RESEARCH ARTICLE

Evaluation of Morphological Growth Response of *Abelmoschus esculentus* (Okra) to Simple Organic Supplements

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Abstract

Soil health and nutrient availability are important for sustaining crop productivity and increasing yield. Farmers have practiced fortifying soil using various supplements (organic and inorganic, natural and synthetic) since the advent of modern agriculture. However, adding inorganic fertilizers, weedicides and pesticides has adversely affected our agroecosystems. Harmful chemicals from synthetic fertilizers get accumulated in soil and plant parts, causing serious health problems. The synthetic agri-products have detrimental effects on soil fertility and soil microbiota, making the soil less fertile and unsuitable for cultivation. In the last decade, a paradigm shift in agri-practices has occurred and organic farming has become a popular sustainable option to improve soil health and achieve sustainable development goals.

The potential of various organic supplements has been studied in the present investigation on the growth parameters of an important vegetable crop okra (*Abelmoschus esculentus*) valued for its multipurpose uses in various parts of the country. Pure line seeds of okra variety *Arka Anamika* were surface sterilized and used for the study. Plants were raised in plastic pots (10 inches) filled with soil treated with leaf compost, foliar spray (Gibberellic acid, 0.001%) and pine bark mulch. Garden soil without organic supplements served as a control. The experiment was carried out in a completely randomized design with three replications. An increase in the vegetative growth parameters and in reproductive parameters in all the treatments as compared to control was observed in the plants. Though all treatments showed an increase in growth parameters, a significant increase was observed with mulch, suggesting that the mulch derived from organic waste and residues have immense potential in improving crop health by making them more robust, and enhancing the yield. Investigating the amelioration of soil physico-chemical properties with these organic supplements and understanding their role in better crop performance is beneficial for the farmers. The present study also provides simple, sustainable, and eco-friendly biofertilizer potential of self-prepared pine bark mulch for vegetable crops.

Keywords: Foliar Spray, Leaf Compost, Mulch, Okra, Organic Supplements.

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Introduction

Okra (*Abelmoschus esculentus)* is a popular vegetable crop grown all over the world. Raised as a summer annual, Okra is valued for its nutritional properties in various parts of the country (Kumar *et al.,* 2013). Fruits are a good source of vitamins, minerals, fibers, and antioxidants. Inorganic fertilizers, weedicides, and pesticides have been used extensively to enhance soil fertility and yield. The overuse of these chemical inputs has in the long run adversely affected the soil physico-chemical properties, soil microbial population and thereafter reduced the crop yield (Nakhro and Dkhar, 2010). To mitigate the impact of inorganic fertilizers on environmental degradation and to enhance food security, eco-friendly agri-practices of organic farming are recommended. Organic farming propagates the elimination of synthetic inputs and encourages reviving of soil health through the natural ways. This method of framing eliminates the use of chemicals in the agroecosystems as is beneficial in many ways: it keeps the substratum and soil healthy and allows the crops to grow profusely without any harmful amendments. A wide range of plant materials such as leaf compost, green manure, and vermicompost, are used as organic supplements for many crops. In the last decade, organic farming has revolutionized agriculture and has risen to prominence as a viable option to conventional farming (Gamage *et al*., 2023).

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Organic supplements are known to improve both macro and micronutrients and sustain soil productivity (Akanbi *et al*., 2000, Kang *et al*., 2005, Shahriazzaman *et al.,* 2014 and Vikas *et al.,* 2020). Research studies on Okra have revealed increased growth rate, leaf area and accumulation of dry matter with compost application (Dada and Adejumo, 2015). The effect of vermicompost, biochar and farmyard manure were studied by Sarma and Gogoi (2015) on seed germination and growth of Okra seedlings. Their study revealed increased seed germination, plant height, root length and leaf area with vermicompost. Applying mulch to the topsoil enhances soil structure and water

holding capacity, reduces pesticide dependence on fertilizers and thus lowers input costs (Azad *et al.,* 2015). Mulch also helps plants to adapt to climate change by modifying its microclimate (Kasirajan and Ngouajio, 2012). Organic mulch suppresses the growth of weeds by preventing sunlight from reaching the soil and improves soil microflora (Iqbal *et al*., 2020). Since people grow vegetables in their backyards and in pots, it is important to develop eco-friendly supplements that are locally available and can be used for specific vegetables in a sustainable way using simple protocols that are cost-effective.

