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Assessing the Influence of Biostimulants on the Growth and Crop Yield of Okra (*Abelmoschus esculentus*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study, carried out at "C" Block Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, during the 2022–23 period, to find out the impact of biostimulants on the growth and yield of Okra (*Abelmoschus esculentus*). The primary goals include examining the significant effects of biostimulants and determining the optimal dosage of the biostimulant, aligning with the growing emphasis on sustainable agricultural practices. The farm, situated near the Tropic of Cancer, exhibits coordinates of approximately 22.89°N latitude and 88.45°E longitude, with an altitude of around 9.75 m above sea level. The experimental design utilized a Randomized Block Design

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(RBD) with three replications and five treatments. Results highlight that the growth and yield parameters of Okra were notably influenced by the foliar application of modulin. Specifically, applying 2.5 kg ha^{-1} of Modulin spray at 25 & 40 days after sowing (DAS) along with 100% NPK demonstrated to be economically rewarding and advantageous for achieving a higher yield of Okra."

Keywords: Okra; bio stimulants; growth; crop yield.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the most important vegetable crops grown in all agro-ecological zones mainly for its immature fruits, which are eaten as cooked vegetable. Apart from its use as a vegetable, its stem and roots are used for clearing of cane juice from which sugar is prepared and dried seeds are source of nutritious food. In a freshpod, approximately 88% of its composition is water, with 0.1% fat, 8% carbohydrates, 1.8% protein, and 0.9% fibre. (Agbo et al. 2008).

Indiscriminate use of chemical fertilizers affects the plant growth, yield and quality of fresh fruits. Organic nutrient sources help to maintain the fertility of the soil, avoids depletion of soil organic matter and plant nutrients besides suppression of some insect-pests and diseases (Gaur 2001). Therefore, the application of plant nutrients through organic sources like compost, farmyard manure and biofertilizers remain the alternative choice of the growers for maintaining its sustainable production. Sole use of traditional farmyard manure may not be sufficient for producing reasonable yield of organic Okra. Therefore, use of enriched organic manure along with biostimulants like humic acid and seaweed extract may be considered as a strategy of modern production practices. Humic acid, a primary component of humic substances, boosts lateral root development, triggers tolerance to abiotic stress, and supports plant physiology and mechanisms (Adani et al. 1998, Trevisan et al.2010, Aydin et al. 2012). Seaweed extract is derived from brown algae (*Ascophyllum nodosum*), enhancing the plant's ability to absorb nutrients, resist diseases, and regulate hormonal activities. (Crouch1990, Khan et al.2009, Zodapeet al. 2011).

The product MODULIN consists of plant extract and leaf protein extracts which are activators of phyto-hormones and growth substances where multiple of the plant extracts serve as precursors of growth factors. The product containing natural extracts of plants (*Glycyrrhizaglabra*& lignosulphonates) along with hydrolysed proteins, triggers the physiological processes of plants and enhance yield. Modulin is an organic activator that regulates the target genes and works as signal inducer in the plant cell metabolic activity by activating for its growth by increasing the number of flowers. Modulin promotes plant growth and leaf development. It improves flower setting and reduces flower dropping. Plant metabolism is regulated to achievehigher yield. It is a natural product and non-toxic to plant & environments. It promotes the plant immune system and aids in higher yield. It is an organic certified product. Though several reports are available on the use of plant extracts in plant culture, there has been less research on the use of plant extracts under tropical and sub-tropical field conditions.

Keeping this in view in the present experiment was conducted to standardize the efficacy of Modulin with the following objectives are to find out the effect of Modulin on growth and development of Okra and to assess the response on the yield of Okra to the application of Modulin.

