**Original Research Article**

**EFFECT OF FOLIAR APPLICATION OF HUMIC ACID ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.)**

**Abstract**

The present experiment entitled "Effect of Foliar Application f Humic Acid on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.)" was undertaken at Horticulture Research Farm, Department of Horticulture, Chandra Bhanu Gupt Agriculture Post Graduate College, Bakshi Ka Talab, Lucknow during Kharif season of 2023-24. The study was consisted for six treatments of Humic Acid levels (control, 0, 5, 10, 15, and 20 ml/l). The experiment was laid out in Randomized Block Design and replicated three times. The results revealed that significantly higher Plant Height (cm), Number of Flowers per plant, Number of Fruits per Plant, Average Fruit weight (g), Fruit Length (cm) and Fruit yield (q/ha), while minimum Days to 50% Flowering, Days to First Fruit Set (Days), Days to First Fruit Picking (Days) were recorded with treatment of Humic Acid 15ml/l.

**Keywords: Okra, Abelmoschus esculentus L., Humic Acid and HA**

**INTRODUCTION**

Okra (*Abelmoschus esculentus* L.), belongs to family Malvaceae, has varying number of chromosomes ranging from 2n=56 to 2n = 199 (Siemonsma, 1982). The fruit is called as capsule which grows up to 15-18 cm long with pentagonal cross-section containing numerous seeds. It has several uses; tender okra fruits are used as vegetable and in culinary preparations as fried pieces. Fresh fruits are the popular ingredient of soups and stews where a gelatinous consistency is desirable and seeds are a source of oil, protein and are also used as a coffee substitute. Mature stems and fruits are used in paper industry, stems and roots of the okra are used to cleaning the sugarcane juice in manufacture of jaggery and sugar. Fruits of okra contain good amount of vitamins A 36mcg, B6 0.215mg, B1 0.2mg, K 31.3mg and C 23mg and protein 1.9g, carbohydrates 7.5g, fat 0.2g, Potassium 299mg, Calcium 82mg and Folate 60mcg in 100g of raw okra (Medical News Today, 2019). Okra has good demand all-round the year for its tender fruits and cultivated in tropical and subtropical regions of the world especially India, U.S.A., Nigeria, Sudan, Iraq, Pakistan, Turkey, Australia, U.K and other neighbouring countries. India stands number one in area and production of okra in the world. The total area and production under okra are reported to be 24.78 million hectare and 10.82 million tonnes, respectively in world and cultivated in an area of 0.53 million hectares, with a total production of 6.47 million tonnes (approximately 60%) in India (FAO, 2021). The key okra growing states in the country are Gujarat, West Bengal, Bihar, Madhya Pradesh, Orissa, Chattisgarh, Uttar Pradesh and Tamil Nadu, Assam, Haryana, Jammu & Kashmir, Maharashtra, Jharkhand (Anon., 2021). As a result, using different organic fertilisers, such as humic acid (HA), that don't affect the environment might help enhance okra yield, especially under these circumstances. For this reason, humic acid is known as an eco-friendly organic fertilizer (Samavat and Malakuti, 2005).

Increasing rate of Humic acid increased growth characters, yield characters and increase the percentage of protein (Aisha *et al*., 2014). Higher seed and stover yield, pods per plant, seed weight and better uptake of major and micronutrients was recorded due to the soil application and foliar spray of Humic acid (Shreelatha *et al*., 2020). Pasha *et al.* (2021) studied that the treatment combination with soil application of HA 15 ml/l + foliar application of HA 15 ml/l in recorded significantly higher plant height, more number of leaves and branches, highest leaf area and highest chlorophyll content in the leaves of okra plant.

Pavani *et al.* (2022) observed highest fruit weight per plant (327 gm) with the treatment T8 (100% RDF + 6 sprays of HA @ 1.5%), which was found statistically at par with treatments T6 (100% RDF+6 spray of HA @ 0.5%) and T7 (100% RDF+6 spray of HA @ 1.0%). While, significantly lowest fruit weight in Chilli plant was recorded in T1 (Absolute control) is 295 gm.