Organic farming in real sense, envisages a comprehensive management approach to improve the health of the underlying productivity of the soil (Palaniappan and Annadurai, 1999). In agrarian countries like India, it has become a popular practice amongst small-scale farmers and people interested in kitchen gardening.

The present study was designed to elucidate the potential of the locally available eco-friendly supplements in enhancing the growth of important vegetable crop species. The supplements proposed can be easily obtained and can be used for small scale farming or containerized growth. Such studies have gained prominence as post-pandemic people have realized the importance of safe and chemical-free food for better health and well-being. Many people now have reverted to the practice of growing vegetable and salad crops in the backyards. Therefore, it is important to have standard nutrients and eco-friendly pesticides for the protection of these crops. In the present study, using the pot-culture study, the effect of leaf compost, pine mulch and foliar spray on vegetative as well as reproductive growth parameters, especially on the fruits of Okra plants, that is consumed almost in every Indian household in many ways (cooked, fried, steamed) were evaluated.

Materials and Methods

The experimental study was carried out in the Botanical Garden, Sri Guru Tegh Bahadur Khalsa College, University of Delhi from February 2021 to June 2021 and repeated in 2022 during the growth season (February-June). The seeds of *A. esculentus* (Okra) var. *Arka Anamika* were procured from National Seed Centre (NSC), Indian Agricultural Research Institute (IARI), Pusa, New Delhi. A nursery of Okra seedlings was raised by sowing the seeds in pro-trays. Seeds germinated under natural sunlight and were watered daily. The experiment with two-week-old seedlings was carried out in plastic pots (with 10 inches diameter) in a randomized manner. Soil was amended to compare the growth parameters. Leaf compost (Ebee leaf compost Leaf mold, Patte ki khad) and Pine Bark Mulch were procured from the nursery of the University of Delhi while Gazab ultra foliar spray (chemical name Gibberellic acid) was procured from a local nursery. Leaf compost was mixed with garden soil in a ratio of 1:3 (50 gm compost: 1.5 kg soil) whereas mulch was added to soil in pots in a (1 inch of mulch to the topsoil). Foliar application, 1ml with a Dispovan syringe was done by drenching soil near the root area (Gibberellic acid, 0.001%) twice during vegetative and once during reproductive growth of Okra. Each application was done in the morning avoiding direct sunlight and the chances of evaporation of the spray were minimized. Garden soil without any supplement was kept as control. Three replicas were maintained for the control as well as the treatments.

Two-week-old seedlings were transplanted to pots containing treated and untreated soil and the test series were maintained under natural light, temperature, and humidity conditions for further study. Effect of various treatments on vegetative and reproductive growth parameters was evaluated after 30 DAS and 60 DAS.

Vegetative Growth Parameters

Plant height, root length, number of branches and leaf area were recorded at 30 and 60 DAS. Shoot and root length was measured using a ruler. Leaf area per plant was calculated using graph paper.

Reproductive Growth Parameters

The effect of organic supplements on days to onset of flowering, number of fruits per plant and fruit size at harvest was determined for all treatments and the control set. Fruit length was also measured using a ruler.

Statistical Analysis

Data recorded was subjected to analysis of variance (ANOVA) and Duncan's post hoc test (DMRT) at *p*-value 0.05 using IBM SPSS Statistics (Version 25) to compare the significant difference between the treatments and control.

Results

Data on vegetative parameters such as plant height, root length, number of branches per plant and leaf area was recorded for each treatment after 30 and 60 days of sowing respectively and was compared with control.

Effect of Organic Supplements on Vegetative Growth Parameters – Plant Height, Number of Branches Per Plant, Leaf Area

After 30 DAS

A significant increase in plant height ($p<0.05$) was observed. Maximum plant height was observed from the plants growing on soil treated with mulch as compared to all other treatments including control (Fig. 1A). Plant height was not significant for leaf compost and foliar spray treatments.

An Increase in branches per plant was observed in plants subjected to all three amendments. Amongst the various treatments, leaf compost and foliar spray resulted in a similar number of branches per plant (Fig. 1B).

Application of foliar spray resulted in increased leaf area followed by mulch and leaf compost treatments (Fig. 1C).

Root length was not significantly affected much by any treatment at 30 DAS (Fig. 2).