2. MATERIALS AND METHODS

The field experiments under the present investigation “Assessing the Influence of Bio stimulants on the Growth and Crop Yield of Okra (*Abelmoschus esculentus*)” was carried out during the period of kharif season of 2022. The details of materials used and experimental techniques adopted during the course of investigation are described in this chapter. The experiment was conducted at "C" Block Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, and West Bengal. The farm is located very close to the Tropic of Cancer having approximately 22.89°N latitude and 88.45°E longitude. The altitude of the place is about 9.75 m above the sea level. The site falls under sub-tropical humid climatic zone, where temperature is moderate i.e., neither too hot in summer nor cold in winter. This zone is not subjected to extreme weather condition. Generally, the monsoon comes in the month of June and continues up to September. The mean annual temperature falls below 20^{o}C in the November

Table 1. Treatments details

Treatments Details	Treatment	Dosage/ha (in 500lit of water)
	T_1 Modulin	100% NPK + 2.0kg ha^{-1} Modulin spray at 25 & 40DAS (Days after sowing)
	T_2 Modulin	100% NPK + 2.5kg ha^{-1} Modulin spray at 25 & 40DAS
	T_3 Modulin	100% NPK +3.00kg ha^{-1} Modulin spray at 25 & 40DAS
	T_4	100% Recommended dose of NPK
	T_5	Control

and continue till the early part of February. The winter is thus mild and short in the Gangetic Plains of West Bengal. The temperature starts rising from second fortnight of February reaches its maximum usually in April May. The soil of the experimental field was alluvial in nature and sandy-loam in texture. The soil in the research station is sandy loam in texture, fine, mixed with good water holding capacity. Ten plants were randomly selected from each plot to record the data on the following attributes. The methods used for recording observations are viz. Plant height, No. of branches /plant, No. of fruits /plant, Fruit Length (cm), Single fruit weight (gm), Fruit yield /plant (gm), Fruit yield (t/ha) etc.For phytotoxicity assessment in Okra, the following observation were made by observing temporary or long-lasting damage to the leaves of Okra if any viz. vain clearing and necrosis on 1,3,7 and 14 days after spraying by recording leaf injury, wilting,necrosis, epinasty, hyponasty and vein clearing leaves of the plants. Crop injury was observed on visual rating from 1-10 scale.The selected land of the experimental site was thoroughly prepared by repeated ploughing. The soil was then pulverized to make it loose and friable. All the weeds and stubbles were removed. The field was properly levelled and divided by the irrigation channels into several plots as per the treatments in each experiment. After the land was prepared about 25 tonnes of FYM was applied. In each crop the recommended dosage of N, P and K was applied in the form of urea, single super phosphate and muriate of potash respectively. Nitrogen was applied in two split doses, the first dose as basal application and the other split dose at 30 days after planting. The entire dose of phosphorus and potash were applied at the time of sowing as basal dose. Other cultural practices in the experiment were followed as per the standard and recommended packages of practices of Okra. As per the treatment schedule the foliar application of Modulin at 2, 2.5 and 3.0 kg ha-1doses were applied at different stages of viz. 25 and 40 days for the treatments T1, T2and T3 as per requirement. For other two treatments (T4 and T5) the foliar spray of Modulin was not performed. Treatments details and phytoxicity of Modulin in Okra were shown in the Table 1 and 2, respectively.

3. RESULTS AND DISCUSSION

The field experiments under the present investigation “Assessment of biostimulant (Modulin) on growth and yield of Okra” was carried out during the period of kharif season of 2022. The results pertaining to the above investigation is presented here as follows.

3.1 Plant Height (cm)

The plant height due to different dose of Modulin as a foliar application were statistically significant, and the results are presented in Table 3.

