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Foliar Nutrient Application with Macro and Micro Nutrients Alters Yield and Total Antioxidative Capacity of Bhendi (*Abelmoschus esculentus*)

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ABSTRACT

Background: Plant nutrient deficiency is the major challenge in agriculture results in lower crop yield and quality. This may lower the farmer's income by reducing marketable value. In other hand, eating nutrient dense vegetables is the most cost effective strategy to combat malnutrition. The efficiency of inorganic micronutrients applied into soils is low as they become easily fixed to soil particles. Hence, exogenous application of nutrients is an effective option to enhance plant nutrient use efficiency.

Methods: This study was conducted at SRM College of Agricultural Sciences, Chengalpattu, Tamil Nadu during 2022-2023 to alleviate nutrient insufficiency challenges in bhendi variety Senora by using Randomized block design with seven different treatments *viz.*, T_1- Control, T_2- Nutrient consortia 1 (N + K + B + Fe+ Mn + Zn @ 1%), T_3- Nutrient consortia 2 (N + K + Fe+ Cu + B @ 1%), T_4- Nutrient consortia 3 (N + K + Mg + B + Fe + Zn @ 1%), T_{5-} Nutrient consortia 4 (T_2 + NAA + SA@ 1%), T_6- Nutrient consortia 5 (T_3 + NAA + SA @ 1%), T_7- Nutrient consortia 6 (T_4 + NAA + SA @ 1%), sprayed at 30, 45 and 60 days after sowing.

Result: Various physiological, biochemical, yield and quality parameters were measured to evaluate the effects of Nutrient consortia. The results of field experiment strongly improved that the eight biochemical parameters viz., chlorophyll a, chlorophyll b, total chlorophyll content, chlorophyll a/b ratio, chlorophyll stability index, leaf soluble protein, lipid peroxidation by melondialdehyde and proline content. The yield and quality traits such as number of fruits per plant, total fruit yield, total phenolics and total antioxidants activity were significantly increased through application of Nutrient consortia 6 followed by Nutrient consortia 4. So this can be used as yield and quality enhancer formulation of bhendi crops.

Key words: Bhendi, Chlorophyll, Nutrient consortia, Total antioxidants, Total phenolics, Yield.

Abbreviation: B- Boron, Cu- Copper, Fe- Iron, K- Potassium, Mg- Magnesium, Mn- Manganese, N- Nitrogen, NAA- 1-Naphthaleneacetic acid, P- Phosphorus, SA- Salicylic acid, Zn- Zinc.

INTRODUCTION

Bhendi is belonging to the malvaceae family with chromosome number 2n= 130 and origin from tropical and subtropical Africa. It is also called ladies finger/ Okra. India is the leading producer of bhendi and it occupies 70% (6.46 MT in 0.53 million hectares) out of the world production 10.8 MT in 2.47 million hectares (FAOSTAT, 2021). Asia and Africa are the major contributors, producing 99% of world total yield. This crop rich in iodine, calcium, potassium and vitamin C and it has high oil content about 40%, protein in seeds about 20-30% and rich in polysaccharides in the mucilage. Growing bhendi during drought and hot season causes flower and premature fruit drop which reduce the yield (Badrie, 2016). On other side, the yield of bhendi plant is also below the potential yield, as result of biotic and abiotic stresses and lack of awareness in plant nutrient management among the farmers. They apply only primary nutrients like nitrogen, phosphorus, potassium and this not enough for better yield and quality of bhendi. In india, Primary nutrients like N, P and K are deficient in 89, 80 and 50% respectively. The status of micronutrients is critical and deficiency in zinc (40%), iron (12%), boron (33%) manganese (5%),