60 DAS

Okra's Shoot and root length were significantly higher ($p<0.05$) for all three organic treatments. Amongst the three treatments tested, maximum shoot length was observed with mulch treatment followed by foliar spray and leaf compost treatments. (Fig. 3). However, leaf compost treatment was not found to differ significantly when compared with the control. Similar results

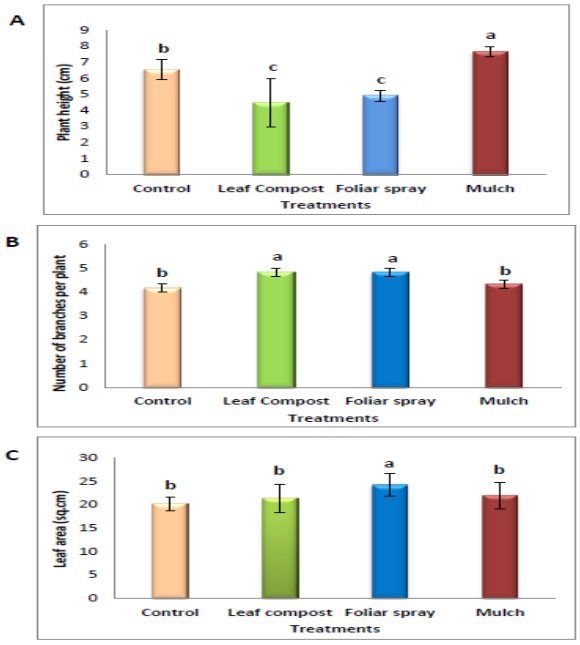

Fig. 1: Effect of organic supplements on vegetative growth parameters after 30 days of sowing on (A) Plant height, (B) Number of branches per plant and (C) Leaf area. error bars represents Mean ± SE. Bars with different lowercase letters indicate significant difference at p<0.05.

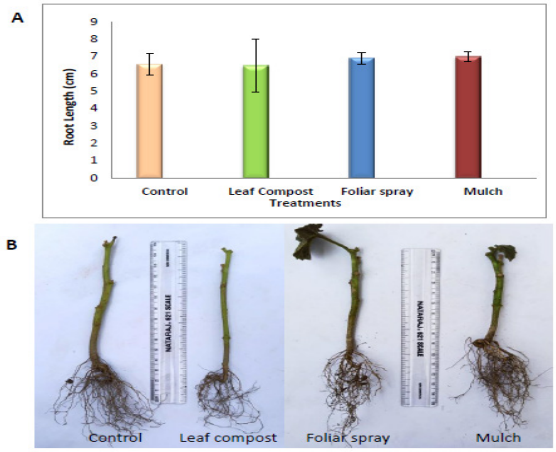

Fig. 2: Effect of organic supplements on root length after 30 days of sowing (A). error bars represents mean ± SE. No significant difference in root length was observed among the treatments at p<0.05 (B).

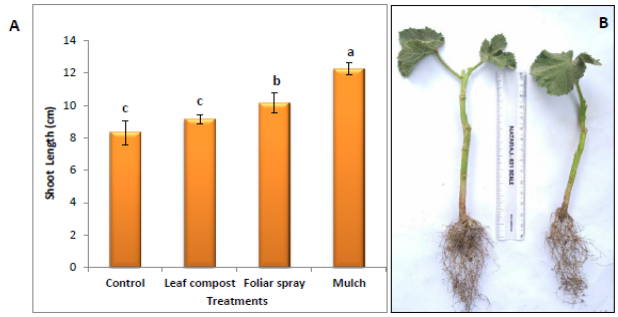

Fig. 3: Effect of organic supplements on shoot length after 60 days of sowing (A). error bars represents mean ± SE. Bars with different lowercase letters indicate significant difference at p<0.05. maximum shoot length was recorded from mulch treatment (B).

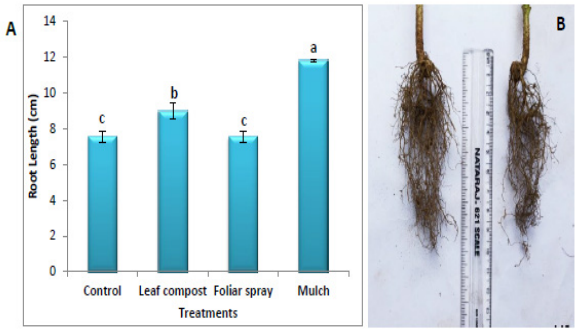

Fig. 4: Effect of organic supplements on root length after 60 days of sowing (A). Error bars represents Mean ± SE. Bars with different lowercase letters indicate significant difference at p<0.05. Okra plants showing highest root length with mulch treatment (B).