During the investigation, the plant heights were recorded at 35 DAS, 55 DAS, and at 75DAS. From the data presented in the Table 1, it is revealed that there was a significant difference in plant height due to the application of different dose of Modulin as foliar application. Data recorded on plant height during 35 days was found to be statistically significant. It is revealed from the Table 1 that plant height during 35 days ranged from 38.64 cm to 44.94 cm. It was observed that maximum plant height of 44.94 cm was obtained with T2 (100% NPK + 2.5kg ha-1 Modulin spray). Similarly, when the plant height was recorded at 55 days and as well as at 75 DAS the same treatment gave maximum plant height of 124.11cm and 161.31cm, respectively. The minimum plant height of 38.64 cm, 105.16cm, and 134.70cm were recorded respectively during 35 DAS, 55 DAS and at 75DAS in the control plots. The second highest plant height with respect to all three stages of growth was found from the T3 (100% NPK +3.00kg ha-1 Modulin spray). Similar result was reported by Kundu et al. (2023) who found that

the application of biostimulant increased plant growth characters like plant height in tomato. Similar results with effect of biostimultant was also reported in Potato by Karak et.al. (2023).

3.2 Number of Branches /Plants

Significant influence on the Number of branches /plants was observed with different doses of foliar application of Modulin. The Number of branches /plants was recorded at 35 DAS, 55 DAS and at 75DAS. The parameters i.e., Number of branches /plant at 35 DAS showed a good amount of differences with different doses of Modulin. At 35 DAS the Number of branches /plants varied from 2.00 to 3.20 (Table 2). The maximum Number of branches /plant of 3.20 was obtained from T2 (100% NPK + 2.5kg ha-1 Modulin spray). The second highest Number of branches /plants was found with T3 (100% NPK +3.00kg ha-1 Modulin spray.) The minimum Number of branches /plant (2.00) was recorded with the control treatment. At 55 DAS (Days after sowing) the number of branches /plants varied from 3.00 to 4.20 numbers/plant.

It is revealed from the data, that the number of branches /plant from 35 DAS to 55 DAS marked showed increasing trend with all the treatments. Although, the maximum number of branches per plant of 4.20 was obtained from T2 (100% NPK + 2.5kg ha-1 Modulin spray) at 55 DAS, it was on par with T3 (Modulin 100% NPK +3.00kg ha-1 Modulin spray) having the value of 3.80. Similar trend at 75 DAS was also noticed on number of branches. The maximum number of branches per plant 5.20 was obtained from the T2 (100% NPK + 2.5kg ha-1 Modulin spray) followed by T3 (100% NPK +3.00kg ha^{-1} Modulin spray.) The lowest number of branches per plant of 4.00 was recorded from the control followed by second lowest number of branches per plant of 4.27 was obtained from the T3 (100% Recommended dose of NPK) From the above observation it was clear that foliar application of Modulin significantly and positively influenced the number of branches per plant. Foliar nutrition helps in

Table 2. Phytoxicity of modulin In Okra

Treatments	Phytotoxic Symptoms in plants					
	Leaf injury	wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
T_1 100% NPK + 2.0kg ha^{-1} Modulin spray at 25 & 40DAS	0	0	0	0	0	0
T_2 100% NPK + 2.5kg ha^{-1} Modulin spray at 25 & 40DAS	0	0	0	0	0	0
T_3 100% NPK + 3.00kg ha^{-1} Modulin spray at 25 & 40DAS	1	0	1	1	0	0
T_4 100% Recommended dose of NPK	2	2	3	2	1	1
T_5	0	0	0	0	0	0

Table 3. Effect of modulin on the height (cm) of Okra

Treatment	Dosage/ha (in 500lit of water)	Plant height		
		35DAS	55 DAS	75 DAS
T_1	100% NPK + 2.0kg ha^{-1} Modulin spray at 25 & 40DAS	42.18	111.18	155.63
T_2	100% NPK + 2.5kg ha^{-1} Modulin spray at 25 & 40DAS	44.94	124.11	161.31
T_3	100% NPK +3.00kg ha^{-1} Modulin spray at 25 & 40DAS	43.70	115.11	158.11
T_4	100% Recommended dose of NPK	40.40	110.69	153.26
T_5	Control	38.64	105.16	134.70
S.Em		1.20	3.25	4.56
	CD @5%	3.65	9.86	13.83
	CV	5.03	5.01	5.15

