*Mysore J. Agric. Sci., 58 (3) : 306-315 (2024)*

# Efficacy of Biostimulants on Growth Attributes and Seed Yield Attributes in Okra [*Abelmoschus esculentus* (L.) Moench]

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*Received* : May 2024
*Accepted* : June 2024

**Abstract**

The study was carried out on 'Efficacy of biostimulants on seed yield and quality in okra [*Abelmoschus esculentus* (L.) Moench]' during *rabi*, 2022 at 'E' block, ZARS, GKVK, UAS, Bengaluru. The experiment constituted of ten different bio-stimulants treatments and replicated three times in Randomized Complete Block Design. Significant difference was noticed in crop growth, seed yield and quality parameters. Among treatments imposed, the treatment Allwin Gold Super @ 750 ml/ha recorded the highest growth, seed yield and quality parameters *viz*., plant height (82.63 cm), number of leaves per plant (15.69), number of branches per plant (6.08), chlorophyll content-SPAD reading (57.71) at 75 days after sowing , number of fruits per plant (12.90), fruit yield per hectare (89.80 q), pod length (18.39 cm), number of pods per plant (7.02), number of seeds per pod (53.98), hundred seed weight (6.98 g), seed yield per plant (24.59 g) and seed yield per hectare (13.75 q). The highest net returns (Rs.5,47,970 $ha^{-1}$) with the highest B:C ratio (4.93) was obtained from treatment Allwin Gold Super @ 750 ml/ha. It could be concluded compared to control that foliar spray of biostimulant Allwin Gold Super @ 750 ml/ha at vegetative stage, flower initiation stage and pod formation stage results in the highest growth and seed yield with maximum B:C ratio.

*Keywords* : Allwin, Biostimulant, Chlorophyll, Okra, Seed quality

Okra (*Abelmoschus esculentus* (L.) Moench), often referred to as lady's finger or bhendi, a member of the *Malvaceae* family, is a significant annual vegetable crop. Okra is predominantly a rainfed crop but it thrives well under irrigated conditions. Okra is grown on 0.659 million hectares in India and produces 6.346 million tonnes of green pods annually and yields 11.9 tonnes per hectare. While in Karnataka, it is cultivated on an area of 8,286 hectares with a productivity of 8.23 tonnes per hectare of green fruits and an annual yield of 68,252 tonnes (Anonymous, 2020).

Okra's growth and yield are influenced by a number of variables, such as the quality of the seed, production practices and special practices like application of plant growth regulators that may bring changes in plant phenotype and growth by stimulating the natural growth regulatory systems, (Das & Das, 1995 and Cardarelli *et al.,* 2022). Foliar spray appears to hold promise for ensuring that nutrients given are used effectively. Foliar spray gives plants the ability to absorb the nutrients from the solution through the surface of their leaves, which may lead to the efficient use of nutrition. The high effectiveness, rapid plant responses, convenience and elimination or reduction of toxicity symptoms brought by excessive soil accumulation of given element due to foliar nutrition makes it more reliable.

Biostimulants are substances other than fertilizers that, when used wisely in lesser quantities, (Kauffman *et al*., 2007). Main categories of biostimulants are acids (Amino acids, Humic acid, Fulvic acid, Salicylic

acid and other organic acids), extracts (Sea weed extract, plant derivatives, polyphenols, secondary metabolites *etc*.), micro-organisms (Beneficial fungi, beneficial bacteria and microbial symbiosis with plants) and others (inorganic salts, vermicompost, manures, *etc*.). These biostimulants acts on different physiological functions of plants like protection of photosynthetic machinery against photo-damage, initiation of lateral roots, scavenging reactive oxygen species by antioxidants, increases synthesis of growth hormones *etc*. All of these activities enhance the effectiveness with which nutrients are used by plants, assisting them in overcoming abiotic stress and producing seeds of higher yield and greater quality seeds (Rajendra Prasad *et al*., 2020).

