Ballal Anand and Kadam 2016).

Chlorophyll content

The treatment which received pressmud @ 40 t ha^{-1} along with foliar application of humic acid [T_{10}] recorded the highest chlorophyll content of 3.10 mg g^{-1} followed by the treatment [T_9] supplied with pressmud @ 40 t ha^{-1} and vermiwash, which recorded the chlorophyll content of 3.05 mg $g^{-1}$and the treatment T_8 recorded the chlorophyll content of 3.03 mg g^{-1} (Table 1). However, the treatments T_8 and T_9 was found to be on par with T_{10}, similar trend was noticed with FYM also. The IAA is the component of various enzymes, such as carbonic anhydrase and alcoholic dehydrogenase, which have a suggestive role in chlorophyll formation, photosynthesis and metabolic reactions in plants (Venkataramana, 2002). Increased growth of bhendi with the foliar application of humic acids might be due to increased rate of photosynthesis and respiration contributed by the protein and quinone groups of the assimilated humic acid (Sanwal *et al*., 2007). The improvement in the persistence of IAA in the plant tissue due to the foliar application of humic acid might have helped for chlorophyll formation; similar result was reported by Halime Ozamar Unlu *et al*. (2011) in cucumber.

Quality characters

Relative water content and Total Soluble Solids

Among the treatments, soil application of pressmud @ 40 t ha^{-1} and foliar application of humic acid [T_{10}] recorded the

highest relative water content of 85.4 percent. However, the treatment T_{10} was found to be on par with T_9 [pressmud @ 40 t ha^{-1} and foliar application of vermiwash (84.7 percent)] and T_8 [pressmud @ 40 t ha^{-1} and foliar application of panchagavya (83.6 percent)]. Among the three growth stimulants tried with pressmud, foliar application of humic acid [T_{10}] out-performed vermiwash [T_9] and panchagavya [T_8] by recording the highest total soluble solids of 5.23 % Brix (Table 2). Zayas *et al*. (2018) evaluated the effect of humic acid on growth and quality of tomato. They observed higher growth rate, and vigor in humic acid treated plants than the control. They also reported that humic acids positively increased several quality parameters of tomato fruit like pH, total soluble solids and total soluble carbohydrates.

Ascorbic acid content

The soil application of pressmud @ 40 t ha^{-1} and foliar application of humic acid [T_{10}] recorded the highest ascorbic acid content of 15.42 mg 100 g^{-1}. However, the treatments T_9 - [pressmud @ 40 t ha^{-1} and foliar application of vermiwash (15.21 mg 100 g^{-1})] and T_8 -[pressmud @ 40 t ha^{-1} and foliar application of panchagavya (14.75 mg 100 g^{-1})] were found to on par the treatment T_{10} (Table 2).The increase in ascorbic acid content might be ascribed to better availability and uptake of plant required nutrients and also favorable soil conditions developed by the applied FYM, which help in the synthesis of chlorophyll and increased ascorbic acid content (Patil *et al*., 2004). Increase ascorbic acid content due to application of organic manures was also reported by Shashidhara (2000) in capsicum fruits and Sable *et al*. (2007) in tomato.

Crude protein content

Among the three natural growth stimulants tried with pressmud, foliar feeding of humic acid to pressmud [T_{10}] applied plant excelled the other two treatments T8 [pressmud @ 40 t ha^{-1} and foliar application of panchagavya (14.1 percent)] and T_9 [pressmud @ 40 t ha^{-1} and foliar application of vermiwash (14.3 percent)] by recording the highest crude protein content of 14.5 percent T_{10} (Table 2). However, the treatments T_8 and T_9 was found to be on par with T_{10}, similar trend was noticed with FYM also. The higher crude protein content in these treatments could be attributed to improved uptake of N from soil (Rani and Jose, 2009).

Crude fiber content

The treatment T_{10} [pressmud @ 40 t ha^{-1} along with humic acid] recorded lowest the crude fiber content of 9.85 percent. However, the treatment [T_{10}] was found to be on par with T_9 - [pressmud @ 40 t ha^{-1} along with vermiwash (9.95 percent)] and T_8 - [pressmud @ 40 t ha^{-1} along with panchagavya (10.17 percent)] (Table 2).The decrease in crude fiber content due to the increase in succulence by application of organic manures was reported by Hisham *et al*. (2014).

Titrable acidity

The soil application of pressmud @ 40 t ha^{-1} along with foliar application of the natural growth stimulant humic acid [T10] recorded the lowest titrable acidity of 0.15 per cent (Table 2). However, the treatments T_8 – [pressmud @ 40 t ha^{-1} along with foliar application of panchagavya (0.15 per cent)] and T_9 – [pressmud @ 40 t ha^{-1} along with foliar application of vermiwash (0.16 per cent)] were found to be on par with [T_{10}]. Zayas *et al*. (2018) evaluated the effect of humic acid on growth and quality of tomato the positively influenced the titrable acidity of fruit.

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