Use of HA at 200 and 400 mg/l. The results showed that the use of HA at different concentrations had a positive effect on chlorophyll a, b and total chlorophyll, seed yield and protein yield. Also, the time of application of HA had a significant impact on the measured traits. It seems that foliar application at the early period of reproductive growth has improved growth, increased flower fertility, and seed yield by increasing the absorption of nutrients. According to the results, foliar spraying with 300 mg/ha HA is the most appropriate treatment for proper Faba bean (Roudgarnejad *et al.,* 2022). The objective of this experiment is to apply different levels of HA at different growth times, evaluate finally, the quantitative and qualitative performance of okra.

**MATERIALS AND METHODS**

**Test site.** This experiment was performed at the research farm of Department of Horticulture, CBG Ag PG College, BKT, Lucknow, with latitude of 26 degrees and 84 minutes north and a longitude of 80 degrees and 94 minutes east and a height of 123 meters above sea level.

**Treatments studied**

The experiment was performed as a randomized complete block design with three replicates. Factors include time of foliar application (T1 - Absolute control, T2 - 100% RDF (125:75:60 kg N, P and K per hectare), T3 - 100% RDF + foliar spray of HA @ 5ml/l, T4 - 100% RDF + foliar spray of HA @ 10ml/l, T5 - 100% RDF + foliar spray of HA @ 15ml/l, T6 - 100% RDF + foliar spray of HA @ 20ml/l).

**Crop management**

The experimental site was prepared for cultivation in early January, 2024. At this time, tillage operations, including plowing, disking, and plotting, were performed. The dimensions of the experimental plots were 1.50 × 3 m. The distance between the planting rows was 25 cm, and the distance between the plants on the row was 15 cm, which was applied equally to all plots. The distance between the plots was considered to be 20 cm, and the distance between the blocks was considered to be 1 m.

**Data analysis**

The observations recorded for the randomly selected plants were worked out to give mean in respect of all the characters, *viz*. plant height (cm), Number of days to 50% flowering, number of branches per plant, day of first fruit set, Number of fruits per plant, Average fruit length (cm), Days to first harvest, Fruit yield per hectare. The statistical analysis of the data recorded in all observations was carried out by the method of “Analysis of the variance” prescribed by Fisher and Yates (1963). Comparison of treatment was made with the help of critical difference (C.D.).

**Results and discussion**

**1. Plant height (cm)**

Significant differences in plant height at 40 and 60 days were recorded among different treatments and the data recorded is presented in Table 1 and Fig. 1. At 40 DAS the maximum plant height (52.19 cm) was recorded with T5 (RDF + HA 15 ml/l, followed by T6 (45.07 cm) with RDF + HA 10ml/l, whereas, absolute control (T1) recorded minimum plant height (30.16 cm).

Similarly, at 60 DAS treatment T5 (RDF + HA 15 ml/l) resulted in significantly highest plant height (81.80 cm) followed by T6 (78.54 cm) RDF + HA 20 ml/l whereas, absolute control (T1) was recorded minimum plant height (54.95 cm) (Table 1). The increase in the plant height with foliar application of humic acid might be due to increased the uptake of calcium which played major role in the mitotic cell division of apical meristems and influenced the plant height as also noticed by Haider *et al*. (2017) in okra. Humic acid directly affect the vegetative growth, absorption of N, Ca, Mg, P and K by plant (Vanitha and Mohandass, 2014). Humic acid increases the uptake of calcium, which plays a major role in the mitotic cell division of apical meristems and influences plant height. Similar findings were reported by Pasha *et al*. (2021).