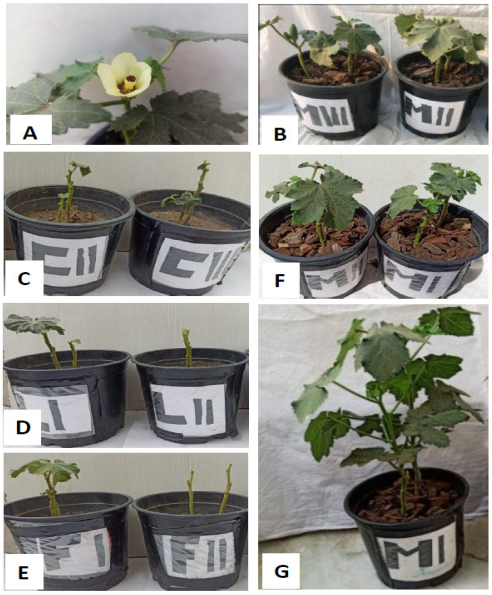

Fig. 5: Effect of organic supplements on flowering and fruiting of Okra. A&B depicts onset of flowering with mulch treatment (42DAS), (C-F) shows plant growth response (70DAS) from untreated soil (control), leaf compost, Foliar application and mulch treatment respectively. (G) Plant growth on mulch treatment after 90days of sowing.

were obtained for the root length. Maximum root length was observed from plants grown on soil treated with mulch (Fig. 4). A Significant difference in root length compared to control was also observed in leaf compost treatment. The application of foliar spray was not effective for root length when compared with control.

Effect of Organic Supplements on Reproductive Growth Parameters – Days to Onset of Flowering, Number of Fruits Per Plant, Fruit Size

Among the three soil treatments, early flowering response was observed from the mulch-treated plants, followed by leaf compost and foliar spray treatments. Late flowering response was observed from the control soil.

There was a significant increase in fruit number per plant in mulch treatment as compared to other treatments, including control. The fruit formation continued till 60DAS in all other

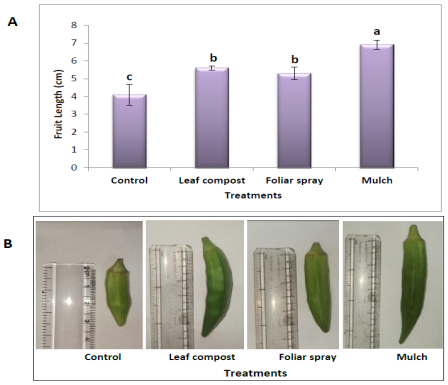

Fig. 6: Effect of organic supplements on fruit length after 60 days of sowing (A). error bars represents mean ± SE. bars with different lowercase letters indicate significant difference at $p<0.05$. maximum fruit length was recorded from mulch treatment (B).

treatments except mulch, which continued for over 90 DAS (Fig. 5).

Fruit size was measured in terms of fruit length as depicted in Fig. 6. Application of organic supplements greatly enhanced the fruit size when compared to the control. Maximum fruit length was, however, recorded for mulch treatment followed by leaf compost and foliar spray treatment.

