



Effect of Integrated nutrient management (INM) on growth attributes, biomass yield, secondary nutrient uptake and quality parameters of bhendi (*Abelmoschus esculentus* L.)

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Abstract: Organic manure from different sources could be an effective substitute of chemical fertilizers. Therefore, a field experiment was conducted to study the impact of various sources of organic manures viz., sole application of composted pressmud, vermicompost, sewage sludge and farmyard manure and its combination with various levels of inorganic fertilizers on growth attributes, biomass yield, yield attributes, secondary nutrient uptake and its available status and quality parameters of bhendi (*A. esculentus* (L.) Moench). The results indicated that application of pressmud @ 5 t ha⁻¹ with 50 per cent recommended dose of fertilizer had recorded the highest calcium and magnesium uptake of 30.9 and 15.4 kg ha⁻¹ respectively and biomass yield of 2233.2 kg ha⁻¹. In comparison to control, the increases in biomass yield and calcium and magnesium uptake were 20 and 51 and 136% higher under the same set of treatment combinations. The results revealed that treatment received with pressmud application @ 5 t ha⁻¹ along with 50 per cent recommended dose of fertilizers registered highest available calcium and magnesium content of 0.14 and 0.28% respectively. In addition to that, there was an improvement in growth parameters such as plant height and number of branches plant⁻¹ at all the growth stages of crop and also quality attributes viz., crude fibre (10.2%) and mucilage content (1.56%) were recorded significantly highest by same treatment compared to control (15.0 and 1.2% respectively). Among the organics, pressmud based inorganic fertilizers application was suitable for higher biomass yield, improvement in quality parameters and also maintaining the fertility status of the secondary nutrients in soil.

Keywords: Biomass yield, Growth attributes, Pressmud, Quality parameters, Secondary nutrient uptake

INTRODUCTION

Bhendi or Okra (*Abelmoschus esculentus* (L.) Moench.) is one of the most important vegetable crops grown in almost all parts of the world. Being a short duration crop, its growth and yield parameters are largely influenced by appropriate nutrient management practices (Singh *et al.*, 2007; Suchitra and Manivannan, 2012 and Iqbal *et al.*, 2014). Sole application of chemical fertilizers to meet the crop nutrient demand is deleterious for both soil and environment health (Tolessa and Friesen, 2001). It is costly input and usually unavailable to farmer at peak season. Hence, organic manures from different sources could be an effective substitute of chemical fertilizers which improve the crop yield and soil properties (physical and chemical) as well (Jamwal, 2005). It has also been proved that organic sources contribute a lot in organic matter percentage in the soil (Iqbal *et al.*, 2012). Thus, under prevailing conditions, application of organic manures becomes a promising solution (Prabu *et al.*, 2003). Among the different organic manures, press-mud is the important source of nutrients and organic matter. Different field studies confirmed the effectiveness of these manures in

crop production (Khan, 2008). However, the effectiveness of these manures varies considerably in its composted and non-composted form (Farhad *et al.*, 2011). It has been observed that composting of sugar mill press mud wastes gave a valuable product, which is proven to be more supportive to plant growth (Sarangi *et al.*, 2009).

Many researchers reported that the cost consumed on inorganic fertilizers can be decreased to a great extent by the application of plant nutrients through organic sources (Bekunda *et al.*, 2010). This would increase nutrient use efficiency soil fertility, besides enhancing crop productivity as well as quality attributes of crop. The demand for vegetables is increasing every year, there is good scope for production and export of vegetables from India. Hence an investigation was conducted to study the impact of application of organic sources along with recommended dose of inorganic fertilizers on growth parameters, biomass yield and yield parameters and quality attributes of bhendi, *A. esculentus* L..