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| --- | --- |
| **Treatments** | **Plant Height (cm)** |
| **40 DAS** | **60 DAS** |
| T1 | Absolute control | 30.16 | 54.95 |
| T2 | 100% RDF (125:75:60 N P K kg ha-1 ) | 32.87 | 65.10 |
| T3 | 100% RDF + HA @ 5ml/l | 40.08 | 71.04 |
| T4 | 100% RDF + HA @ 10ml/l | 42.07 | 75.86 |
| T5 | 100% RDF + HA @ 15ml/l | 50.19 | 81.80 |
| T6 | 100% RDF + HA @ 20ml/l | 45.07 | 78.54 |
|  | SE(m)± | 0.23 | 0.28 |
|  | C.D. (P=0.05) | 0.74 | 0.89 |

**Table 1:** **Effect of Foliar Application of Humic Acid on Plant Height (cm) in Okra.**

**2. Days to flowering**

 The data on number of days taken to 50% flowering as influenced by foliar application of humic acid are presented in Table 2. The significant variation on number of days taken to 50% flowering was noticed among the treatments except in between control and RDF treated plants. Treatment T5 (44.33 days) (RDF + HA 15 ml/l) showed earliness in 50% flowering whereas, absolute control T1 had taken more (49.67 days) number of days taken to 50% flowering. From the present study RDF + HA 15 ml/l recorded least number of days taken 50% flowering. It might be due to increase in nutrient uptake due to humic acid. Humic acid acts like hormone in plant body and plays a major role in cell elongation and improve fungal and microbial activities in the soil (Haider *et al*., 2017). Similarly Kumar *et al.* (2015) also reported early flowering in okra with the application of humic acid. The data on number of days taken to first fruit picking as influenced by foliar application of humic acid are presented in Table 2.

 The significant variation on number of days taken to first fruit picking was noticed among the treatments. Treatment T5 (50.33 days) (RDF + HA 15 ml/l) recorded minimum number of days to first harvest followed by T6 (51.67 days) (RDF + HA 20 ml/l). Whereas, absolute control T1 had taken more (56.67 days) number of days to first fruit picking. Similarly Kumar *et al.* (2015) also reported early flowering in okra with the application of humic acid.

**3. Fruit Yield component and Fruit Yield**

The results pertaining to the number of fruits per plant in okra with humic acid application showed a significant difference (Table 2). Plants treated with RDF + HA 15 ml/l (T5) recorded the highest number of fruits per plant (21.33), followed by T6 (RDF + HA 20 ml/l) (20.00) which was on par with T4 (RDF + HA 10 ml/l) (18.67). The minimum number of fruits (13.67) produced per plant was in absolute control (T1). The increase in fruits per plant might be due to the positive effects of nutrients. NPS compost and humic acid sprays, which could have induced higher vegetative growth, ultimately helped in the synthesis of food material, which increased the number of fruits per plant. Similar results have also been recorded by Khalate *et al*., (2023) in brinjal. The data on fruit length with different concentrations of humic acid treatments in okra are presented in Table 2.

Length of fruit varied significantly with humic acid treatments. Maximum fruit length was recorded in treatment T5 (RDF + HA 15 ml/l) (12.25 cm) which is on par with T6 (RDF + HA 20 ml/l) (11.85 cm) followed by T4 (RDF + HA 10 ml/l, 11.10 cm). Fruit length was minimum 9.59 under absolute control T1. It might be due to the hormone-like activity of humic acids i.e., auxin, gibberellin and cytokinin like activity (Ibrahim *et al.*, 2019). Similar findings were also reported by (Pavani *et al*., 2022).

The data on average fruit weight with different concentrations of humic acid treatments in okra are presented in Table 2. The maximum average fruit weight was recorded in treatment T5 (RDF + HA 15 ml/l) (12.35 cm) which is on par with T6 (RDF + HA 20 ml/l) (12.10 cm) followed by T4 (RDF + HA 10 ml/l) (11.76 cm), while average fruit weight was minimum (8.93 cm) under absolute control (T1). Studied that using 5ml/l of humic acid increased significantly fruit set, yield and fruit weight of okra (Abd El-Baky *et al.,* 2020). Higher seed and stover yield, pods per plant, seed weight and better uptake of major and micronutrients was recorded due to the soil application and foliar spray of Humic acid (Shreelatha *et al*., 2020). The increase in fruit weight per plant in response to humic acid might be due to enhanced plant growth, plant canopy due to which plant can intercept light in a good way and as a result fruit weight of plant increased (Pavani *et al.*, 2022).