Plant growth can be influenced by biostimulants both internally and externally [(Roberts *et al*., 2015, Gowramma *et al.,* 2023)]. Internally, they stimulate a variety of biological processes, including photosynthesis, respiration, synthesis of nucleic acids, production of antioxidants and chlorophyll and improved metabolism (Sharma *et al*., 2013). Externally, by promoting soil microbial activity and soil enzymes through the development of phytohormone activity, they interact with the environment (Duan-yin *et al*., 2014). Additionally, several biostimulants promote the growth of organisms that interact with phytohormones, both endophytic and non-endophytic (Brown and Saa, 2015). Therefore, biostimulants can enhance quality and production, increase plant tolerance to abiotic stress and recovery from it, promote nutrient uptake and translocation as well as its usage and stimulate efficient water use (Calvo *et al*., 2014, Bulgari *et al*., 2019). All growth phases of a plant's life cycle, from germination to full maturity, are facilitated by biostimulants (Calvo *et al*., 2014 and Gouramma *et al.,* 2023).

With this background, an investigation on Use of biostimulants on okra (*Abelmoschus esculentus* (L.) Moench crop to study its influence on growth, seed yield and quality with objective to know the impact of bio stimulants on increasing growth and yield parameters, improving seed quality and economics on use of biostimulants.

## Material and Methods

The field experiment was conducted at 'E' Block, ZARS, UAS, GKVK, Bengaluru during *rabi*, 2022. The experiment site was situated at an altitude of 924m above Mean sea level (MSL) between a attitude of $13^0$ 05" North longitude of $77^0$ 34' East. The experiment was conducted in RCBD with ten treatments in three replications. A total rainfall received during the experimentation period from December, 2022 to April, 2023 was 14420 mm.

### Source of Seeds

Seeds of okra - Arka Anamika variety were procured from ICAR-IIHR, Bengaluru. Seeds having initial germination of 80 per cent were used for the study.

**Treatment details**

| SI. No. | Treatments | Dosage |
|---|---|---|
| $T_1$ | Allwin Gold Super | 500 ml/ha |
| $T_2$ | Allwin Gold Super | 750 ml/ha |
| $T_3$ | Allwin Gold Super | 1000 ml/ha |
| $T_4$ | Allwin Gold Super | 1500 ml/ha |
| $T_5$ | Jaivizyme | 900 ml/ha |
| $T_6$ | Vermihume SL | 600 ml/ha |
| $T_7$ | Ascorbic acid | 300 ppm |
| $T_8$ | Gibberellic acid | 100 ppm |
| $T_9$ | Salicylic acid | 100 ppm |
| $T_{10}$ | Control | - |

Arka Anamika, a okra variety developed at ICAR-IIHR, Hesaragatta, Bengaluru derived from interspecific hybridization between *Abelmoschus esculentus* (IIHR 20-31) x *A.manihot spp. Tetraphyllus* (Resistant to YVMV) followed by backcross. Plants are tall, well branched. Fruits are lush green, tender long and borne in two flushes. Green stem with purple shade. Fruits free from spines having 5-6 ridges, delicate aroma. Good keeping and cooking qualities. This variety is suited for irrigated condition. The variety takes 130-135 days for maturity and is resistant to Yellow Vein Mosaic Virus.

Variety Arka Anamika of okra was sown during *rabi* 2nd December, 2022 with hand sowing at the spacing

of 60 × 30 cm with seeds at a proper depth of 3 cm. Recommended dose of fertilizer for okra 125:75:63 NPK kg/ha was applied to all the treatments as basal dose at the time of sowing in the form of Urea, Di Ammonium Phosphate and Muriate of Potash. surface irrigation was provided for one to two times weekly. The irrigation schedule varied based on the weather parameters persisted during the investigation period, the quantity of irrigation was decided looking into the soil moisture. Two to three hand weeding's were taken during the first six weeks after sowing with an interval of 15 days commencing from 20 days after emergence. The foliar application of the biostimulants was taken at 25, 45 and 65 Days After Sowing.

The different bio stimulant includes were Allwin Gold Super consists of seaweed extract (*Ascophyllum nodusum*), amino acids, humic acid and its derivatives. Jaivizyme consists of seaweed extract (*Sargassum* sps.) and proteins compounds. Vermihume SL consists of concentrated vermicompost liquid which content bio-acitve humic and fulvic substances.