Table 4. Effect of modulin on the no. of branches per plant of Okra

Treatment	No. of branches per plants		
	35DAS	55 DAS	75 DAS
T_1 100% NPK + 2.0kg ha^{-1} Modulin spray at 25 & 40DAS	2.77	3.70	4.72
T_2 Modulin 100% NPK + 2.5kg ha^{-1} Modulin spray at 25 & 40DAS	3.20	4.20	5.20
T_3 Modulin 100% NPK +3.00kg ha^{-1} Modulin spray at 25 & 40DAS	2.93	3.80	4.87
T_4 100% Recommended dose of NPK	2.40	3.34	4.27
T_5 Control	2.00	3.00	4.00
S.Em	0.10	0.18	0.19
CD @5%	0.29	0.56	0.57
CV	5.92	8.70	7.04

numerical improvement on number of branches. The reason for this rise in growth parameters is because, in addition to the primary nutrient NPK, Modulin is an excellent source of mineral activators and has an extra benefit over other nutrient sources in terms of its translatability, bioavailability, and solubility.

3.3 Number of Fruits /Plants

Number of fruits per plant for different dose of Modulin as foliar was statistically significant and the detailed observation is presented in the Table 5. The effect of Modulin on number of fruits per plant was found to be significant. It is apparent from Table 5 that the application of Modulin had marked influence on number of fruits per plant. It was observed that, the number of fruits (43.87) was highest in the T2 (100% NPK + 2.5kg ha-1 Modulin spray) followed by T3 (100% NPK +3.00kg ha-1 Modulin spray) (43.20). The maximum number of fruits per plant due to application of Modulin might be due to its activity boost to the vegetative growth of the plant, which in turn helps to produce more number of fruits. Amongst the different treatments, thelowest number of fruits per plant of 29.53 was obtained from T5 (Control) followed by T4 (100% Recommended dose of NPK) which produced 39.87 number of fruits per plant. Similar type of result was observed by Mishra et al. (2020) where number of fruits was increased with application of liquid seaweed extract.

3.4 Fruit Length (cm)

The data on fruit length (cm) was analysed statistically and results are presented in Table No. 5. Among the treatments, foliar application of Modulin exhibited significant influence on the length of fruits of Okra. Application of Modulin at 2.5kg ha-1on 25 and 40 DAS (T2) significantly registered the highest fruit length of (12.01cm). The treatments viz. application of Modulin @ 3.0 kg ha-1on 25 and 40 DAS (T3), stood next in order of ranking at all the stages of crop growth. The 100% NPK + 2.0kg ha 1 Modulin spray at 25 & 40DAS (T1) was next in descending order and followed by 100% Recommended dose of NPK (T4). Overall, the lowest fruit length of 10.78cm was noticed from the control.

3.5 Single Fruit Weight (g)

Significant influences on single fruit weight (g) were observed with different treatments. The mean value of single fruit weight (g) varied from 10.47gm to 12.47 gm. Foliar application of Modulin significantly and positively influenced the single fruit weight (g) From the present data it is revealed that maximum single fruit weight (g) of 12.47 gm was obtained in T2 (100% NPK + 2.5kg ha-1 Modulin spray) Improved single fruit weight under foliar treatment of Modulin was mainly because of increase in translocation of photosynthates from leaves and stems to developing fruits resulting in sound and matured fruits. The lowest single fruit weight of 11.73gm and 10.47was recorded in the treatment receiving only 100% recommended dose of NPK and from control, respectively. The second highest single fruit weight (12.07 gm) was obtained in T3 (100% NPK +3.00kg ha-1 Modulin spray).