The data on fruit yield per hectare as influenced by application of humic acid are presented in Table 2. The treatment T5 with the application of (RDF + HA 15 ml/l) produced highest fruit yield per hectare (162.77 q/ha), which was found to be significantly superior over the other treatments followed by T6 (156.67 q/ha) (RDF + HA 20 ml/l), which was on par with T­4 (153.39 q/ha) (RDF + HA 10ml/l). Lowest fruit yield per hectare was recorded in absolute control T1 (115.45 q/ha).

Application of humic acid helps to increase the yield attributing characters by activating hormones like auxin and cytokinin and by increasing the cell division and enlargement and also maintains higher soil water potential and increase nutrient holding capacity of soil, thus the higher growth of plants in terms of height, number of leaves, number of nodes as well as number of branches per plant which ultimately increases the yield. Similar results were reported by Haider *et al*. (2017) and Kumar *et al*. (2015). Canellas *et al*. (2022) also reported the significant roles humic acid played in plant growth and development. Humic acid increases the leaf chlorophyll content which aids photosynthetic activity and increase photosynthate formation and hence, the yield of a crop is increased. The findings from this study are in agreement with the reports of Sadeghi *et al*. (2023) who found a significant increase in the yields of cucumber, pepper, and tomato respectively with the application of humic acid.

**CONCLUSION**

On the basis of the obtained results following conclusion may be drawn. Treatment RDF + HA 15ml/l was found to be the best with the maximum plant height (cm), number of branches per plant, earliest days to 50% flowering, number of flowers per plant, days to first fruit set (days) and days to first fruit picking (days). It also showed highest number of fruits per plant, average fruit weight (g), fruit length (cm), fruit yield per hectare (q), economics, as compared to absolute control.

**References**

Abd El-Baky, M.M.H., EL-Desuki, M., Salman, S.R., Mona, A.E.W., Abou Hussein, S.D. and Bakry, M.O. (2020). Effect of humic acid and Fulvic acid on growth and yield of two okra cultivars grown in Wadi El – Tor, South Sinai, Middle East. *Journal of Applied Science*, **10**(1): 101-109.

ANONYMOUS., 2024, National Horticulture Board, New Delhi, **p***.* 1-3.

Blandino, M., Badeck., F.W., Giordano., D., Marti., A., Rizza., F., Scarpino. V., Vaccino, P. (2020). Elevated CO2 impact on common wheat (*Triticum aestivum* L.) yield, whole meal quality, and sanitary risk. J. Agric. Food Chem., 68, 10574–10585.

Canellas L.P., Canellas N.O.A., Da Silva R.M., Spaccini R., Mota G.P., Olivares F.L. (2022) Biostimulants using humic substances and plant-growth-promoting bacteria: Effects on cassava (*Manihot esculentus*) and Okra (*Abelmoschus esculentus*) Yield. *Agronomy*,**13**:80.

FAO STAT (2021). Production stat: crops. FAO statistical databases (FAO stat), *food and agriculture organization of the United Nations* (FAO), <http://faostat.fao.org>.

Fisher RA, Yates F. Statistical tables for biological agricultural and medical research, 6th Edn. Long Man Group Limited, London, 1963.

Haider, N., Alam, M., Muhammad, H., Gul I., Ul-Haq, S., Hussain, S. and Rab, A. (2017). Effect of humic acid on growth and productivity of okra (*Abelmoschus esculentus*) cultivars. *Pure Appl. Biol.,* **6**(3): 932-941.

Ibrahim A., Abdel-Razzak H., Wahb-Allah H., Alenazi M., Alsadon A. and Dewir Y.H. (2019). Improvement in Growth, Yield, and Fruit Quality of Three Red Sweet Pepper Cultivars by Foliar Application of Humic and Salicylic Acids. *HORTTECH*., **21273**(10): 04263-04318.

Khalate, A.M., Sonkamble A.M., Tayade V.D., Wagh, A.P. and Jadhao, S.D. (2023). Effect of integrated nutrient management and foliar spray of humic acid on growth, yield and quality of Brinjal (*Solanum melongena* L.). *The Pharma Innovation Journal*, **12**(5): 3373-3776.

