



Enhancing Okra Growth and Yield Through Foliar Nutrient Application in Conjunction with Mulching and Drip Irrigation

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ABSTRACT

Background: Okra (*Abelmoschus esculentus*) is an important vegetable crop that belongs to family malvaceae and is grown both in tropical and subtropical regions of India. In north-coastal Andhra Pradesh, okra is cultivated frequently so, optimizing the nutrient management practice is an efficient method for increasing yield. Among those practices, foliar fertilizers, mulching and irrigation methods are essential in maximizing the yield and quality of okra. Therefore, the present investigation deals with the combined effects of foliar nutrients, mulching and irrigation methods, providing valuable data for sustainable okra production in a particular area.

Methods: The present investigation was conducted during June to September 2023, with seven different treatments using randomized block design. This experiment mainly focuses on combinations of mulching and foliar sprays of 19:19:19 and 13:0:45 at different concentrations. Collected data were analyzed using ANOVA and Fisher's least significant difference test at a 5% significance level.

Result: Among all the treatments, 100% RDF along with the foliar application of 19:19:19 @ 1.0% + 13:0:45 @ 2% at 30, 45 and 60 days after sowing has proven the best treatment, where it recorded the highest yield of 101 q per hectare (Q/ha) due to the application of sufficient nutrients. Whereas, the lowest yield was recorded with control plot due to insufficient nutrient supply in relation to growth and yield parameters.

Key words: Foliar nutrients, Growth parameters, Mulching, Okra, Yield.

INTRODUCTION

Okra, commonly known as bhendi or lady's finger, is a popular vegetable crop grown in the tropical and subtropical regions of India. Its scientific name is *Abelmoschus esculentus*, belongs to malvaceae family. Okra is a nutritive vegetable and contains a good amount of dietary fiber. Nutritively, it contains vitamins A, C, K, folate, magnesium and calcium and is low in fat, especially unsaturated fats and cholesterol. The presence of mucilage in okra helps with digestion and for this reason, it is considered healthy (Madhuri *et al.*, 2017).

On an annual basis, India is a leading producer of okra, cultivating approximately 8.1 million metric tons of okra annually, which remarkably constitutes around 70% of global okra production (FAOSTAT, 2020). Generally, 100 grams of okra contains 0.2 g (fat), 1.9 g (protein), 6.4 g (carbohydrates), 0.7 grams of minerals and 1.2 grams of fiber reported by Habtamu Fekadu Gemede *et al.* (2015). Beyond its nutritional importance, okra emerges as a key player in generating foreign exchange earnings, contributing approximately 60% of the export of fresh vegetables, excluding potatoes, onions and garlic (Dhall *et al.*, 2014). The okra fruit contains an excellent source of iodine, which is necessary to resist throat diseases such as goiter (Chavan *et al.*, 2007).

Agriculture claims a substantial 75% share of overall water withdrawal in developing nations. The major constraint to productivity is the lack of water, the only limiting factor in agricultural productivity and land utilization (Molden, 2007). Fereres and Soriano, (2007) reported that agriculture is one of the most prominent water users; understanding the

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high proportion of water usage in this sector should highlight the need to practice efficient irrigation methods like drip irrigation. Ensuring its efficient utilization, water is crucial for enhancing productivity and, consequently, facilitating the structured developmental procedures within agricultural domains, particularly in sectors like irrigation as it is a key factor.

Factors affecting growth and yield of okra are listed below:

- ❖ Soil quality - Texture and structure, pH level, fertility, temperature.
- ❖ Water availability - Irrigation, moisture conservation.
- ❖ Nutrient supply - Macronutrients, micronutrients.

- ❖ Light - Sunlight, photoperiod.
- ❖ Pest and disease management.
- ❖ Agricultural practices - Planting time, spacing, weed control.
- ❖ Cultural practices - Mulching, pruning and training.