3.6 Fruit Yield /Plant (g)

Fruit yield /plant due to different doses of Modulin were found statistically significant. The analysis of variance on fruit yield showed significant differences due to the different treatments. The fruit yield per plant ranged from

466.23 gm to 528.75gm. It is clearly revealed from the Table 3 that the highest fruit yield per plant of 528.75 gm of Okra was received in T2 (100% NPK + 2.5kg ha-1 Modulin spray) followed by T3 (100% NPK +3.00kg ha-1 Modulin spray) which obtained 526.03gm. The highest fruit yield from the T2 (100% NPK + 2.5kg ha-1 Modulin spray) might be due to the reason that rapid availability of the nutrients with foliar application of Modulin enhances the number of the fruits, which leads to increase the fruit yield. The lowest fruit yield of 466.23 gm was obtained from the plant which received no foliar application Modulin and with 100% RDF. The second lowest fruit yield per plant was also found from the plants which received 100% Recommended dose of NPK only. The lowest yield of the present investigation it with 100% RDF clearly indicates that foliar spray of Modulin plays an important role to boost the fruit yield per plant.

3.7 Fruit Yield (t/ha)

The data on fruit yield (t/ha) as influenced by different treatments were statistically significant and presented in Table 5.

Among the treatments, foliar application of Modulin exhibited significant influence on the fruit yield (t/ha) of Okra. Modulin @ 2.5kg ha-1on 25 and 40 DAS (T2) significantly registered the highest fruit yield ha-1of 23.70 tonnes. The treatments viz. application of Modulin 3.00kgha-1produced second highest yield of 22.23t/ha. The treatment 1, resulted in a fruit yield of 20.41t/ha, whereas lowest fruit yield of Okra was noticed from the plant where Modulin was not sprayed. The lowest yield of 19.49t/ha was obtained with the control followed by 20.03 t/ha of fruit yield that was obtained with T4 (100% Recommended dose of NPK).