## Results and Discussion

### Plant Height (cm)

The data on plant height as influenced by foliar application of biostimulants is presented in Table 1 and Plate 1.

**Table 1**

**Influence of foliar application of biostimulants on plant height (cm) at 35, 55 and 75 DAS in Okra var. Arka Anamika**

| Treatments | Plant height (cm) | | |
|---|---|---|---|
| | 35 DAS | 55 DAS | 75 DAS |
| $T_1$ | 23.16 | 57.95 | 75.69 |
| $T_2$ | 25.83 | 63.25 | 82.63 |
| $T_3$ | 24.92 | 60.75 | 76.65 |
| $T_4$ | 23.42 | 59.19 | 73.09 |
| $T_5$ | 21.96 | 54.67 | 68.80 |
| $T_6$ | 21.10 | 54.04 | 68.09 |
| $T_7$ | 21.94 | 58.50 | 67.76 |
| $T_8$ | 21.18 | 50.49 | 65.63 |
| $T_9$ | 20.63 | 49.98 | 64.85 |
| $T_{10}$ | 19.85 | 48.03 | 61.64 |
| Mean | 22.40 | 55.69 | 70.48 |
| S.Em± | 1.06 | 2.68 | 3.65 |
| CD (P=0.05) | 3.16 | 7.96 | 10.85 |
| CV (%) | 8.22 | 8.33 | 8.97 |

The results revealed that the plant height at different days interval differed significantly due to foliar application of biostimulants. At 35 DAS, the highest plant height (25.83 cm) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (24.92 cm) (Allwin Gold Super @ 1000 ml/ha). The

Control ($T_{10}$) Allwin Gold Super @ 750 ml/ha ($T_2$)

Plate 1 : Influence of bio stimulants on pod length in okra var. Arka Anamika

lowest plant height (19.85 cm) was recorded in control ($T_{10}$). The same trend was noted at 55 and 75 days after sowing.

The application of Allwin Gold Super @ 750 ml/ha resulted in significant enhancement in the growth of okra plants. These findings align with those reported by Layek *et al.* (2023), wherein the application of *Kappaphycus alvarezii* (K sap) similarly elevated the plant height of both French bean and okra. Consistent observations of increased plant height following seaweed application have also been documented by Divya *et al.* (2015a) for okra. The increase in plant vegetative growth, as observed in plant height, could be due to the growth regulators and nutrients found in seaweed extract. These elements may have influenced the cellular metabolism of the treated plants, resulting in improved plant growth (Crouch & Stoden, 1992 and Reitz & Trumble, 1996).

The increased plant height with application of seaweed extract might be because of increased root proliferation and establishment, thereby the plants were able to mine more nutrients even from the distant places and deeper soil horizons, in balanced proportion and it also regulated plant bio-physiological activities which collectively result in maintaining higher photosynthetic activities (Zodape *et al*., 2008).

**Number of Leaves Per Plant**

The results on number of leaves per plant as influenced by foliar application of biostimulants is presented in Table 2.

The results revealed that the number of leaves per plant differed significantly due to foliar application of biostimulants at 35, 55 and 75 days after sowing (DAS). At all intervals and also at 75 DAS, the highest number of leaves per plant (15.69) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (14.26) (Allwin Gold Super @ 1000 ml/ha). The lowest number of leaves per plant (11.79) was recorded in control ($T_{10}$).