While traditional agricultural research has historically focused on maximizing overall production, recent years have witnessed a shift towards addressing limiting factors within production systems, particularly the constraints of available land or water resources. Water-saving techniques like plastic mulching, deficit irrigation (DI) and micro-irrigation have become crucial strategies in this context, mainly when crop cultivation is limited by water supply.

Micro-irrigation is a technique that excels at precise water application to plants, resulting in greater water efficiency (Lamm *et al.*, 2007). The cooperation of drip irrigation and plastic mulching has proven effective in increasing yields compared to conventional surface irrigation methods, especially in challenging climatic conditions marked by temperature extremes, mulching has positively impacted the growth and productivity of vegetables. This practice conserves soil moisture, increases soil aeration, promotes microbial activities, facilitates nitrification and regulates soil temperature reported by Singh and Singh, (2004).

Typically, okra is grown using irrigation techniques during the zaid season, allowing its successful growth and development. Water scarcity is solved through connecting means such as drip irrigation, where water is delivered directly to the roots of plants as you seek to improve okra population and production. The above provided information for need of water underlines the need to adopt efficient farming practices to increase crop yields for every unit of water consumed and directly relates to this study.

Mulching is commonly implemented using organic materials such as straw, green leaves, or dry leaves and can also involve the utilization of plastic sheets. Generally, poly mulches vary in colors and thickness. Based on purpose specific mulch sheet will be selected. Black polyethylene mulch sheets prove to be highly effective in suppressing weed growth during vegetable cultivation. On the other hand, yellow plastic mulch serves a dual purpose: it attracts whiteflies and also act as a control measure against the leaf curl virus and for moisture conservation. Research by Ganesh Babu *et al.* (2015), highlighted that integrating a drip irrigation system alongside mulching could lead to a potential 61% increase in okra yield compared to surface irrigation methods utilizing the same amount of water.

Providing a well-balanced nutrition is especially crucial for plant growth and development. Plant progress and maturation depend on receiving the appropriate nourishment at the appropriate intervals. However, consistent provision of excessive nutrients has been associated with decreased okra growth and yield.

Foliar fertilizers (FF) increase the crop's nutrient status by successfully applying nutrients to the foliage and supplementing nutrient intake efficiently (Imamasaheb *et al.*,

2011). They avoid the soil and offer instant nutrient top-ups, beneficial for application as supplements, for increasing the vigor of plants, for bringing about increased yields and especially during shifts in phases or situations where there are suboptimal root nutrient intakes. As a source of essential nutrients, FF enhances the yield and quality of crops while at the same time boosting plants immunity to diseases and pests (Kannan, 2010; Fageria *et al.*, 2009). Also, foliar fertilization increases the soils applied nutrients efficiency since it triggers the efficient macronutrient utilization (Philips *et al.* 2004). It is eco-efficient, conforms to the principles of sustainable farming and enhances crop productivity and quality. Due to these advantages, foliar feeding can be adopted as a preferred source in the management and administration of nutrients, as suggested by Zodape *et al.* (2011) and El-Aal *et al.* (2010).

Additionally, foliar fertilizers have been found to be very effective on okra growth towards recent studies by Durgesh *et al.* (2022) and Sharma *et al.* (2020). However, despite these studies, there is still a research gap on how okra behaves under combined application of drip irrigation, foliar fertilizers and mulching with respect to the specific agro-climatic context of Vizianagaram District in Andhra Pradesh. To bridge this gap, this study will investigate optimal irrigation management strategies under both mulched and non-mulched conditions while also assessing the most efficient foliar nutrient applications that potentially maximize growth and yield of okra. This research therefore seeks to provide useful insights into sustainable agricultural practices that can enhance the productivity as well as improve the quality of okra crops thereby improving socio-economic wellbeing by generating income for many small-scale farmers who are almost 70% dependent on agriculture in Vizianagaram district itself.

MATERIALS AND METHODS

The present investigation at the Center for Agricultural Research and Training Center, Centurion University of Technology and Management (CUTM) andhra Pradesh, from June 2023 to September 2023. The experimental plot is located geographically at 18° 17' N latitude and 83° 38' E longitude, which was laid in RBD (randomized block design). Following table represents the treatments selected for okra cultivation.

