



IMPACTS OF AZOLLA APPLICATION ON GROWTH AND YIELD PARAMETERS OF OKRA PLANT (*Abelmoschus Esculentus*)

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Abstract: A study was conducted to know the effect of azolla on seed germination, growth parameter and yield parameter of *Abelmoschus esculentus* plants for 75 days. Triplicates of potted plants were grown in four azolla treatments: 50g azolla treatment, 100g azolla treatment, 150g azolla treatment, and 200g azolla treatment along with control respectively. The plants were monitored and their height, leaf number, pod number, and fresh weight were determined after 75 days. Height, number of leaves, number of pods, and fresh mass results were subjected to ANOVA to determine the effect of applying azolla on the growth performance and yield of okra plants at $p < 0.05$. Significant differences were observed in the growth and yield of okra plants. It was noted that 200g and 150g azolla treatments were very effective in enhancing the growth and yield of okra and thus could effectively be used as an eco-friendly, accessible, and cheap fertilizer input in the management of soil health. Also, the amount of chlorophyll content was found to increase with the concentration of treatment of azolla. This study and field experiments are thus recommended to evaluate its feasibility and farmers are encouraged to adopt the use of azolla fern because of its potential economic benefits.

Index Terms - Agriculture, Organic, Chlorophyll, Growth, Yield

I. INTRODUCTION

India is one of the largest producers of agricultural commodities like rice, spices, fresh fruits, fresh vegetables, tea, coffee, etc. In the production of rice and wheat, India stands second largest in the world ranking (Ramdas et al, 2019). It plays a significant role in the growth of the Indian economy. But the agriculture practices are gradually decreasing due to soil infertility, low yield, poor marketing facilities, climate change, and many other reasons (Kanderp et al, 2021). The application of these chemicals increased more than a hundred times and caused tremendous loss to the environment and human health. But we can overcome the crisis with the help of organic farming.

The ancient Indian farmers believed in nature-friendly farming such as mixed cropping, mixed farming, and crop rotation. Organic farming provides us with healthy and harmless food. Organic products like vegetables, fruits, and rice have high demand in the market (Gopinath and Jayalakshmi, 2018). Organic farming is one of the best farming methods to decrease the cost of production and gives you the best quality of a product without any chemical or toxic substance (Kumar, 2020). Further, sustainability in agriculture production refers to the capacity to remain productive while maintaining the soil fertility.

Azolla, an aquatic water fern belongs to the family of Azollaceae and the genus *Azolla*. The azolla are separated into two subgenera: *Euazolla* and *Rhizosperma* (Sood, 2007). *Azolla* is native to tropics, subtropics, and warm temperate places such as Asia, America, and Africa (Nayak and Reddy, 2005). The important species of azolla include *A. microphylla*, *A. pinnata*, *A. rubra*, *A. fuiliculodes*, *A. Mexicana*, *A. nilotica*, and *A. caroliniana* (Waseem et al, 2012). The use of azolla also rises the organic matter and potassium contents of the soil (Bhuvaneshwari and Singh, 2015). It has the capability to preserve considerable amounts of nutrients (Kumar et al, 2012). Also, azolla can serve as a good nitrogen supplement for plants (Choudhary et al, 2004). The death and decay of azolla release nutrients as fresh matter in water (Marwaha et al, 1992). *Azolla* consists of cyanobacteria which can release nutrients into soil in easily available, to plants (Wagner, 1997). Therefore, this current study explores ways to extend the use of azolla as a biofertilizer to enhance the yield and growth of okra.

II. MATERIALS AND METHODS

The study was carried out in the botanical garden of the Department of Environmental Science, School of Life Sciences, JSS Academy of Higher Education & Research, Mysuru. This is located in the equatorial region along the coordinates 12.34N latitude and 76.65E longitudes. The area experiences a tropical climate with an annual temperature of 33⁰ C. The study followed a completely randomized experimental design, whereby the effect of azolla treatment on the growth performance and yield of *Abelmoschus esculentus* was studied.

2.1. Application of Azolla

Fresh azolla plants were collected in 5 litre buckets from the culture pond maintained by the Department of Environmental Science, JSS Academy of Higher Education & Research, Mysuru. Five experimental setups were laid in triplicates. Correct volume measurements were made, and the azolla was mixed with soil in variations of 50g, 100g, 150g, and 200g per 6 kilograms of soil. The soil and azolla mixture were properly mixed with 1kg of vermicompost thoroughly rotating it using a spade to ensure homogeneity of the mixture (Table 1). This homogeneous mixture was then left to decompose for 15 days because the decomposition of azolla fern helps in releasing all the nutrients from azolla into the soil. During this period, the mixture was watered every 2 days to avoid drying up.