**TABLE 2**

**Influence of foliar application of biostimulants on number of leaves per plant and number of branches per plant at 35, 55 and 75 DAS in Okra var. Arka Anamika**

| Treatments | Number of leaves per plant | | | Number of branches per plant | | |
|---|---|---|---|---|---|---|
| | 35 DAS | 55 DAS | 75 DAS | 35 DAS | 55 DAS | 75 DAS |
| $T_1$ | 7.51 | 9.75 | 14.12 | 2.45 | 3.72 | 5.62 |
| $T_2$ | 8.32 | 10.60 | 15.69 | 2.98 | 4.20 | 6.08 |
| $T_3$ | 7.89 | 9.79 | 14.26 | 2.55 | 3.94 | 5.44 |
| $T_4$ | 7.27 | 9.78 | 13.52 | 2.54 | 3.53 | 5.25 |
| $T_5$ | 7.13 | 9.29 | 13.05 | 2.62 | 3.47 | 5.02 |
| $T_6$ | 7.01 | 9.22 | 13.16 | 2.37 | 3.57 | 5.06 |
| $T_7$ | 6.93 | 9.06 | 12.82 | 2.54 | 3.40 | 4.73 |
| $T_8$ | 7.07 | 9.29 | 13.06 | 2.38 | 3.54 | 5.07 |
| $T_9$ | 6.57 | 8.83 | 12.47 | 2.37 | 3.36 | 4.76 |
| $T_{10}$ | 6.18 | 8.24 | 11.79 | 2.29 | 3.13 | 4.39 |
| Mean | 7.19 | 9.38 | 13.39 | 2.51 | 3.59 | 5.14 |
| S. Em± | 0.36 | 0.49 | 0.71 | 0.12 | 0.19 | 0.28 |
| CD (P=0.05) | 1.08 | 1.45 | 2.11 | 0.36 | 0.56 | 0.83 |
| CV (%) | 8.74 | 9.03 | 9.17 | 8.46 | 9.08 | 9.42 |

Seaweed extracts, abundant in nutrients encompassing both macronutrients and micronutrients, were taken up by plants through their stomata, thereby enhanced overall plant health and vigour and resulted in increased leaf production. The results are in accordance with the earlier findings of Divya *et al*. (2015) in brinjal.

The result obtained for number of leaves per plant due to presence of cytokinins in sea weed extract (Stirk *et al*., 2004), this plant hormone stimulates axillary bud growth by cell division and cell elongation (Taiz *et al*., 2017). Albrecht *et al*. (2011) studied a growth regulator containing cytokinin, gibberellin and auxin in soybean crops and also observed positive effect up to certain dose. Author reported that high dose causes negative physiological effect due to hormonal imbalance.

**Number of Branches Per Plant**

The results pertaining to number of branches per plant as influenced by foliar application of biostimulants is presented in Table 2.

The results revealed that the number of branches per plant differed significantly due to foliar application of biostimulants. At 35 DAS, the highest number of branches per plant (2.98) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_5$ (2.62) (Jaivizyme @ 900 ml/ha). The lowest number of branchesper plant (2.29) was recorded in control ($T_{10}$). At 55 DAS, the highest number of branchesper plant (4.20) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (3.94) (Allwin Gold Super @ 1000 ml/ha). The lowest number of branchesper plant (3.13) was recorded in control ($T_{10}$). The same trend was noted at 75 DAS.

The rise in the number of branches per plant following the use of seaweed extract could be attributed to the auxins, cytokinins and additional nutrients found in the extract. These components are believed to facilitate cell division and elongation and play a pivotal role in maintaining the equilibrium of biological processes within plant tissues (Wajahatullah *et al*., 2009).

**Chlorophyll Content (SPAD- Reading)**

The data related to the chlorophyll content in leaves as influenced by foliar application of biostimulants is presented in Table 3.

**TABLE 3**

**Influence of foliar application of biostimulants on chlorophyll content of leaves at 35, 55 and 75 DAS in Okra var. Arka Anamika**

| Treatments | Chlorophyll content of leaves (SPAD-reading) | | |
|---|---|---|---|
| | 35 DAS | 55 DAS | 75 DAS |
| $T_1$ | 44.44 | 47.69 | 52.72 |
| $T_2$ | 46.26 | 52.88 | 57.71 |
| $T_3$ | 44.58 | 49.70 | 54.73 |
| $T_4$ | 43.41 | 47.71 | 52.09 |
| $T_5$ | 42.55 | 47.08 | 51.85 |
| $T_6$ | 42.07 | 46.77 | 51.06 |
| $T_7$ | 38.76 | 44.46 | 49.11 |
| $T_8$ | 41.49 | 46.86 | 50.09 |
| $T_9$ | 39.77 | 43.08 | 48.40 |
| $T_{10}$ | 37.28 | 42.22 | 45.83 |
| Mean | 42.06 | 46.85 | 51.36 |
| S. Em± | 2.08 | 1.92 | 2.11 |
| CD (P=0.05) | NS | 5.71 | 6.27 |
| CV (%) | 8.57 | 7.11 | 7.12 |