- T₁ - Control.
- T₂ - Mulching + Spraying of 19:19:19 @ 1% at 30, 45 and 60 days after sowing.
- T₃ - Mulching + Spraying of 13:0:45 @ 2% at 30, 45 and 60 days after sowing
- T₄ - Mulching + Spraying of 19:19:19 @ 1% and 13:0:45 @ 2% at 30, 45 and 60 days after sowing
- T₅ - No Mulching + Spraying of 19:19:19 @ 1% at 30, 45 and 60 days after sowing
- T₆ - No Mulching + Spraying of 13:0:45 @ 2% at 30, 45 and 60 days after sowing
- T₇ - No Mulching + Spraying of 19:19:19 @1% and 13:0:45 @ 2% at 30, 45 and 60 days after sowing.

Each treatment was allotted with a minimum plot size of 20.16 m², with an average of 56 plants in each plot. Each treatment was replicated three times using variety Ankur. The recommended dose of fertilizer (RDF) for okra is 100:60:50 kg of NPK /ha (half of the dose of N and the total dose of P₂O₅ and K₂O are applied at the time of planting). The remaining nitrogen balance is given at 30 days after sowing followed by an earthing operation. Drip irrigation was given daily at three intervals, according to rainfall from the single-leaf stage.

Intercultural operations like weeding, irrigation and plant protection were carried out as per requirements. Proper standard procedures were followed to collect the data, such as plant height, dry matter production, number of pods plant⁻¹, pod yield and stalk yield. This experiment was conducted to estimate the effect of foliar nutrients on the vegetative and reproductive stage of okra under mulching and non-mulching areas, along with drip irrigation. Data were analyzed using ANOVA and significance was tested using Fisher's least significant difference (p=0.05) as described by (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The foliar nutrient's effect on the growth and yield of okra is clearly explained in the following data (Table 1). Further, the combination of organic and foliar nutrients has shown significant improvements in various growth parameters such as days to 50% flowering, plant height, branch development, fruit yield and overall crop productivity Abasi *et al.* (2010).

Plant height

At different growth stages, the height of the okra was found to be significantly affected by various levels of foliar applications and mulching. In this study, treatment T₃, which involved the combination of mulching and spraying with a

fertilizer solution of 19:19:19 at a concentration of 1% and fertilizer of 13:0:45 at 2% (30, 45 and 60 days after sowing), resulted in the tallest plants. This combination can be attributed to the superior ability of T₃ treatment to promote plant height growth. Mulching created a favorable microclimate around plants, reduced evaporation and maintained soil moisture levels Jayapiratha *et al.* (2010). Plant growth and development are enhanced by adding the necessary foliar nutrients. By combining these two practices, plants under treatment, T₄, could access optimal nutrient supply and maintain favorable growth conditions, resulting in improved plant height growth. Treatment T₁ (control) recorded the lowest plant height, which might be because plants without mulching received a high dose of fertilizers and a low irrigation quantity, thus leading to severe weed competition for water and nutrient uptake.

The treatment T₆ also resulted good plant height with 65 cm by spraying of 19:19:19 @ 1% and 13:0:45 @ 1% at 30, 45, 60 days after sowing without mulching. This may be because foliar fertilization is an efficient method of feeding plants because nutrients are supplied to the foliage, averting the constraints that soils pose to nutrient delivery. Foliar fertilizer allows nutrients to be received and utilized quickly, stimulating more effective vegetative development. Such an observed height indicates that normal physiological activities like cell elongation and division, which are crucial for achieving healthy plants with possible bearing on the actual yield, are doing well. These findings correlate to the existing literature that supports foliar fertilization as an efficient way to improve plant growth and nutrient use efficiency as well as enhanced crop productivity in the absence of mulching Fageria *et al.* (2009); Marschner, (2011); Makela and Muurinen, (2019).

The treatments T₅ and T₂ had comparable effects on plant height despite differences in mulch application.