Table 1. Treatment for targeted plants

Treatment numbers	Treatments
T1	6 kg Soil + 1 kg vermicompost
T2	6 kg soil + 1 kg vermicompost + 50g azolla
T3	6 kg soil + 1 kg vermicompost + 100g azolla
T4	6 kg soil + 1 kg vermicompost + 150g azolla
T5	6 kg soil + 1 kg vermicompost + 200 g azolla

2.2. Estimation and extraction of chlorophyll in okra leaves

0.2g of leaf sample was taken each plant of the grow bags with respect to their concentration (T1, T2, T3, T4, T5), 10ml of 80% acetone was added and made into a paste. The contents were centrifuged at 5000rpm for 5minutes. Next by using a spectrophotometer the absorbance was noted at 645nm and 663nm respectively.

The estimation of chlorophyll content is calculated using the formula given below (Rajalakshmi and Banu, 2015).

$$\text{Chlorophyll a: } 12.7(A_{663}) - 2.69(A_{645})$$

$$\text{Chlorophyll b: } 22.9(A_{645}) - 4.68(A_{663})$$

$$\text{Total Chlorophyll: } 20.2(A_{645}) - 8.02(A_{663})$$

III. RESULT AND DISCUSSION

3.1. Germination Percentage (GP%)

The results of this study showed that germination percentage increases significantly with an increase in concentration and decreased germination percentage was detected in control (water-soaked). The okra seeds have been observed to germinate after a week of sowing. The maximum germination percentage of okra seeds was found to be 90%, 80%, 70%, 60%, and 50% was observed in 200%, 150%, 100%, 50%, and in control respectively.

3.2. Growth parameters

3.2.1. Shoot Length

Azolla treatment had a significant effect on the shoot length of okra plants at $p < 0.05$ level (ANOVA, $P = 4.39$). T5 azolla treatment has the highest mean height with 83.3cm, while control indicated the lowest mean height at 33.5cm. Significant variations in the heights were observed among the treatments (Fig. 1). An increase in the length of the shoot was taken as the parameter for growth, besides, browning in the shoots at different concentrations was also studied (Pandey and Gopal, 2020). Similarly, various studies like growth parameter of shoot length are increased which enhanced the nutrient level of soil (Kumar et al, 2018).

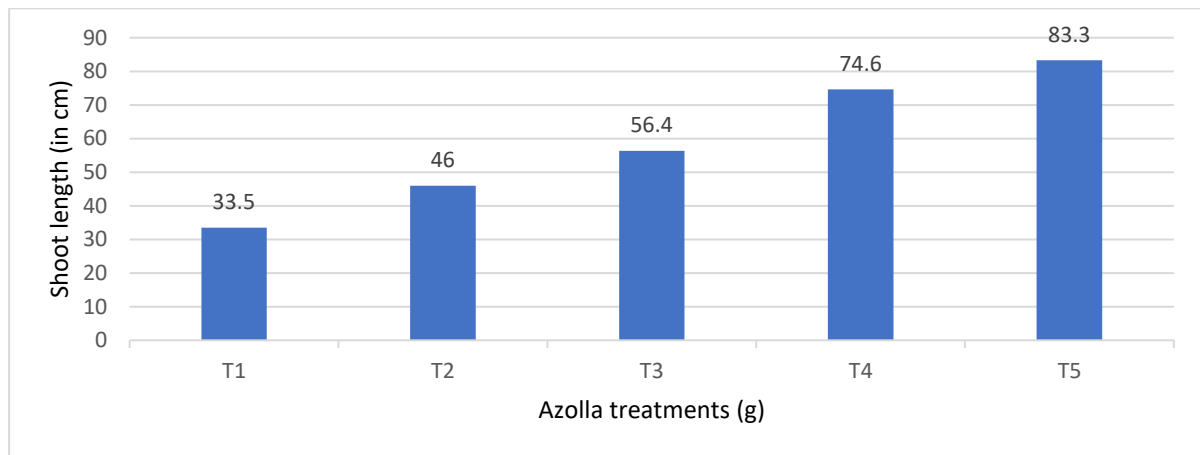


Figure 1. A graph showing the effect of azolla treatments on shoot length of okra plant

3.2.2. Root Length

Azolla treatment had a significant effect on the root length of okra plants at $p < 0.05$ level (ANOVA, $P = 0.000478$). T5 azolla treatment has the highest mean height with 53.6cm, while control indicated the lowest mean height at 15.6cm. Significant variations in the heights were observed among the treatments (Fig. 2). Compared to the fresh azolla treatment the root length increased can be observed in the composted azolla treatment (Rashid et al, 2021). Composted azolla enhanced the soil aeration and porosity by losing the soil and making it easier for roots to penetrate and absorb more nutrients. Besides, Azolla application led to increased soil microbiological activities such as mineralization by microbes (Khan et al, 2020).