The results revealed that the chlorophyll content in leaves varied significantly due to foliar application of biostimulants. At 35 DAS, there was no significant difference in the chlorophyll content in leaves due to the application of biostimulants. However, the highest chlorophyll content in leaves (46.26) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha). The lowest chlorophyll content in leaves (37.28) was recorded in control ($T_{10}$). At 55 DAS, there was significant difference was found, highest chlorophyll content in leaves (52.88) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (49.70) (Allwin Gold Super @ 1000 ml/ha). The lowest chlorophyll content in leaves (42.22). At 75 DAS, the highest number of branches per plant (57.71) was

recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_1$ (54.73) (Allwin Gold Super @ 500 ml/ha). The lowest number of branches per plant (45.83) was recorded in control ($T_{10}$).

The rise in chlorophyll content could be attributed to the micronutrients such as iron and magnesium found in seaweed extract, both of which are vital constituents of chlorophyll molecules. The seaweed extract also contains betaine which reduces chlorophyll degradation thus enhancing chlorophyll content of treated plants (Whapham *et al*., 1993). The results were in accordance with Aremu *et al*. (2022) in okra when applied with *Ecklonia maxima* seaweed extract at low concentration.

**Pod Length (cm)**

The results on the pod length as influenced by foliar application of biostimulants is presented in Table 4. and Plate 1. The results showed that the pod length had a significant difference between the different treatments due to the foliar application of biostimulants. The highest pod length (18.39 cm) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) with 33.41 per cent increase over the control ($T_{10}$) which was followed by $T_3$ (17.29 cm) (Allwin Gold Super @ 1000 ml/ha) with 25.44 per cent increase over the control ($T_{10}$). The lowest pod length (13.79 cm) was recorded in control ($T_{10}$).

The notable augmentation in pod length could potentially be attributed to the presence of growth regulators such as gibberellic acid and cytokinin found within seaweed extract. Gibberellic acid is known to enhance both cell division and cell elongation, as documented in prior research (Tripathi *et al*., 2011). It has been reported to stimulate growth by augmenting the plasticity of the cell wall, subsequently leading to the hydrolysis of starch into sugar. This enzymatic process ultimately reduces the cell wall potential, facilitating the entry of water into the cell and consequently resulting in its elongation.

**TABLE 4**

**Influence of foliar application of bio stimulants on pod length (cm), number of pods per plant, number of seeds per pod, hundred seed weight (g), seed yield per plant (g), seed yield per plot (kg) and seed yield per hectare (q) in Okra var. Arka Anamika**

| Treatments | Pod length (cm) | Number of pods per plant | Number of seeds per pod | Hundred seed weight (g) | Seed yield per plant (g) | Seed yield per plot (kg) | Seed yield per hectare (q) |
|---|---|---|---|---|---|---|---|
| $T_1$ | 17.22 | 6.39 | 51.04 | 6.42 | 21.08 | 0.88 | 11.69 |
| $T_2$ | 18.39 | 7.02 | 53.98 | 6.98 | 24.59 | 1.04 | 13.75 |
| $T_3$ | 17.29 | 6.54 | 52.51 | 6.48 | 23.52 | 0.99 | 13.13 |
| $T_4$ | 16.81 | 6.28 | 51.04 | 6.29 | 22.42 | 0.94 | 12.47 |
| $T_5$ | 16.35 | 6.02 | 48.35 | 6.20 | 21.94 | 0.92 | 12.22 |
| $T_6$ | 16.52 | 5.94 | 47.56 | 6.24 | 21.74 | 0.91 | 12.09 |
| $T_7$ | 15.92 | 5.73 | 46.53 | 6.10 | 20.25 | 0.85 | 11.22 |
| $T_8$ | 16.57 | 6.11 | 50.24 | 6.16 | 21.38 | 0.90 | 11.87 |
| $T_9$ | 14.97 | 5.60 | 45.52 | 5.71 | 20.17 | 0.85 | 11.17 |
| $T_{10}$ | 13.79 | 5.21 | 43.74 | 5.48 | 18.45 | 0.77 | 10.19 |
| Mean | 16.38 | 6.08 | 49.05 | 6.21 | 21.56 | 0.91 | 11.98 |
| S. Em± | 0.75 | 0.26 | 2.04 | 0.25 | 1.08 | 0.05 | 0.64 |
| CD (P=0.05) | 2.24 | 0.78 | 6.07 | 0.76 | 3.20 | 0.14 | 1.89 |
| CV (%) | 7.97 | 7.45 | 7.21 | 7.11 | 8.67 | 9.01 | 9.20 |