Table 1: Okra growth and yield parameters as influenced by mulching and foliar spray of nutrients.

Treatment	Plant height at maturity	No of branches /plant	No. of pods /plant	Fruit weight (g)	Days to 50% flowering	Pod yield (Q/ha)
T ₁ - Mulching + Spraying 19:19:19 @ 1% at 30, 45, 60 days after sowing	60	2	22	25.33	36.33	83.6
T ₂ - Mulching + Spraying 13:0:45 @ 2% at 30, 45, 60 days after sowing	63.1	2.3	25	26.67	36	86.6
T ₃ - Mulching + Spraying 19:19:19 @ 1% and 13:0:45 @ 1% at 30, 45, 60 days after sowing	67.1	3	30.6	27.33	35.33	101
T ₄ - Without Mulching + Spraying 19:19:19 @ 1% at 30, 45, 60 days after sowing	59.8	2.26	23	26	36.67	81.3
T ₅ - Without Mulching + Spraying 13:0:45 @ 1% at 30, 45, 60 days after sowing	62.6	2.3	24.3	27.33	34.67	85.3
T ₆ - Without Mulching + Spraying 19:19:19 @ 1% and 13:0:45 @ 1% at 30, 45, 60 days after sowing	65	2.53	25.6	27.33	38.33	92
T ₇ - Control	58.4	1	16	24.67	39.33	75.6
CD (p = 0.05)	2	NS	1	1.6	1.9	1.8
CV (%)	2.5	2.1	2.5	4.6	3.7	2.7

Treatment T_5 , did not involve mulching but spraying with a 13:0:45 fertilizer at a concentration of 2% and treatment T_2 , which included mulching and spraying with the same fertilizer, resulted in similar plant heights. The results suggest that mulching may not significantly affect plant height when combined with 13:0:45 fertilizer at a concentration of 2%. These findings demonstrate that treatment T_5 or T_2 can effectively promote plant growth and development concerning to height.

The significant increase in plant height observed at all sampling intervals, resulting from the recommended application of NPK to the soil, can be attributed to the favorable response of okra plants to balanced doses of nitrogen along with proportional enhancements in the availability of phosphorus (P) and potassium (K). Nitrogen, a crucial nutrient element in plant metabolism, was likely pivotal in promoting extensive cell multiplication and enlargement, characterized by thinner cell walls. Research conducted by Arun Kumar *et al.* (2020) reported positive results with recommended nutritional supplementation on plant growth. This consistency in the findings of different studies strengthens the validity of the observations made in the current study.

Number of branches

Same trend was followed with both mulching and non-mulching plots along with foliar sprays. While comparing the treatments with mulching and foliar sprays, a significantly higher number of branches per plant was recorded with treatment mulching + foliar application of 19:19:19 @ 1% and 13:0:45 @ 1% on days 30, 45, 60 and at maturity (T_3), attributed to an overall improvement in plant vigor and growth. This improvement is due to a balanced supply of the three primary nutrients in conjunction with foliar applications. The liberal application of nitrogen plays a crucial role in enhancing the plant's physiological processes, promoting cell enlargement and, the development of auxiliary buds, which contribute to an increased number of branches.

Application of 19:19:19 @ 1% at 30, 45, 60 days after sowing with mulching (T_1) was found to be statistically in parity with application of 19:19:19 @ 1% at 30, 45, 60 days after sowing without mulching (T_4). This parity implies that although mulching usually provides positive impacts on growth, the balanced foliar fertilizer (19:19:19) used in the recommended intervals would be adequate to supply the nutrient demands of the okra plants without mulching. This foliar fertilizer, 19:19:19, gives the plant a balanced amount of nitrogen, phosphorous and potassium required for growth and development. They stimulate the physiological functions of plant, increase nutrient uptake, vigor, all of which serve the positive things that are attributed to mulching.

Treatment with mulching + 13:0:45 @ 2% (T_2) resulted in a slightly higher pod yield than treatment mulching + 19:19:19 @ 1% (T_2), which might be due to higher potassium content, the timely application of fertilizers and the improved

compatibility with the physiological needs of okra plants during the critical growth stages of T_2 , contributing to its superior performance.

