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Effect of different plant growth regulators on growth, yield and yield attributing characters of *kharif* Okra (*Abelmoschus esculentus* L.) in Konkan region

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Abstract
Field experiment was conducted during *kharif*, 2021 at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli, Ratnagiri, Maharashtra in lateritic soils of Konkan to study the effect of different plant growth regulators on growth, yield and yield attributing characters of *kharif* Okra (*Abelmoschus esculentus* L.) The treatments comprise of various levels of bio-stimulant *viz*., 100, 175, 250, 325, 500 g ha^{-1} and triacontanol 250 ml ha^{-1} along with RDF which are applied on okra after sowing. Significantly positive effects and higher values were observed on plant height, number of functional leaves $plant^{-1}$ and dry matter production at 60 DAS (Days after sowing) and 90 DAS of okra crop with the application of bio-stimulant @ 500 g ha^{-1} (T_6) whereas, least values were recorded with untreated control or RDF only (100: 50: 50 NPK kg ha^{-1}) treatment. Significantly higher fruit yield (16.34 t ha^{-1}) was observed when biostimulant @ 500 g ha^{-1} (T_6) was applied over other treatments and lower fruit yield was observed with respect untreated T_1 (applied RDF only) treatment.

Keywords: Bio-stimulant, Okra (*Abelmoschus esculentus*), RDF

Introduction
Okra (*Abelmoschus esculentus* L.) is an important fruit vegetable crop belonging to the family malvaceae. Okra is grown throughout the tropical and subtropical regions of the world and in warmer part of temperate zone. India is the largest producer of okra globally, with a contribution of more than 72% (6 million tonnes) from an area of 0.5 million hectares (NHB, 2020) Okra is grown commercially in West Bengal, Bihar, Gujarat, Telangana, Maharashtra, and other states among them West Bengal placed first in production with 0.88 MT from 0.75 M ha. Maharashtra was rated 13th in okra production, with 0.09 MT produced annually from 0.11 M hectares of land (National Horticulture Board - 2015-16). In Maharashtra Okra is mostly grown in Nashik, Pune, and Thane districts of Maharashtra. In Konkan region Raigad, Palghar and Thane districts contributing major area under its cultivation.

Bio-stimulants have increasingly been considered as valuable advanced farming techniques used in worldwide agricultural production. They enhance quality, crop health and grower profitability and can effectively contribute to overcome the challenges posed by the increasing demand for food by the world's population in continuous growth. Current resources are directed toward the development of safer bio-stimulants, for the worker and for the environment, as well as toward more efficient application and formulation technologies. Application of these compounds during the growth and developmental stages of the crops can promote crop growth and nutrient balance, resulting in improved quality and yield (Henk-Maarten Laane, 2018) [5]. In terms of yield and productivity, proper foliar application of biostimulants is one of the better solutions. Growth and yield of okra depends upon many factors like seed quality, nutrition, climatic conditions, and cultural practices (Kusvuran, 2012) [6]. Chemical substances like plant growth regulators used to bring changes in the phenotypes of plants and affect growth either by enhancing or by stimulating the natural growth regulatory systems from seed germination to senescence. These helps to improve physiological efficiency of plants including photosynthetic capacity and effective partitioning of assimilates. The productivity in the field crops can be increased by stimulating the translocation of photo-assimilates. Although plant growth regulators have more potential for growth improvement but their application must be planned sensibly in terms of optimal concentration, stage of application, species specificity and seasons.

These are considered as new generation of agrochemicals after fertilizers, insecticides, and herbicides. Plant physiologists have recognized five well defined groups of plant growth substances *viz*., auxins, GA's, cytokinins, inhibitors (abscisic acid) and senescent hormone ethylene. The use of plant growth regulators has led to intensive scientific activity for their commercial exploitation. Since, 1949 several valuable effects of different plant growth regulators have been studied on several horticultural crops. Hence, the present investigation was conducted to study the effect of different plant growth regulators on growth, yield and yield attributing characters of *kharif* Okra (*Abelmoschus esculentus* L.).

Materials and Methods

The field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *kharif*, 2021 with the okra variety of Hybrid Mahyco-10. The site was selected based on suitability of soil for growing okra. Topography of the plot was the uniform. The soil analysis indicated that, the experimental plot was sandy clay loam in texture, medium in available nitrogen (253.16 kg ha^{-1}), phosphorus (11.22 kg ha^{-1}) and potassium (279.17 kg ha^{-1}), medium in organic carbon (11.20 g kg^{-1}), acidic in reaction (pH 5.80) and 0.12 dS m^{-1} electrical conductivity.

The experiment was laid out in Randomized Block Design (RBD) with seven treatments and replicated three times. The treatments are as given in table 1. The following seven treatments (Table 1) are included in the study. The recommended dose of fertilizers (100: 50: 50 kg N, P and K kg ha^{-1}) and other package of practices for okra were imposed uniformly for all the treatments including control treatments.