In the current investigation, foliar applications of seaweed extract yielded a significant increase in pod length when compared to the control. Previous research by Blunden *et al.* (1997) has revealed that seaweed extract contains substantial quantities of cytokinin, auxins and betaines, which may have exerted an influence on cell division during the early stages of pod growth. Notably, betaine present in the seaweed extract also plays a role in reducing chlorophyll degradation, thus enhancing the chlorophyll content in treated plants (Whapham *et al*., 1993). This enhancement subsequently leads to an increased rate of $CO_2$ assimilation, thereby augmenting the supply of assimilates to the pods and consequently enhancing pod size and weight.

**Number of Pods Per Plant**

The data related to the number of pods per plant as influenced by foliar application of biostimulants is presented in Table 4. The results revealed that the number of pods per plant had a significant difference between the different treatments due to the foliar application of biostimulants. The highest number of pods per plant (7.02) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (6.54) (Allwin Gold Super @ 1000 ml/ha). The lowest number of pods per plant (5.21) was recorded in control ($T_{10}$).

**Number of Seeds Per Pod**

The results with respect to the number of seeds per pod as influenced by foliar application of biostimulants is presented in Table 4. The results showed that the number of seeds per pod showed a significant difference between the different treatments due to the foliar application of biostimulants. The highest number of seeds per pod (53.98) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (52.51) (Allwin Gold Super @ 1000 ml/ha). The lowest number of seeds per plant (43.74) was recorded in control ($T_{10}$).

**Hundred Seed Weight (g)**

Hundred seed weight was influenced by foliar application of biostimulants are presented in Table 4. The higher test weight/ hundred seed weight (6.98 g) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (6.48 g) (Allwin Gold Super @ 1000 ml/ha). The lowest hundred seed weight (5.48 g) was recorded in control ($T_{10}$).

The foliar spray of bio-stimulants was found to be promising in obtaining the larger pod length, higher number of pods per plant, higher number of seeds per pod and higher test weight of the seeds. The substantial increase in the growth of the plants leading to higher values in all above treatment. The beneficial effects of seaweed extract may be due to presence of some growth promoting substances like IAA, gibberellins, cytokinins, micronutrients and amino acids due to which there is increased cell division, cell elongation and also increased photosynthetic activity and subsequent accumulation of the photosynthates in plant organ accounting for more weight, longer pod length and more number of seeds per pod, ultimately resulting in higher test weight of seeds (Shahid *et al*., 2013).

Saeed *et al*. (2005) on soybean noticed that treatments of amino acids significantly improved growth parameters of shoots and fresh weight as well as pod yield. The similar results observed by Venkat *et al*. (2015) in green gram and Kocira *et al*. (2013), who found that foliar spraying of seaweed extract influenced on the number of pods in common bean plant.

**Seed Yield Per Plant (g)**

The results with respect to the seed yield per plantas influenced by foliar application of biostimulants is presented in Table 4. The data revealed that the seed yield per plant showed a significant difference between the different treatments due to the foliar application of biostimulants. The highest seed yield per plant **(**24.59 g) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (23.52 g) (Allwin Gold Super @ 1000 ml/ha). The lowest seed yield per plant (18.45 g) was recorded in control ($T_{10}$).