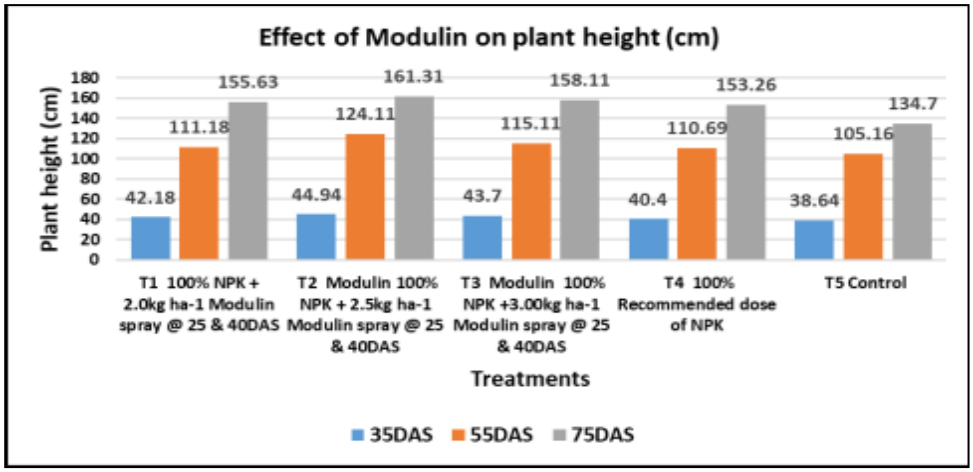

Fig. 1. Effect of modulin on plant height

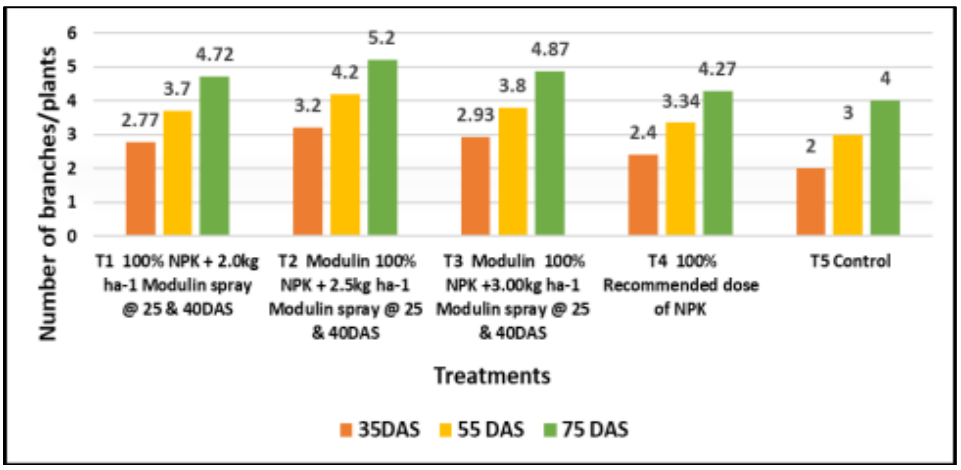

Fig. 2. Effect of modulin on number of branches per plant

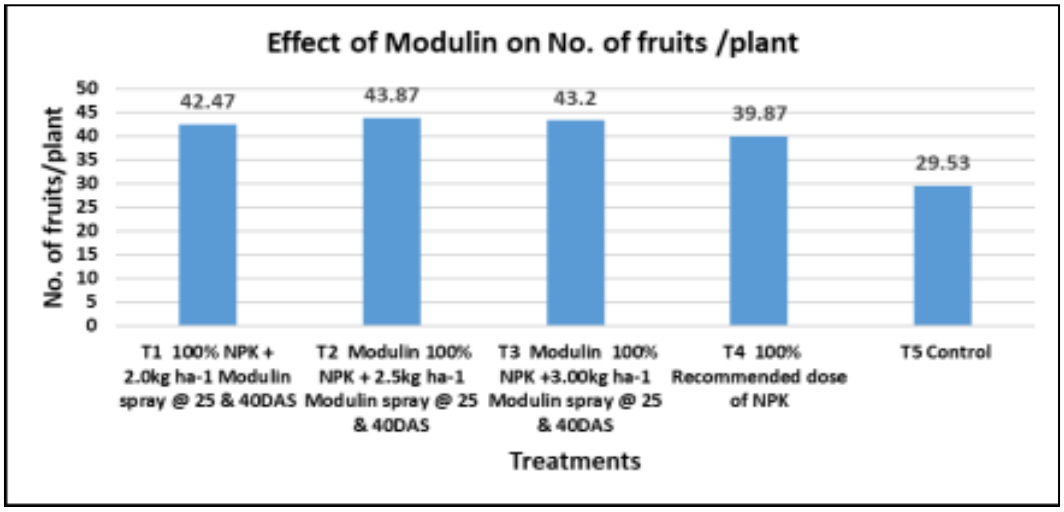

Fig. 3. Effect of modulin on number of fruits per plant

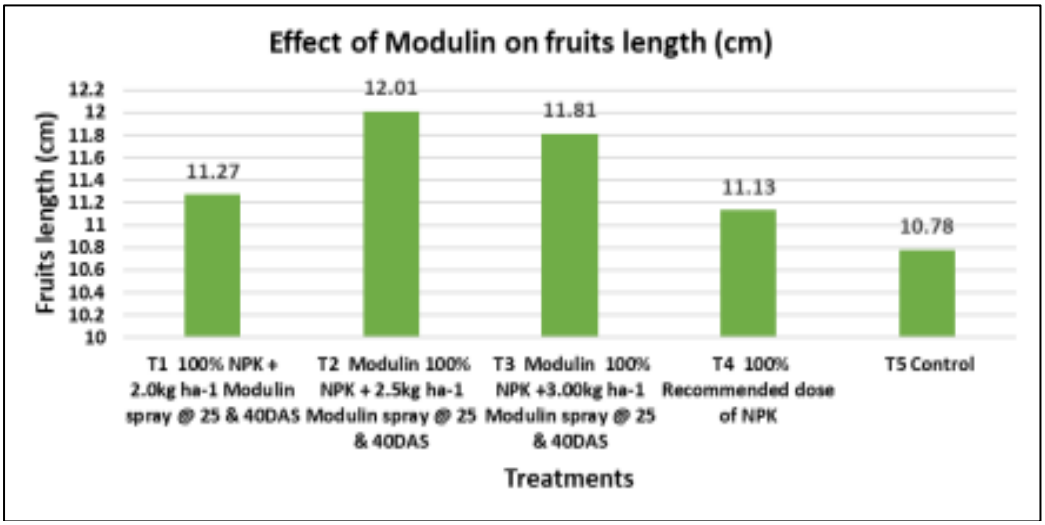

Fig. 4. Effect of modulin on fruits length

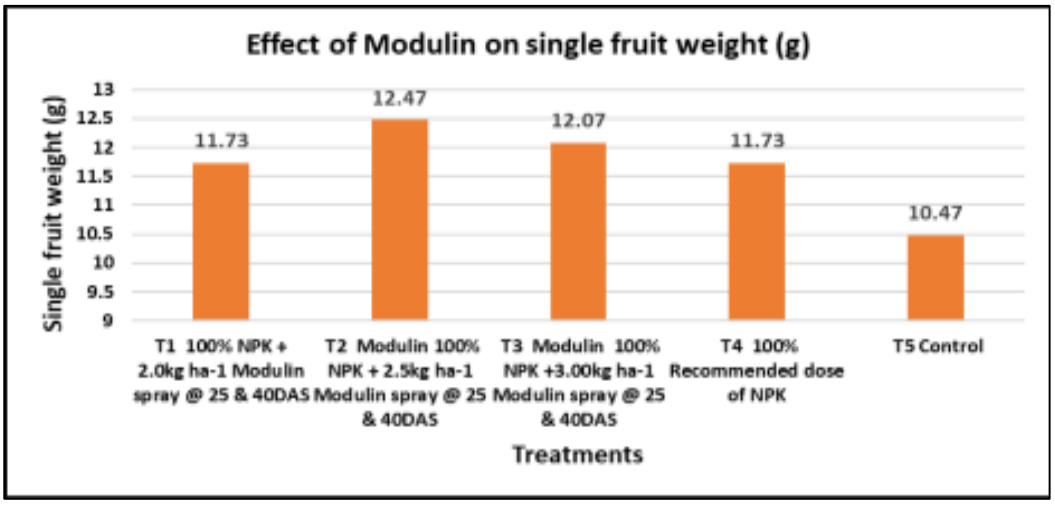

Fig. 5. Effect of modulin on fruits weight

Table 5. Effect of modulin on quantitative yield characters of Okra

Treatments	No. of fruits/plant	Fruits length (cm)	Single fruit weight (g)	Fruit yield per plant (gm)	Fruit yield per hectare (t)	Percentage of Yield increase (%)
T_1 100% NPK + 2.0kg ha^{-1} Modulin spray at 25 & 40DAS	42.47	11.27	11.73	520.25	20.41	4.51
T_2 100% NPK + 2.5kg ha^{-1} Modulin spray at 25 & 40DAS	43.87	12.01	12.47	528.75	23.70	17.76
T_3 100% NPK +3.00kg ha^{-1} Modulin spray at 25 & 40DAS	43.20	11.81	12.07	526.03	22.23	12.33
T_4 100% Recommended dose of NPK	39.87	11.13	11.73	509.85	20.03	2.70
$T_{5\ Control}$	29.53	10.78	10.47	466.23	19.49	-
SE(m)	0.687	0.472	0.38	12.80	0.78	-
CD @5%	0.972	1.43	1.15	38.83	2.35	-
CV	4.187	11.47	8.86	6.93	6.16	-