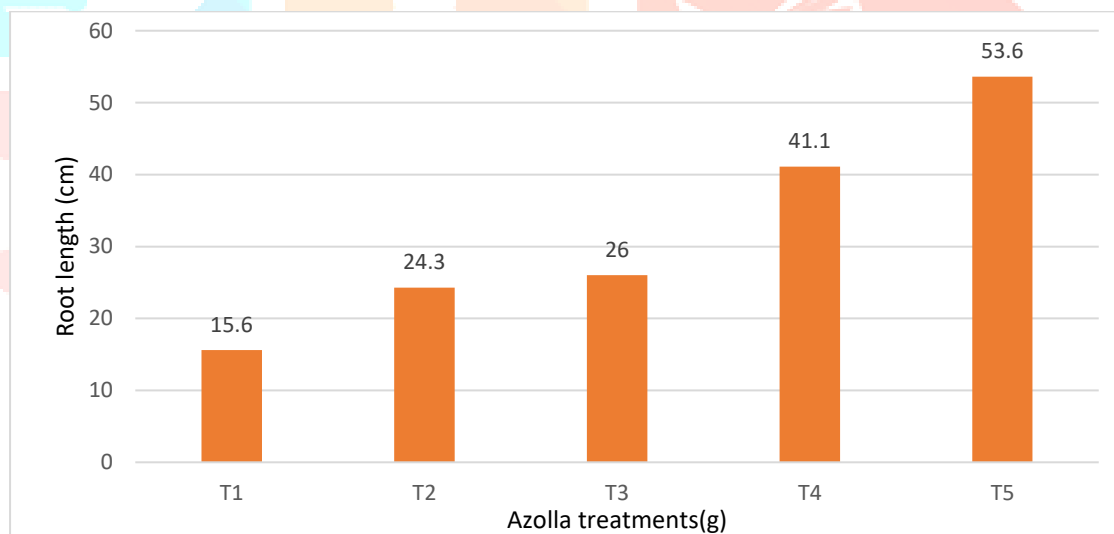


Figure 2. A graph showing the effect of azolla treatments on root length of okra plant

3.2.3. Shoot Weight

Azolla treatment had a significant effect on the shoot weight of okra plants at $p < 0.05$ level (ANOVA, $P = 0.000148$). T5 azolla treatment has the highest mean weight with 0.165g, while control indicated the lowest mean weight at 0.026g. Significant variations in the weights were observed among the treatments (Fig. 3). It is inferred from results that shoot weight was significantly increased in treatments, (81%) the maximum increase (Sharma et al, 2021).

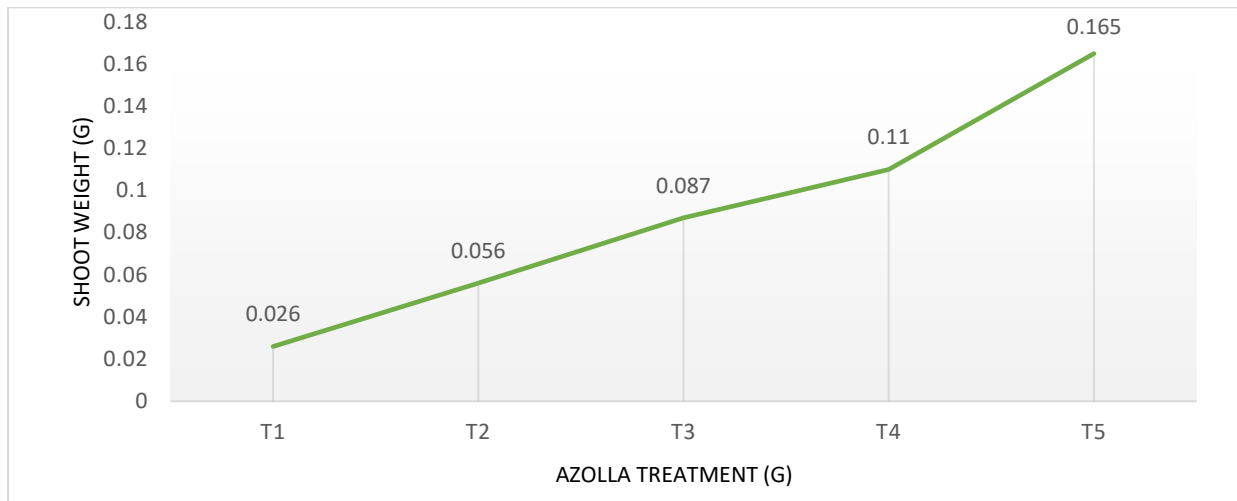


Figure 3. Effect of azolla treatments on shoot weight of okra crops

3.2.4. Root Weight

Azolla treatment had a significant effect on the root weight of okra plants at $p < 0.05$ level (ANOVA, $P = 0.0188$). T5 azolla treatment has the highest mean weight with 0.032g, while control indicated the lowest mean weight at 0.008g days. Significant variations in the weights were observed among the treatments in Fig. 4. A high value of available nutrients was recorded during the harvest stage, and the highest root weight was observed in the treatment (Manjunath et al, 2016). In a similar way, microbial treatments had a significant effect on root weight, yield, and disease indices. Root weight values ranged from 10.59–14.97 g–1 plant. The treatment T3 (An-Az biofilm) recorded the highest values (Pathak, 2011).