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molybdenum (11%) and copper (13%) is noticed in many states of the country (Bana *et al*., 2022). Vegetable cultivation is hampered by a lack of nitrogen, potassium, magnesium, boron, iron and zinc based on the agro climatic zones and soil type in India. In other hand, Bhendi is very sensitive to deficiencies of Magnesium (Mg), Boron (B), Iron (Fe) and Zinc (Zn) based on plant growth and development characters. These conditions affect nutrient uptake, plant growth and development, as well as crop production and quality, which affect farmer revenue. These nutrients are involved in the various processes related to photosynthesis and respiration. Foliar sprays of these nutrients combined with plant growth regulators in some cases have proved useful in enhancing yield and quality by reducing flower and fruit drop, resistance to biotic and abiotic stresses (Ahmed *et al*., 2023). Presently there is no foliar application of macro and micro nutrients in these area. In order to reduce the yield and quality losses due to nutrient deficient soils it is needed for application of secondary nutrients with micronutrients for improving yield and fruit quality parameters of bhendi. The Foliar application of nutrients with plant growth regulators (PGRs) is an effective option for improving nutrient absorption; reduce the nutrient losses in the form of soil fixation and leaching process. Hence, this study was conducted with an aim of to know the effect of crop specific nutrient booster for improving growth, yield and fruit quality.

MATERIALS AND METHODS

The field experiment was carried out during 2022 to 2023 at SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu, Tamil Nadu, India by Randomized Block Design (RBD) in Bhendi variety Senora with seven different treatments and three replications *Viz*., T_1- Control (Water spray), T_2- Nutrient consortia 1 (N + K + B + Fe+ Mn + Zn @ 1%), T_3- Nutrient consortia 2 (N + K + Fe+ Cu + B@ 1%), T_4- Nutrient consortia 3 (N + K + Mg + B + Fe + Zn@ 1%), T_5- Nutrient consortia 4 (T_2 + NAA + SA @ 1%), T_6- Nutrient consortia 5 (T_3 + NAA + SA @ 1%), T_7- Nutrient consortia 6 (T_4 + NAA + SA @ 1%), sprayed at 30, 45 and 60 days after sowing. Because 30 DAS in bhendi coincide with peak vegetative stage, 45 DAS coincide with flowering and 60 DAS with Fruiting. Field has been prepared to get fine tilth with application of 12.5 t farm yard manure (Decomposed mixture of dung and urine of farm animals). Spacing was maintained with 90 cm between the rows and 45 cm between the plants and NPK fertilizers (200:25:100 NPK) applied as per soil test recommendations in four intervals. Fifty percentages of nitrogen, phosphorus and potassium were applied as basal and the remaining 50% were applied at 40 DAS. Observations on physiological and biochemical aspects were recorded 4 days after the nutrient consortia application.

The total chlorophyll content, chlorophyll a, chlorophyll b and chlorophyll a/b were determined according to procedures of Yoshida *et al*. (1971**)** at 3 days after treatment spray and physiologically active leaves were collected by using ice box. Chlorophyll Stability Index (CSI) was determined by adopting the method of Murthy and Majumdar (1962). Soluble protein content of the leaf was estimated at by using Folin Ciocalteau reagent by following the procedure described by Lowry *et al*. (1951). The level of lipid peroxidation in leaf tissue was measured in terms of malondialdehyde (MDA) content by thiobarbituric acid (TBA) reaction (Heath and Pacber, 1968). To estimate the proline content based on the protocol of Bates *et al*. (1973). Total phenolics content of fruit were quantified by the method of Malik and Singh, (1980) by Folin-Ciocalteau reaction which involves reduction of the reagent by phenolic compounds, with concomitant formation of a blue colour. Total antioxidant content of fruit was estimated based on Hanato *et al*. (1988) method. 1 ml of 500 mM 2, 2 –Diphenylpicrylhydrazyl radical (DPPH) was added in to methanolic fruit extract (1:10). The content was shaken and stored under dark condition for 30 minutes and then the absorbance was recorded at 517 nm. Finally, the DPPH inhibition percentage of free radical was calculated by the following formula,

$$\text{Inhibition percentage (\%)} = \frac{\text{(A blank - A sample)}}{\text{A sample}} \times 100$$

A_{blank}: Absorbance at control samples.
A_{sample}: Absorbance at fruit extract samples.