MATERIALS AND METHODS

An experiment was conducted using bhendi (*A. esculentus*

(L.) Moench) as test crop in orchard of Agriculture College and Research Institute, Madurai, Tamil Nadu during kharif season, situated at 9^o54 N and 78^o5 E and at an altitude of 147 m above mean sea level. The field experiment was laid out in randomized block design with 10 treatments and replicated in three times. The treatment comprised of T₁ - Control, T₂ - Recommended dose of fertilizer (RDF), T₃ - Vermicompost @ 5 t ha⁻¹, T₄ - Composted pressmud @ 5 t ha⁻¹, T₅ - Farm yard manure (FYM) @ 12.5 t ha⁻¹, T₆ - Sewage sludge @ 2 t ha⁻¹, T₇ - 50 % RDF + Vermicompost @ 5 t ha⁻¹, T₈ - 50 % RDF + Composted pressmud @ 5 t ha⁻¹, T₉ - 50 % RDF + Farm yard manure @ 12.5 t ha⁻¹ and T₁₀ - 50 % RDF + Sewage sludge @ 2 t ha⁻¹. The net plot size was 7.5 m² (3 m x 2.5 m) and the treatments in the replication are randomly distributed. The bhendi (*A. esculentus* (L.) Moench) variety Arka anamika was sown. The physico-chemical properties of the experimental soil were soil reaction (7.5), electrical conductivity (0.42 dS m⁻¹), texture (sandy loam), available nitrogen (266.5 kg ha⁻¹), phosphorus (12.3 kg ha⁻¹), potassium (265.3 kg ha⁻¹), cation exchange capacity (22.5 C mol (P⁺) kg⁻¹) and organic carbon (0.49%).

The crude fibre content of fruit was estimated using the method given by Chopra and Kanwar (1976). Mucilage content of fresh *A. esculentus* fruits was determined by procedure of Roy and Convad (1954). The calcium and magnesium content of fruit sample was analyzed by Versenate method (Jackson, 1973). The nutrient content was multiplied with dry matter production to get the nutrient uptake of *A. esculentus*. Fruit diameter was measured approximately at the middle of the pod (Sistrunk *et al.*, 1960). Fruit length was measured from basal cap to the tip of the pod (Sistrunk *et al.*, 1960) and expressed in centimeter. The plants used for growth measurements were dried at 60^oC for 24 hour in a hot air oven and cooled in a desiccator, weighed and expressed in kg ha⁻¹ to get the dry matter production.

RESULTS AND DISCUSSION

Plant height: The results revealed that application of pressmud @ 5 t ha⁻¹ along with 50 per cent RDF was recorded the highest plant height of 49.21, 79.54, 97.92 and 116.30 cm at vegetative, flowering, fruiting and harvesting stage, respectively. The control treatment recorded the lowest plant height of 28.05, 54.18, 72.56 and 82.70 cm at all the growth stages of bhendi (*A. esculentus* (L.) Moench) (Table 1). The increased plant height might be due to beneficial effect of applied pressmud with inorganic fertilizers that accelerated the plant growth by assimilating more amounts of nutrients which were made available through fertilization. The use of pressmud would have facilitated better aeration, adequate drainage and created a favourable soil environment for deeper penetration of roots and higher nutrient extraction from soil (Sabir *et al.*, 2013).

Number of branches: The highest number of branches at harvest stage was recorded of 4.5 in the pressmud incorporated treatment @ 5 t ha⁻¹ along with 50 per cent RDF whereas the lowest number of branches of 1.7 recorded in control (Table 1). The results revealed that application of organic sources increased the number of branches which might be due to the involvement of nutrients in cell wall development and cell differentiation which resulted elongation of shoot and root in plants. Similar results were obtained by Muhammad and Khattak (2009) who had reported that an appropriate supply of nutrients through organic and inorganic sources increased the number of branches of maize (*Zea mays* L.) through active photosynthesis and ultimately helped towards the increase in number of branches.