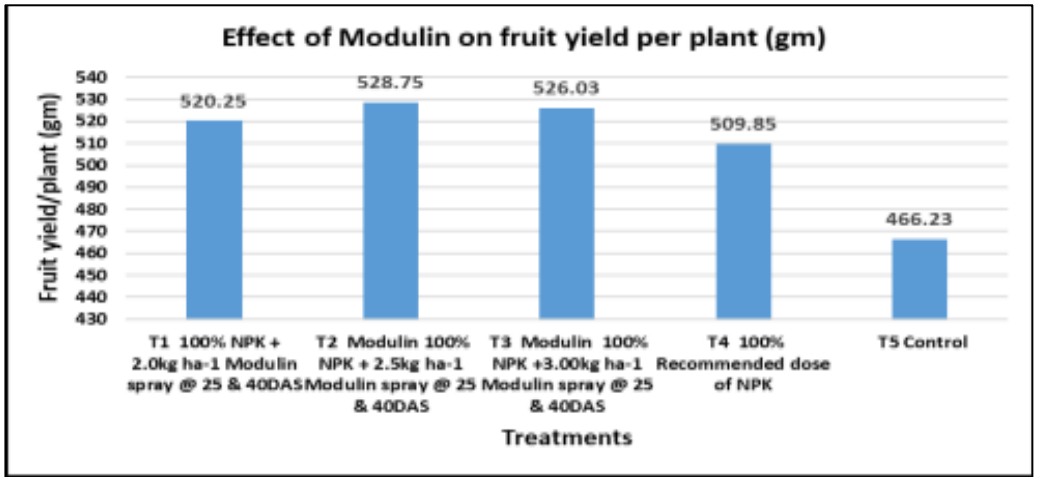

Fig. 6. Effect of modulin on fruit yield per plant

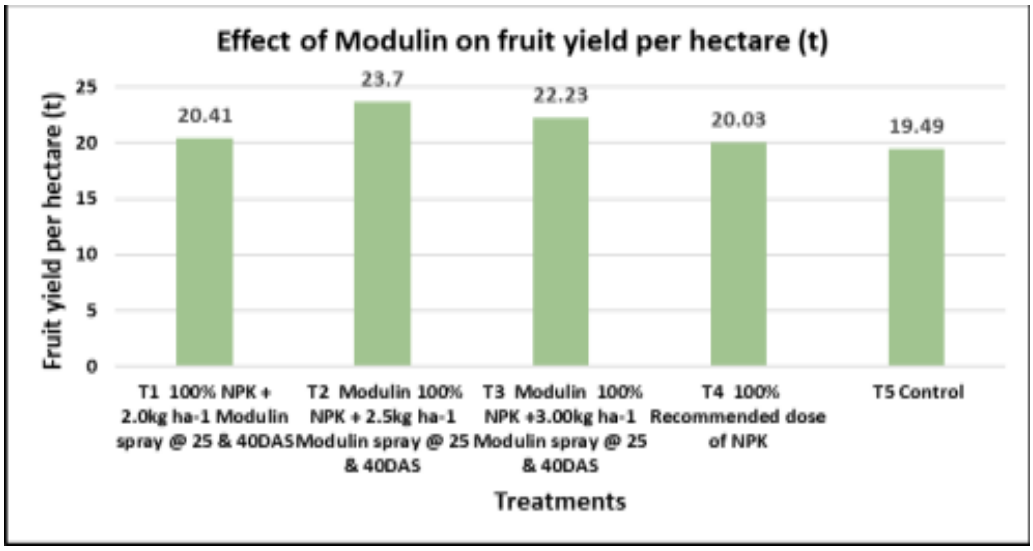

Fig. 7. Effect of modulin on fruit yield per hectare

The symptoms of toxicity were high with 100% Recommended Dose of NPK (2-3), which was subsidized when applied in combination with Modulin.

4. CONCLUSION

From the outcome of this experiment, it can be inferred that the growth and yield parameters of Okra was significantly influenced by foliar application of modulin. Foliar application of MODULIN is efficient in reducing the deficiency symptoms in the plants and promotes plant growth and leaf development. It promoted the plant immune system and resulted in the higher yield. MODULIN holds promise as an eco-friendly and economically suitable component in nutrient management system for Okra cultivation. Among the treatments, foliar application of 2.5kg ha^{-1}Modulin spray at 25 & 40DAS along with 100% NPK proved to be remunerative and advantageous in order to get higher yield of Okra.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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