Fruit numbers was recorded at each treatment plot about 13 harvests and expressed in number of fruits $plant^{-1}$. The total weight of fruits harvested from each plant of all picking was added and average yield per plant was worked out and expressed in gram per plant.

The data on various parameters were analyzed statistically by SPSS version 29 tool as per the procedure suggested by Gomez and Gomez (1984). Wherever the treatment differences are found significant, critical differences were worked out at 5% probability level and the values were furnished. The mean values with Standard error are given in all figures.

RESULTS AND DISCUSSION

The amount of plant tissue and membrane damage can be measured by leaf chlorophyll content. Chlorophyll is the green pigment that is required for photosynthesis which allows plants to absorb energy from light. Among the different pigments, Chlorophyll *a* and *b* are almost essential pigments for the conversion of light energy to chemical energy. The increased amount of leaf chlorophyll content is the key indicator of yield enhancement (Liu *et al*., 2022). In the present study, the increased level of chlorophyll a, chlorophyll b, total chlorophyll and chlorophyll a/b ratio were observed (Fig 1). The 39.4% increment of chlorophyll a was observed in nutrient consortia 6 followed by nutrient consortia 4 by 24.7% over control plants. There was a reduction of chlorophyll b content was observed in nutrient consortia 4 by 9.6% followed by nutrient consortia

6 by 7.08%. In other hand, the total chlorophyll content was increased in the treatment 2 (nutrient consortia 1) by 25.2% followed by treatment 7 (24.3%). Chlorophyll a is the primary pigment that absorbs light energy and converted in to chemical energy but in case of chlorophyll b is the secondary or accessory pigment which only absorbs light energy and transfer in to chlorophyll a. However, during the process of chlorophyll degradation, chlorophyll '*b'* may be converted into chlorophyll '*a',* thus resulting in the increased content of chlorophyll '*a*'. Increased level of chlorophyll a/b ratio is the benefit for plant to improve photosynthesis and yield (Fatima *et al.,* 2019). In our study, the chlorophyll a/b ratio was increased by nutrient consortia 6 treatment about 55.8% followed by nutrient consortia 4 (33.5%). This can improve the yield and quality parameters of bhendi.

The improved level of biochemical parameters were recorded due to foliar application of nutrient consortia (Fig 2). Chlorophyll stability index (CSI) is also important parameter to measure the chlorophyll degradation in plants with respect to environmental stresses. The higher CSI in the plant that means the plant have higher tolerant to biotic and abiotic stresses and lower chlorophyll degradation. The higher CSI was recorded in nutrient consortia 6 by the 11.5 % increment over control followed by nutrient consortia 4 (9.4%). Leaf soluble proteins determine the Rubisco enzyme activity which is directly involved in photosynthetic activity. Over 70 per cent of leaf soluble protein is occupied by RuBisCO which ultimately induce carbon fixation in photosynthesis (Pawar *et al.* 2019). The effect of nutrient consortia on leaf soluble protein revealed that significant influence on Bhendi. It was observed that leaf soluble protein content was found to be increased due to nutrient consortia 4 treatment by 60 per cent followed by nutrient consortia 5 by 52.3%. The increase in soluble protein is directly correlated with higher photosynthesis. Malondialdehyde (MDA) is the product of lipid peroxidation of poly unsaturated fatty acid in plant membranes in response to Reactive Oxygen Species (ROS) and it is mostly used an indicator of membrane integrity (Morales *et al*., 2013; Ajaykumar *et al*., 2023).

The decrease amount of MDA was observed in nutrient consortia applied plants and nutrient consortia 6 showed 19.8% decreases of malondialdehyde content in comparison with other treatments and control. Proline is