Yield

Among all the treatments, maximum yield was obtained with mulching + spraying 19:19:19 @ 1% and 13:0:45 @ 1% at 30, 45, 60 days after sowing (T_3), which gave 101 Q/ha, indicating the mulching can work in conjunction with combined foliar fertilization. The results are clearly showing the importance of integrating mulching with balanced foliar fertilization to enhance okra yield. The combination of mulching and fertilizers conserves soil moisture, regulates temperature and reduces weed competition. Foliar fertilizers provide a direct nutrient boost, making this approach highly effective. Evidences given by Fageria *et al.* (2009) and Marschner *et al.* (2011), highlights the importance of foliar fertilization in supplying nutrients directly to plants, avoiding the soil-related issues. Makela and Muurinen, (2019) supports the idea that targeted nutrient applications significantly impact the plant growth and yield, especially when combined with practices like mulching and drip irrigation. Imamsaheb *et al.* (2014)a, have established that the enhancement of nutrients in the foliar has enhance efficiency in terms of growth parameters, nutrient uptake and utilization. Jayapiratha *et al.* (2010)a, who said that foliar feeding reduces nutrient mobilization and optimizes plant nutrient deposition. Haris, S. *et al.* (2014) also observed that foliar nutrients aid in regulating metabolic and photosynthetic activities in plants, enhancing growth and yield.

Whereas, treatment control (T_7) gave lowest yield of 75.6 Q/ha among all the treatments. The control plot showed lower yield and pod weight due to restricted watering and manure use. Similarly, drip irrigation and mulching practices improve vegetative attributes and yield characteristics and the yield of okra has been revealed in the literature. Suresh and Misra (2004) opined that drip irrigation enhances water availability to the plants, leading to better vegetation growth and high yields. Varughese *et al.* (2014) reported that mulching has proved to help reduce soil moisture loss and competition from weeds and uplift crop performance.

Other treatments with mulching has shown improved yields, with mulching + spraying 19:19:19 @ 1% at 30, 45, 60 days after sowing (T_1) being 83.6 Q/ha and mulching + spraying 13:0:19 @ 2% at 30, 45, 60 days after sowing (T_2) gave 86.6 Q/ha.

Rekha *et al.* (2005); Parmar *et al.* (2013) and Bhatt *et al.* (2011) reported that the supply of drip irrigation systems and mulching results in better nutrient uptake and alters the microclimate of the root zone area, which is vital to plant growth and production. Sunikumar and Jaikumaran, (2002) also supported the view that these customs decrease the fluctuations in the temperature of the soil and, therefore, encourage the growth of the root system and the harvest. Mahadevan, (2014) supported the above

finding that mulching and drip irrigation enhance water use efficiency (WUE) and improve okra productivity.

CONCLUSION

These studies prove that appropriate management practices like drip systems, mulching and foliar feeding all translate into enhanced plant growth and yield. When rightly implemented, these practices conserve water, check weed growth, improve nutrient uptake, minimize soil compaction and offer a suitable microclimate and, therefore, have an overall beneficial influence on crop performance. The highest returns for okra plants were found to result from a combination of the application of specific foliar fertilizers at different concentrations at different growth stages and mulching (mulching helps farmers reduce labor costs, ET, disease and pest attack, ultimately leading to the highest net returns). Therefore, the treatments involving mulching and fertilizers at different concentrations- 19:19:19 and 13:0:45 - showed better results than other treatments with respect to okra growth yield. So, we can suggest that, this combination of treatments can be used to cultivate okra in the north coastal zone of Andhra Pradesh to maximize the yield.

Data availability

The corresponding author has all the details of this experiment. The author presents data collected and analyzed during this experiment. The data used and analyzed during the current study are available with the corresponding author upon reasonable request. All data supporting this study's findings are included in this article.

Conflict of interest

The author (s) has declared that no conflict is involved in this article's publication.

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