Kumar P., Rana, D.K., Singh, V. and Shah, K.H.N. (2015) Effect of Humic Acid on Growth, Yield and Quality of Okra (Ablemoschus Esculantus (L.) Moench) cv. Arka Anamika under Subtropical Conditions of Garhwal Himalaya. IJIRST - *International Journal for Innovative Research in Science & Technology*, **1**(8), 2349-6010.

Pasha N., Vasanthakumari R., Hanamantharaya B. G., Nirmala K.S. and Vidya A. (2021), Effect of Humic Acid on Growth of okra (*Abelmoschus esculentus* L.) cv. Arka Anamika.*Int. J. Curr. Microbiol. App. Sci,* 10(2): 3530-3534.

Pavani T., Deshmukh PW and Yadav O. S. (2022), Effect of foliar application of Humic acid on yield parameters and quality of chilli. *Journal of Pharmacognosy and Phytochemistry,* 11(3): 235-239.

Roudgarnejad S., Samdeliri M., Mirkalaei A. M. and Moghaddam M. N. (2022), Improving Faba Bean seed yield, protein and chlorophyll content by foliar application of Humic acid. *Acta Sci. Pol. Hortorum Cultus, 21(2): 2022,* 115-121.

Sadeghi CA, Abootalebi JA, Behrooznam B, Hassanzadeh KH, Ejraei A. (2023). Effect of Humic Acid and Amino Acid Foliar Applications on the Growth Characteristics, Yield, and Fruit Quality of Tomato (*Solanum lycopersicom* L.). *International Journal of Horticultural Science and Technology*, **10**(3): 309- 318.

Samavat, S., Malakuti, M. (2005). The important use of organic acid (humic and fulvic) to increase quantity and quality agriculture productions. Water Soil Res. Tech., 463, 1–13.

Shreelatha, B., S.N., Balanagoudar, S.R., Kmble, A.S., Rao, S. and Beladhadi, R.V. (2020). Response of Chickpea to application of Humic Acid along with Vermicompost on Uptake of Nutrients, Yield attributes and Yield, *International Journal of Current Microbiology and Applied Sciences,* **9**: 2319-7706.

Siemonsma, J.S., (1982) West African okra- Morphological and cytological indications for existence of a natural amphidiploids of (*Abelmoschus esculentus* L. Moench and *Abelmoschus manihot* L. Medikus). *Euphytica*, **31**(1): 241-252.

Vanitha, K. and Mohandass S. (2014). Effect of humic acid on plant growth characters and Grain yield of drip fertigated aerobic rice (*oryza Sativa* l.). *The Bioscan*, **9**(1): 45-50.

**Table 2:** **Effect of Foliar Application of Humic Acid on Days to 50% Flowering.**

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| **Treatments** | **Days to 50% flowering** | **Days to first fruit picking** | **Number of Fruit/plant** | **Fruit Length (cm)** | **Average fruit weight (g)** | **Fruit yield (q/ha)** |
| T1 | Absolute control  | 56.67 | 13.67 | 13.67 | 8.93 | 9.59 | 115.45 |
| T2 | 100% RDF (125:75:60 N P K kg ha-1) | 55.00 | 16.33 | 16.33 | 9.63 | 10.35 | 134.29 |
| T3 | 100% RDF + HA @ 5ml/l | 54.33 | 17.67 | 17.67 | 10.47 | 10.84 | 147.83 |
| T4 | 100% RDF + HA @ 10ml/l | 52.67 | 18.67 | 18.67 | 11.10 | 11.76 | 153.39 |
| T5 | 100% RDF + HA @ 15ml/l | 50.33 | 21.33 | 21.33 | 12.25 | 12.35 | 162.77 |
| T6 | 100% RDF + HA @ 20ml/l | 51.67 | 20.00 | 20.00 | 11.85 | 12.10 | 156.67 |
|  | SE(m)± | 0.20 | 0.29 | 0.29 | 0.13 | 0.02 | 0.19 |
|  | C.D. (P=0.05) | 0.64 | 0.93 | 0.93 | 0.43 | 0.06 | 0.61 |