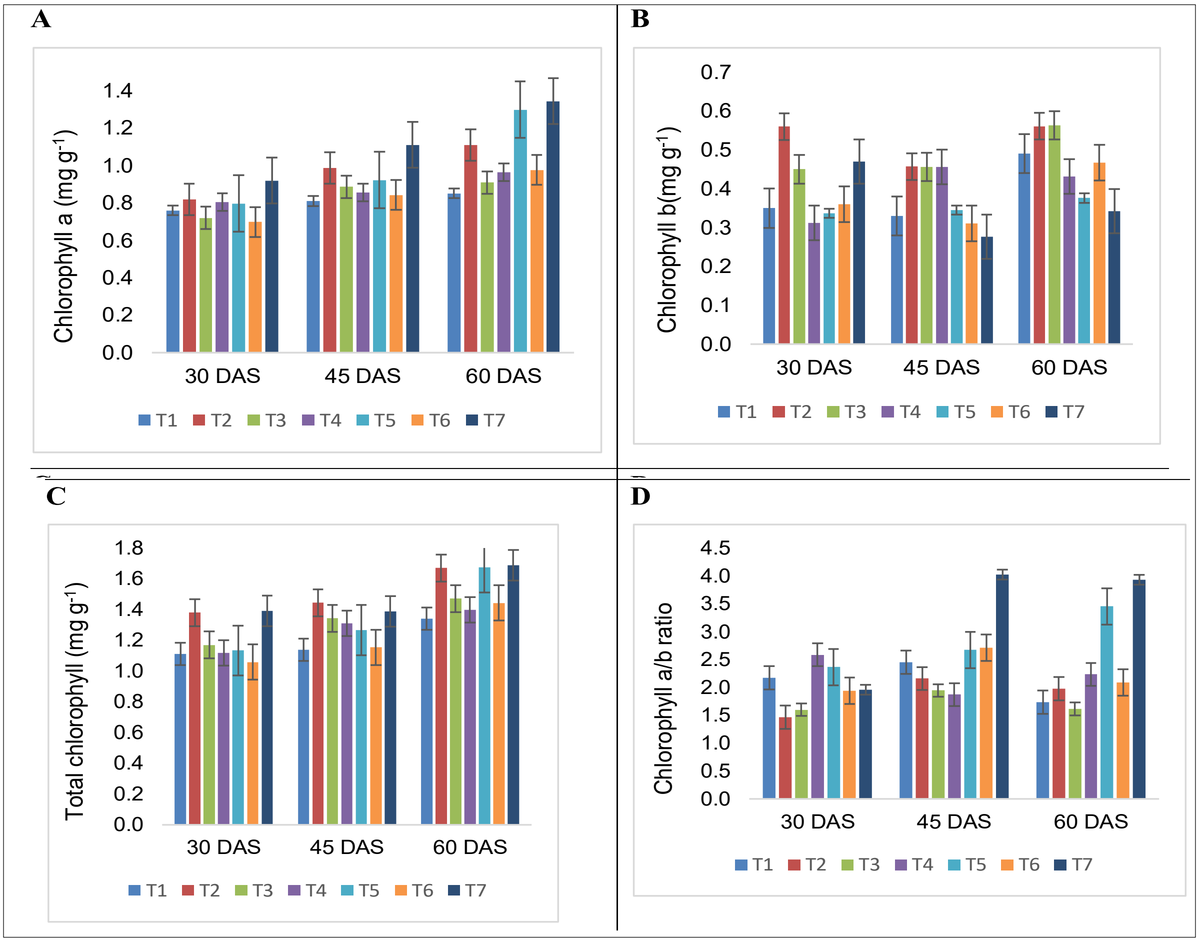

Fig 1: Effect of nutrient consortia on chlorophyll parameters of Bhendi; A): Chlorophyll a, B): Chlorophyll b, C): Total chlorophyll, D): Chlorophyll a/b ratio.