Discussion

The present study revealed a significant increase in vegetative and reproductive growth parameters with the application of leaf compost, foliar spray, and mulch as organic supplements in the Okra plants. Amongst the different organic supplements tested, soil amendment with mulch gave better results as growth performance increased considerably followed by leaf compost and foliar spray treatments. Mulching reduces excessive evaporation from soil surface, making more water available for transpiration. This balance between soil and plant surface evaporation and transpiration helps maintain the plant-water status (Chakraborty *et al*., 2008). The improved soil water content promotes nutrient leaching from topsoil to deeper layers, resulting in organic carbons accumulating. Organic carbon is also added in the form of organic acids produced upon organic matter decomposition (Haynes and Mokolobate, 2001). Mulching with coconut fronds is known to increase leaf N, P and K content in *Capsicum annum* (Hassan *et al*., 1994). The warm season vegetables such as cucumber, pepper, and musk melon also show early maturity and higher yield with mulch (Ray and Biswasi, 2016). In another study, mulch resulted in faster plant growth, early fruiting, reduced P and increased N concentration in the leaves and fruits of peppers (Vos and Sumarni, 1997). Thus, mulch proves to be a highly efficient soil supplement with effect on plant height and the number of leaves and fruit parameters at 60 DAT (Sharma *et al.,* 2003). Several research studies have revealed the positive effect of foliar application on growth and yield of many vegetable plants (Ketsiyal and Thatheyus, 2021; Ratnarajah *et al*., 2022). It is also understood that when plant has excellent vegetative growth, it invests in the foliar growth and allocates its resources to sustain robust flowering and, ultimately, fruiting. A significant increase in the number of branches per plant as well as the leaf area was also observed with foliar application after 30 days of sowing in the present study. This could be due to plants' immediate uptake and translocation of nutrients as foliar spray in the form of gibberellins was applied near the plant rhizosphere. Mehraj *et al*. (2015) also found (in Okra) an increase in plant height and number of branches with the application of gibberellic acid which further supported the present study. The foliar spray was used as drench in the present work and applied near the plant's base. As it is a hormone-based application, the aerial parts could take up the growth regulator, resulting in enhanced branches and leaf area. A significant increase in shoot and root length was also observed with mulch treatment after 60 days of sowing as compared to other treatments, including control. Maximum shoot length was recorded with mulch treatment followed by foliar and leaf compost treatments. Profuse root growth was also observed from mulch treatment, leaf compost, and foliar application. The root development is also reported to be dense with mulch as seen in Tea Olive plants (Ni *et al*., 2016). Since mulch is degraded slowly, the nutrients are also released slowly and in small amounts. These nutrients then leach down close to the rhizosphere and influence the root growth. However, it is important to note that the soil conditions, structure, porosity and density vary from one geographical region to other and the responses of plants may significantly vary with different conditions.

The present work is a clear indication that pine wood mulch enhances and augments the growth period as sustained on mulch treatment for more than 90 DAS whereas a decline in plant growth was observed in response to leaf compost, foliar application of gibberellin. Mulch considerably improves soils that are degraded and devoid of humus. It enhances the diversity of soil microflora and microfauna by building the soil substrate improving soil aeration and water holding capacity. In the present study on Okra, mulch treatment resulted in early flowering and fruiting response and the duration of fruit formation continued over 90 DAS. This could be attributed to the slow and gradual release of nutrients from mulch which probably helped in the effective use of nutrients for a longer duration. Thus, better root growth, plant health and yield were observed. The pine mulch used helps in building up the substratum. This happens due to the presence of a high quantity of soluble or little-polymerized lignin, which provides a base for soil aggregation and the formation of humus. It is also known to promote the growth of soil fungi which serve as a food source for beneficial *fungivores*, crucial to the nutrient cycling process. Pine mulch is known to settle more slowly than rest of the types and according to Duryea and Minogue (2017), pine mulch can be maintained even after two years. Experimental studies have suggested the potential importance of mulch for improved growth and yield of crop plants by maintaining soil moisture soil temperature, decreasing stress of plants by increasing resistance to weed and pest attack, reducing fungicides and herbicides and increasing soil microbiota (Chalker-Scott, 2007; Kader *et al*., 2019; Iqbal *et al*., 2020). The lack of an organic matter layer on the soil surface also delays the process of natural succession, reducing the population of soil mesofauna, such as mites (Acari) (Lindberg and Bengtsson, 2005).

Conclusion

The present study clearly depicts that supplementing soils with wood chip mulch is an effective organic farming strategy as it maintains soil fertility, retains the soil nutrients for longer durations and sustains microbial population. Okra seeds planted in soil with different organic amendments improved the vegetative and reproductive growth of the plant. The number of flowers per plant on addition of wood mulch also increased the yield of this important vegetable crop. This is also because the plant health was not compromised in the wood mulch-treated plants. Okra plants supplemented with mulch also protect plants from insect infestation observed in treated plants. This study provides a simple, eco-friendly, and cost-effective method of raising plants for kitchen and terrace gardens. After harvesting the first crop, the pots can be further used for next season as nutrients are retained in the mulch and soil's water-holding capacity is retained, suggesting it as a viable and feasible method of vegetable crop plantation. This method can also be replicated for other seasonal vegetable and ornamental plants. However, further investigation on soil physical properties and plant nutrient analysis would help to correlate the effectiveness in ameliorating and amending degraded and nutrient-deficient soils.

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Author's Contributions

The authors Inderdeep Kaur (IDK), Preeti Kaur (PK), Jaskaran Singh (JS) and Monika Koul (MK) conceptualized the work. IDK, PK and JS carried out the experiments, PK did statistical analysis. All the four authors contributed to drafting the MS. IDK and MK fine-tuned the MS and finalized the MS.

Conflict of Interest

None.

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