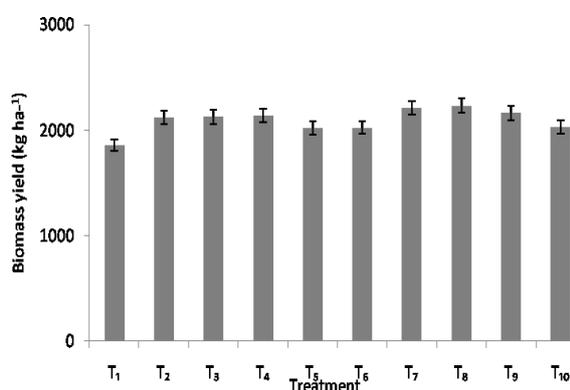
Biomass yield or dry matter production: The highest dry matter yield of 2233.19 kg ha⁻¹ was recorded in plot which received pressmud @ 5 t ha⁻¹ with 50 per cent RDF and was found to be significantly (P= 0.05%)

Table 1. Effect of INM on plant height at various growth stages and number of branches of bhendi (*A. esculentus*) (Values are mean of three replications).

Treatment	Vegetative (cm)	Flowering (cm)	Fruiting (cm)	Harvest (cm)	Number of branches
T ₁	28.05	54.18	72.56	82.70	1.7
T ₂	43.51	65.24	83.62	99.54	3.9
T ₃	40.46	61.85	80.23	97.69	3.7
T ₄	42.69	63.80	82.18	98.74	3.8
T ₅	38.33	61.66	80.04	95.71	3.5
T ₆	36.99	59.23	77.61	93.31	2.9
T ₇	48.30	78.08	94.13	110.88	4.3
T ₈	49.21	79.54	97.92	116.30	4.5
T ₉	47.49	77.23	93.28	110.85	4.1
T ₁₀	45.48	65.74	86.79	103.71	4.1
SEd	0.26	0.26	0.88	0.85	0.06
CD (P = 0.05)	0.55	0.54	1.85	1.78	0.12

Table 2. Effect of INM on yield attributes of bhendi (*A. esculentus* (L.) Moench) (Values are mean of three replications).

Treatments	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of fruits plant ⁻¹
T ₁	9.46	4.75	7.50	9.07
T ₂	13.01	5.82	17.37	11.64
T ₃	12.39	5.52	16.12	10.35
T ₄	12.89	5.65	17.03	10.74
T ₅	12.12	5.25	15.59	9.92
T ₆	12.27	5.01	14.23	9.83
T ₇	14.01	6.19	18.67	12.43
T ₈	15.18	6.88	21.50	13.85
T ₉	13.81	6.15	18.64	12.17
T ₁₀	12.86	5.89	17.44	11.93
SEd	0.28	0.12	0.23	0.26
CD (P = 0.05)	0.59	0.24	0.48	0.54

**Fig. 1.** Effect of INM on biomass yield or dry matter production of bhendi (*A. esculentus*).

superior to the rest of treatments involving integrated and sole application of organic sources (Fig. 1). The lowest dry matter yield of 1860.57 kg ha⁻¹ was recorded in control. Suchitra and Manivannan (2012) reported that the enhancement in biometric parameters like plant height, leaves, branches and length of fruit of bhendi (*A. esculentus* (L.) Moench) when supplied with integrated treatment like combination of organic sources with chemical fertilizers.

Yield parameters: The data on yield attributes showed that the plants received pressmud @ 5 t ha⁻¹ with 50 per cent RDF was registered the highest number of fruits per plant (13.8), fruit length (15.2 cm), fruit girth (6.88 cm) and fruit weight (21.50 g) which was followed by the application of vermicompost @ 5 t ha⁻¹ with 50 per cent RDF (Table 2). The lowest number of fruits per plant (9.1), fruit length (9.5 cm), fruit girth (4.8 cm) and fruit weight (14.2 g) were recorded by control treatments. Application of organics with inorganic sources resulted in enhanced fruit length, fruit girth and ultimately increased the average fruit weight of *A. esculentus* in agreement with findings of Akande *et al.* (2010) who had reported that the organic fertilizer plus NPK fertilizers had recorded higher number of fruits per *A. esculentus* is due to organic manures enhanced plant growth and development when compared

to untreated controls and also it provide better nutrition to okra and attain maximum yields.