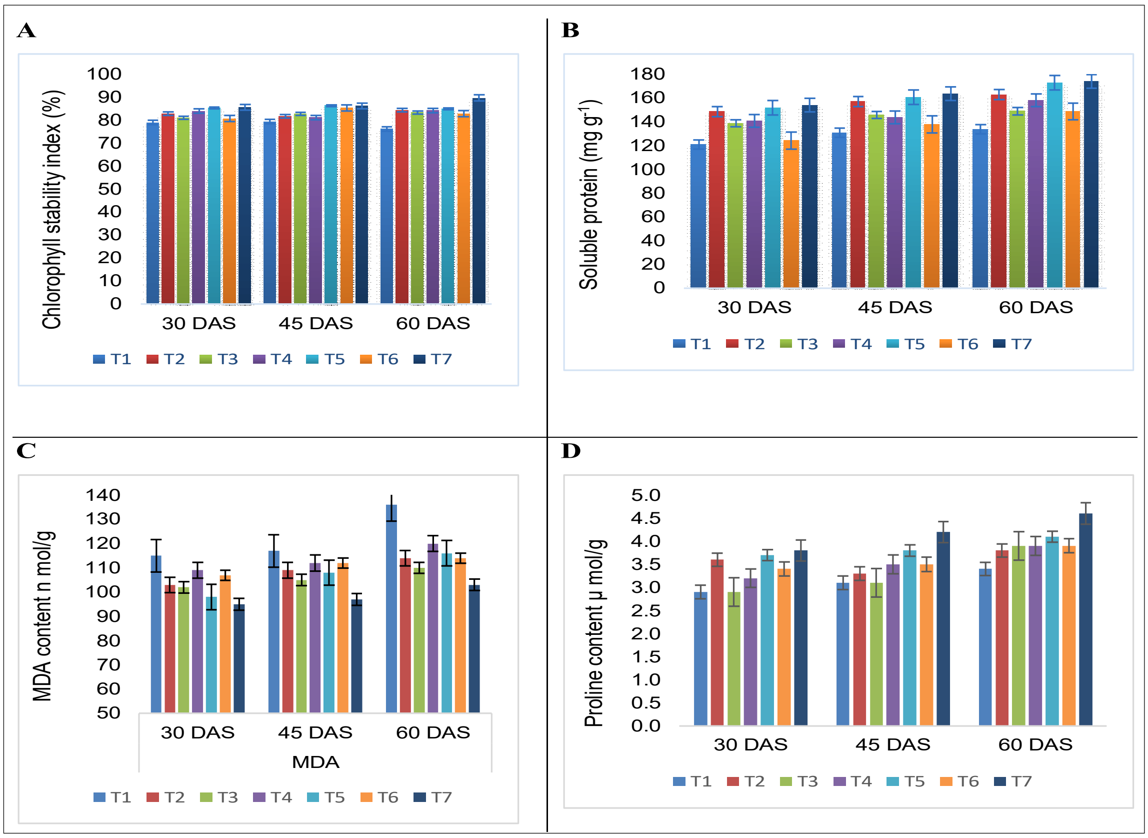

Fig 2: Effect of nutrient consortia on biochemical parameters of Bhendi; A): Chlorophyll stability index, B): Soluble protein, C): MDA content, D): Proline content.