Table 1: Treatment details for the field experiment

Symbols	Treatments
T1	Untreated control.
T2	Bio-stimulant @ 100 g ha^{-1} Danza powder
T3	Bio-stimulant @ 175 g ha^{-1} (Danza powder)
T4	Bio-stimulant @ 250 g ha^{-1} (Danza powder)
T5	Bio-stimulant @ 325 g ha^{-1} (Danza powder)
T6	Bio-stimulant @ 500 g ha^{-1} (Danza powder)
T7	Tricontanol bio-stimulsnt @ 0.05% EC @ 250 ml ha^{-1}
Method of application: Foliar applications) **1st Application**: 2-3 weeks after sowing **2nd Application**: 1st week after flowering.	
Note: Bio-stimulant made from amino acid, sea weed extract vitamins and fermented product.	

Results and Discussion

In okra (*Abelmoschus esculentus* L.) var. Hybrid Mahyco-10, the plant growth and yield attributes and crop yields were highly influenced by application of bio-stimulant.

Effect on growth parameters

There was significance difference between treatments for the plant height, number of leaves per plant and dry matter production of okra crop at 60 DAS (Days after sowing) and 90 DAS of okra crop but no significant difference at 30 DAS.

Significantly higher plant height is depicted for T_6 treatment (Bio-stimulant @ 500 g ha^{-1}) at 60 DAS (98.67 cm) whereas T_5 and T_4 treatments were found at par with T_6 treatment. At 90 DAS, significantly higher plant height of 191.58 cm was observed for T_6 treatment (bio-stimulant @ 500 kg ha^{-1}) whereas T_5 and T_4 treatments were found at par with T_6 treatment (Table 2). This increase might be due to the existence of organic constituents of sea weed extract, amino acid, vitamins etc. which elicit strong physiological responses in lower doses (Pramanick *et al*., 2013) [8]. From the present investigation it was found that, at 30 DAS there was no any significant difference among the treatments for functional leaves per plant but from 60 DAS and 90 DAS number of functional leaves $plant^{-1}$ were significantly higher for T_6 treatment (11.16 and 10.17 respectively) whereas T_5 and T_4 treatments were found at par with T_6 treatment. Gaikwad *et al.*, (2021) [2] reported that plant growth regulators enhanced morpho-physiological parameters such as plant height, number of branches per plant, number of leaves per plant, number of flowers per plant, and days to 50 percent flowering significantly when compared to control.

At 30 DAS there was no significant difference among the treatments for dry matter produced $plant^{-1}$. At 60 DAS and 90 DAS dry matter produced $plant^{-1}$ was significantly higher (5.37 and 16.77 g respectively) for T_6 treatment (bio-stimulant @ 500 g ha^{-1}) and lowest (4.42 and 15.40 g respectively at 60 and 90 DAS) for T_1 treatment (control treatment). T_5 and T_4 treatments were found at par with T_6 treatment. Gaikwad *et al.*, (2021) [2] reported that plant growth regulators enhanced morpho-physiological parameters such as plant height, number of branches per plant, number of leaves per plant, number of flowers per plant, and days to 50 percent flowering significantly when compared to control. These results agree with those of Muhammad *et al*., (2018) [7], Verma *et al*., (2019) [12].

Table 2: Influence of plant growth regulators on growth parameters

Treatments	Plant height (cm)			No. of functional leaves $plant^{-1}$			Dry matter accumulation $plant^{-1}$ (g)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1	83.77	169.33	171.14	8.18	7.58	7.16	4.42	15.40	15.63
T_2	86.65	173.69	176.10	8.85	8.51	7.91	4.55	16.07	16.20
T_3	86.73	183.00	185.69	9.91	9.21	8.12	4.72	16.20	16.33
T_4	95.90	188.17	190.07	10.72	9.74	8.89	5.13	16.33	16.47
T_5	95.94	188.38	190.44	10.91	9.91	9.17	5.21	16.40	16.57
T_6	98.67	191.58	193.57	11.16	10.17	9.26	5.37	16.77	16.83
T_7	84.73	171.57	173.38	8.17	8.17	7.42	4.48	15.53	15.97
S.Em. (±)	0.90	0.35	0.37	0.14	0.26	0.23	0.35	0.46	0.45
C.D. at 5%	2.77	1.09	1.13	0.43	0.81	0.70	4.84	16.10	16.29

Effect on yield and yield attributing characteristics

Total yield may appraise to be the mirror of all the growth and yield features. Significantly higher yield attributes were recorded under T_6 treatment (bio-stimulant @ 500 g ha^{-1}) *viz*., Number of fruits $plant^{-1}$ (17.66), Avg. length of fruit (cm) (14.46) and avg. fruit weight (12.49 cm) whereas T_5 and T_4

treatments were found at par with T_6 treatment (Table 3). Numerically lesser no. of fruits per plant (13.46), avg. length of fruit (cm) (9.83) and avg. fruit weight (11.23 cm) found for untreated treatment (T_1). Gadade *et al.* (2017) [3] also reported that, application of Plant growth regulators significantly boosts the yield per plant of okra.