Crude fibre: The results indicated that the highest crude fibre content 15.01 per cent was recorded in control whereas the lowest value of 10.15 per cent was observed in the treatment received with pressmud @ 5 t ha⁻¹ combined with 50 per cent RDF and it was followed by the treatment which received vermicompost 5 t ha⁻¹ with 50 per cent RDF and FYM 12.5 t ha⁻¹ with 50 per cent RDF with the crude fibre content of 11.50 and 11.68 per cent respectively (Fig. 2). Crude fibre content is one of the most important criteria to judge the quality of *A. esculentus* fruit. Low crude fibre content is considered to be a desirable character. Among the various treatments, application of pressmud @ 5 t ha⁻¹ with 50 per cent RDF was superior to all other combinations. This might be due to the easy availability of nutrients leading to balanced C: N ratio enhancing the vegetative growth resulting in high photosynthetic activity. Organic sources with higher level of nutrients reduced the inorganic fertilizers application in *A. esculentus* was reported by Mani and Ramanathan (1981).

Mucilage content

The results obtained from the treatment received with pressmud @ 5 t ha⁻¹ combined with 50 per cent RDF was recorded highest mucilage content (1.56%) of *A. esculentus* which was followed by the application of vermicompost @ 5 t ha⁻¹ with 50 per cent RDF of 1.54% mucilage content. The lowest mucilage content of *A. esculentus* was registered with control treatment of 1.19 % (Fig. 2). Individual as well as combined application of different organic sources *viz.*, pressmud, vermicompost and FYM significantly (P = 0.05%) increased the mucilage content of *A. esculentus* fruits over control. This could be attributed to the increase in D- galactose, L. rhamnase and D- galacturonic acid contents in *A. esculentus* fruits by the application of nutrients through organic and inorganic sources which might have resulted in increase of mucilage content (Mani and Ramanathan, 1981).

Secondary nutrients uptake: The highest calcium and magnesium uptake of *A. esculentus* at harvest

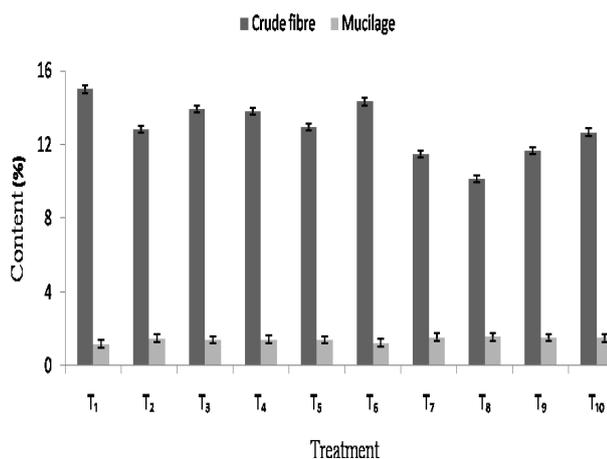


Fig. 2. Effect of INM on quality parameters of bhendi (*A. esculentus*).

stage were recorded of 30.9 and 15.4 kg ha⁻¹, respectively under the pressmud application @ 5 t ha⁻¹ with 50 per cent RDF. The lowest calcium and magnesium uptake of 20.5 and 6.5 kg ha⁻¹ were found in control treatment by *A. esculentus* (Fig. 3). The calcium uptake was influenced by synergistic effect of nitrogen on calcium. Similar results were reported with findings of Dadhwal and Katiyar (1989) who had revealed that the nitrogen application through organic and inorganic sources increased the calcium uptake of *A. esculentus* that resulted from synergistic effect of nitrogen over calcium. The application of organic sources caused a significantly ($P = 0.05\%$) enhanced magnesium uptake over control. It was clearly shown that nitrogen increased the magnesium uptake indicating the synergistic effect of nitrogen on magnesium. These findings corroborate the results of Kanna (1990) who had revealed that amount of nitrogen uptake was increased from combined addition of organic and inorganic sources of fertilizers that stimulated the magnesium uptake of *A. esculentus* crop due to its positive impacts of nitrogen over magnesium.