**Seed Yield Per Plot (kg)**

The data related to the seed yield per plot as influenced by foliar application of biostimulants is presented in Table 4. The results revealed that the seed yield per plot showed a significant difference between the different treatments due to the foliar application of biostimulants. The seed yield per plot (1.04 kg) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (0.99 kg) (Allwin Gold Super @ 1000 ml/ha). The lowest seed yield per plot (0.77 kg) was recorded in control ($T_{10}$).

**Seed Yield Per Hectare (q)**

The data with respect to the seed yield per hectare as influenced by foliar application of biostimulants is presented in Table 4. The results revealed that the seed yield per hectare showed a significant difference between the different treatments due to the foliar application of biostimulants. The highest seed yield per hectare (13.75 q) was recorded in $T_2$ (Allwin Gold Super @ 750 ml/ha) which was followed by $T_3$ (13.13 q) (Allwin Gold Super @ 1000 ml/ha). The lowest seed yield per hectare (10.19 q) was recorded in control ($T_{10}$).

According to several studies (Spinelli *et al*., 2009 and Abdel-Mawgoud *et al*., 2010), seaweeds include a variety of trace elements (Fe, Cu, Zn, Co, Mo, Mn and Ni), vitamins, amino acids and plant growth hormones like IAA, IBA and Cytokinins due to which there is an increased translocation and assimilation of the photosynthates from source to sink and also increase in seed yield due to application of Allwin Gold Super @ 750 ml/ha. Albrecht *et al*. (2011) reported that high dose causes negative physiological effect due to hormonal imbalance. This is reason why $T_3$ (Allwin Gold Super @ 1000 ml/ha) and $T_4$ (Allwin Gold Super @ 1500 ml/ha) showed poor results when compared to $T_2$ (Allwin Gold Super @ 750 ml/ha).

**Economics**

The treatment $T_2$ (Allwin Gold Super @ 750 ml/ha) recorded the highest gross and net returns (Rs.687500 $ha^{-1}$ and Rs.547970 $ha^{-1}$, respectively), subsequently highest B:C ratio (4.93) was observed in $T_2$ (Allwin Gold Super @ 750 ml/ha) and lowest B:C ratio (3.68) was recorded in the treatment $T_{10}$ (Control).

**Table 5**

**Influence of different biostimulants on net returns (Rs.$ha^{-1}$) and B:C ratio in Okra var. Arka Anamika**

| Treatments | Cost of cultivation (Rs. /ha) | Gross return (Rs. /ha) | Net return (Rs. /ha) | B:C ratio |
|---|---|---|---|---|
| $T_1$ | 139155 | 584500 | 445345 | 4.20 |
| $T_2$ | 139530 | 687500 | 547970 | 4.93 |
| $T_3$ | 139905 | 656500 | 516595 | 4.69 |
| $T_4$ | 140655 | 623500 | 482845 | 4.43 |
| $T_5$ | 139377 | 611000 | 471623 | 4.38 |
| $T_6$ | 138681 | 604500 | 465819 | 4.36 |
| $T_7$ | 138562 | 561000 | 422438 | 4.05 |
| $T_8$ | 140395 | 593500 | 453105 | 4.23 |
| $T_9$ | 138419 | 558500 | 420081 | 4.03 |
| $T_{10}$ | 138405 | 509500 | 371095 | 3.68 |

Seed cost Rs.500 per kg

Treatment Allwin Gold Super @ 750 ml/ha can be used to for seed production to obtain maximize seed yield and highest growth parameters higher economic benefit also achieved with the B:C ratio of 4.93. As okra seeds are high value inputs and the foliar application of biostimulants is a simple inexpensive technology that could be adopted by the farmers and seed industry to improve the seed yield and quality (Table 5).

There is need to study the different combination of biostimulants that can be used to optimize both seed yield and quality. Further study needs to be done on the bio-chemical and physiological changes and mode of action due to application of biostimulants on plant.

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