Table 3: Influence of plant growth regulators on fruit yield and yield attributing characteristics

Treatments	Number of fruits plant^{-1}	Average length of fruit (cm)	Average fruit weight (g)	Weight of fruits plant^{-1} (g)	Weight of fruit yield (t ha^{-1})
T_1	13.46	9.83	11.23	151.21	11.50
T_2	14.52	10.50	11.16	162.10	12.58
T_3	15.88	11.37	11.37	180.55	14.15
T_4	17.21	13.14	12.14	208.94	15.48
T_5	17.31	13.49	12.16	210.50	15.59
T_6	17.66	14.16	12.49	220.64	16.34
T_7	14.49	9.76	11.25	163.15	12.42
S.Em. (±)	0.43	0.34	0.27	6.99	0.43
C.D. at 5%	1.34	1.04	0.85	21.54	1.32

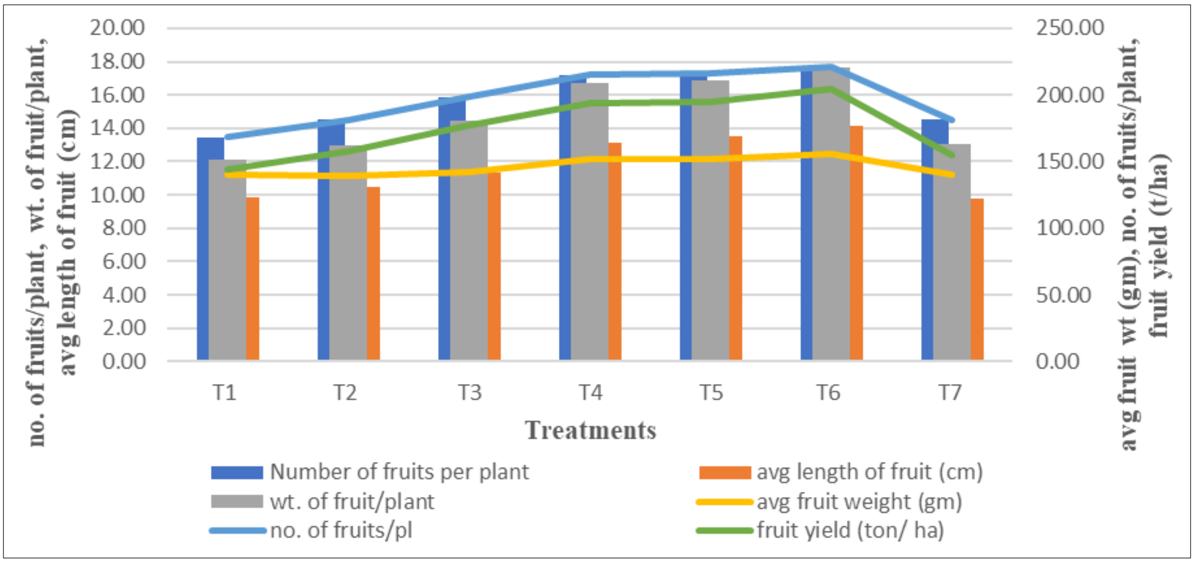

Fig 1: Graph showing yield and yield attributing characters

All these characters contributed positively towards the fruit yield. Application of bio-stimulant @ 500 g ha^{-1} (T_6) recorded highest fruit yield of 16.34 t ha^{-1}. Whereas T_5 and T_4 treatments were found at par with T_6 treatment which is depicted in Table 3 and Fig 1. T_6 treatment produced 42.08 percent higher fruit yield then untreated treatment (T_1). Lower value of fruit yield (11.50 t ha^{-1}) is recorded by untreated treatment (T_1). Favourable response to yield might be attributed to the better availability of plant nutrients throughout the growth period and especially in critical growth period of okra crop which resulted into better plant vigour and superior yield attributes. Compare to control plants bio-stimulants treated plants significantly improves morphological, physiological and yield traits of okra. Similar findings were also reported by Sekar *et al.*, 1995 [9] that the application of seaweed extracts increased the growth and yield of horticulture crops. Durand *et al.*, (2003) [1] reported that the liquid extract obtained from seaweeds has recently gained much interest as foliar spray for increasing growth and yield in cereal crops, vegetables, fruits, orchards and horticultural plants. The extracts obtained from the marine algae improved the growth and yield of various crops (Turan and Kose 2004; Stirk *et al.*, 2004) [11, 10]. Seaweeds provide an excellent source of bioactive compounds like essential fatty acids, vitamins, amino acids, minerals and growth promoting substances.

Conclusion

The study on the effect of plant growth regulators on growth, yield and yield attributing characters of *kharif* okra (*Abelmoschus esculentus* L.) concluded that, foliar application of bio-stimulant @ 500 g ha^{-1} (at 2-3 weeks after sowing and 1st week flowering of okra) had higher crop growth parameters *viz*., plant height, number of leaves per plant and dry weight and yield parameters *viz*., fruit length, no. of fruits per plant, avg. length of fruit and fruit yield. The fruit yield was also increased by 42.08 per cent over untreated treatment.

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