Available status of secondary nutrients: The calcium and magnesium status of the post harvest soil of (*A. esculentus*) was considerably increased by the soil application of different organic sources. The highest soil available calcium and magnesium content of 0.14 and 0.28% were recorded with application of pressmud @ 5 t ha⁻¹ with 50 per cent RDF. The control treatment was recorded available calcium and magnesium contents of 0.11 and 0.23%, respectively (Fig. 4). The increase in the exchangeable calcium and magnesium content of soil might be due to release of those nutrients from added organic sources with inorganic fertilizers to the soil after mineralization. These observations are close agreement with the findings of Muthuraju *et al.* (2005) who had indicated that the organic acids released from the decomposition of pressmud might have released calcium and magnesium from the exchange sites in the soil

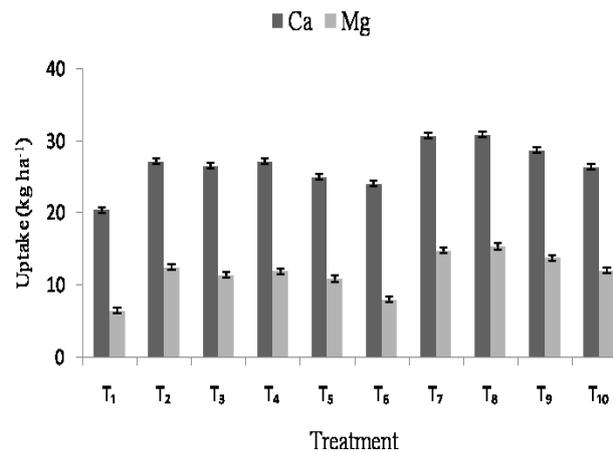


Fig. 3. Effect of INM on secondary nutrient uptake of bhendi (*A. esculentus*).

Conclusion

The findings revealed that the application of pressmud @ 5 t ha⁻¹ along with 50% recommended dose of fertilizers was effective and significantly improved the growth attributes of bhendi crop (*A. esculentus*) such as plant height, number of branches per plant, dry matter production, quality parameters viz., crude fibre and mucilage contents, calcium and magnesium removal besides buildup of the availability of secondary nutrients in the soil. A comparable level of biomass yield can be achieved with a lowered level of mineral fertilizer combined with press mud. The amount of organics required for optimum crop production can reduce the inorganic fertilizer requirement for *A. esculentus* and also combined application of organic and inorganic fertilizers may be a sound soil fertility management strategy to get higher yield of the bhendi crop.

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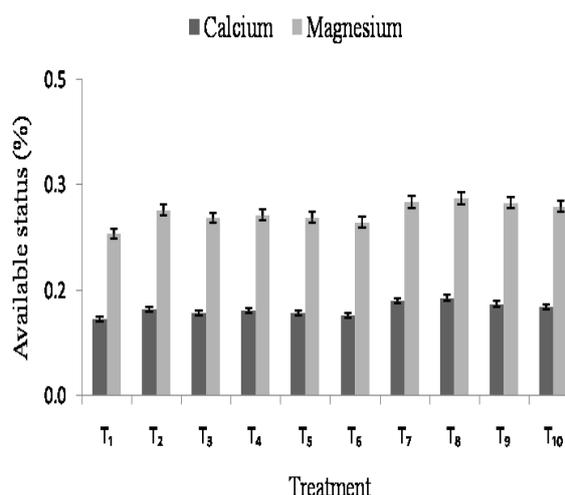


Fig. 4. Effect of INM on available status of secondary nutrients at harvest stage of bhendi (*A. esculentus*).

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