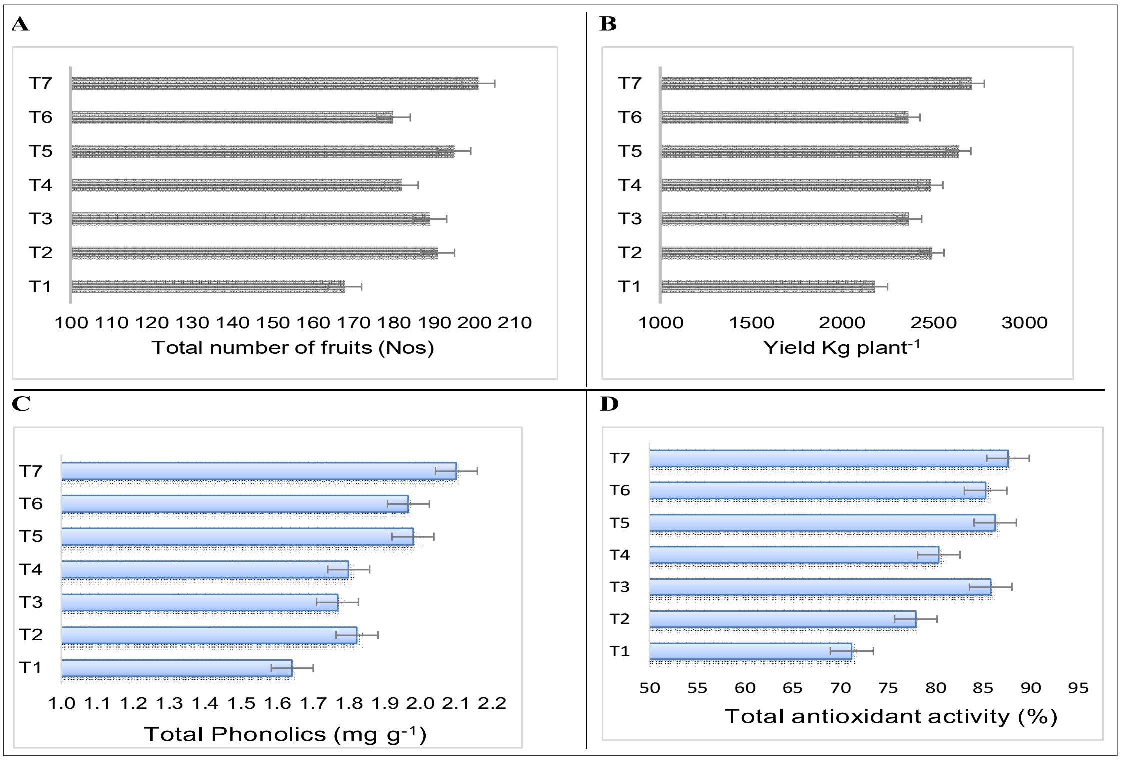

Fig 3: Effect of nutrient consortia on yield and quality parameters of Bhendi; A): Total number of fruits, B): Yield per plant, C): Total phenolics, D): Total antioxidant activity.

believed to protect plant tissues against stress by acting as nitrogen storage, osmoregulator and protectant for enzymes and cellular structure. It is one of the important amino acids, is known to occur widely in higher plants and normally accumulates in large quantities in response to environmental stress (Hayat *et al*., 2012). From the current study, the higher accumulation of proline was found in nutrient consortia 6 up to 34.0 per cent than control and other treatments.

Nutrient deficiency in the soil and plant affect the number of fruit, number of flower and ultimately reduce the fruit yield. The exogenous application of nutrients can decrease the effect of nutrient insufficiency issue by enriching the availability of nutrients to the plant (Naseer *et al*., 2022). It also improves the plant chlorophyll concentration, soluble protein and other biochemical parameters which increase the yield through increasing the photosynthesis. In our study, number of fruit was increased up to 19.6% by nutrient consortia 6 followed by nutrient consortia 4 (16.1%). In other hand, total fruit yield was increased up to 24.4% by nutrient consortia 6 followed by nutrient consortia 4 (21.1%). Among the treatments used, nutrient consortia 6 increased the total phenolics content in fruits by 27.8 per cent over control followed by nutrient consortia 4 treatment (20.5%). Also, the highest fruit total antioxidant activity was found in nutrient consortia 6 (23.0%) followed by nutrient consortia 4 (21.1%) (Fig 3).

CONCLUSION

Boron, manganese, copper, iron and molybdenum nutrients are the most common deficiencies affecting vegetable crops, followed by deficiencies in potassium, zinc and nitrogen. These nutrients play different roles in photosynthesis and respiration-related processes. Lack of these specific nutrients in the soil impacts nutrient uptake, translocation and assimilation, which in turn affects the vegetables' nutritional status. Therefore, applying nutrients by foliar spray is the most practical and cost-effective way to increase vegetable yield and quality. In our study we concluded that the foliar application of Nutrient consortia 6 can improve the yield by 24.4% and this treated plant fruits have increased level of total antioxidants and total phenolics content. This significant improvement of yield in nutrient consortia 6 applied plants is due to increment of total chlorophyll, chlorophyll a/b ratio and soluble protein content in the leaves. These parameters are important components of photosynthesis and these may increase the photosynthetic efficiency of bhendi plants which helps to increase the yield and quality.

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Conflict of interest

The authors declare no conflict of interest.

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