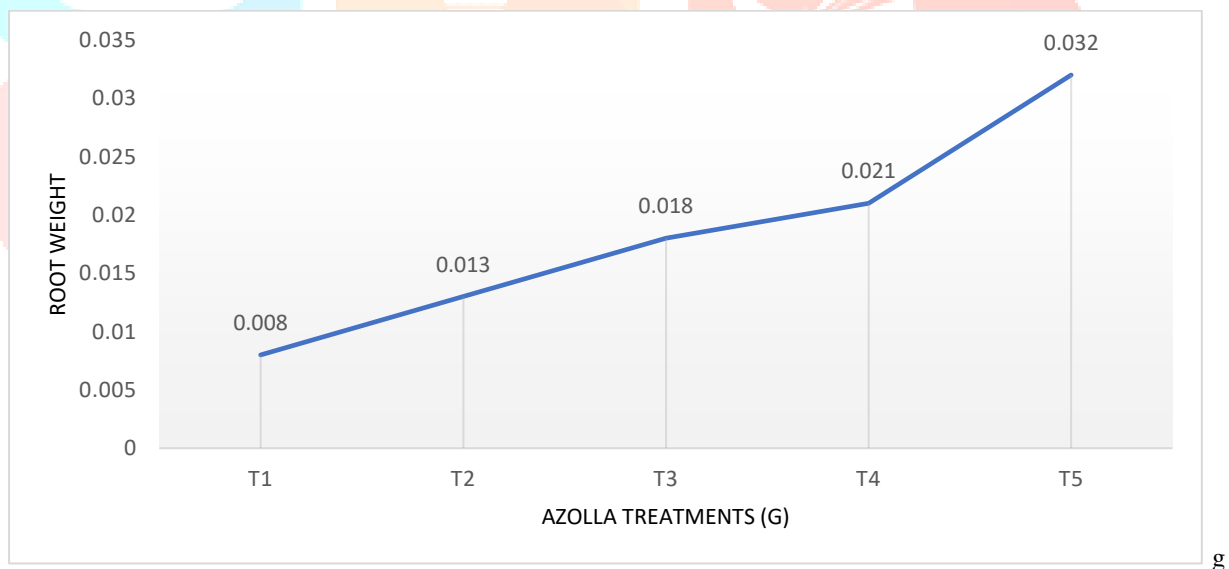


Figure 4. A graph showing the effect of azolla treatments on the root weight of the okra plant

3.3. Yield parameters

3.3.1. Number of pods

The mean number of pods produced is shown in Table and Azolla treatment had a significant effect to produce the pods of okra plants at $p < 0.05$ level (ANOVA, $P = 0.0479$). T5 azolla treated plants have produced the highest number of pods, while control indicated the lowest number of pods produced. The first flowering happened in the 6th week after sowing and the first fruit appeared on the 48th day after sowing. The length of the okras was impressive in T5 azolla treated plants. Significant variations in the pods' number were observed among the treatments (Table 1). A significant increase in okra fruit yield due to improvement in the number of fruits /plants, fruit weight (g per fruit), and fruit yield q/ ha of okra under integrated nutrient management was observed (2016).

Table 1. Mean Number of pods produced by okra plant

Azolla Treatments (g)	Number of pods
T1	2
T2	2.6
T3	3
T4	4
T5	5

3.3.2. Numbers of leaves

The mean number of leaves present is shown in Table 3 and Azolla treatment had a significant effect on the number of leaves in okra plants at $p < 0.05$ level (ANOVA, $P = 0.018$). T5 azolla treated plants have the highest number of leaves, while control indicated the lowest number of leaves produced. Significant variations in the leaves number were observed among the treatments (Table 2). Azolla treatment had been subjected to the number of leaves and a large number of nutrients available to the plant. Similarly, azollafiliculoides and caroliniana allow the good growth of cabbage. The average number of leaves of the plants resulting from these treatments is 10.27 ± 0.19 (Ouedraogo, 2015).

Table 2. Mean Number of leaves in okra plant

Azolla Treatments (g)	Number of leaves
Control	9
50	11.3
100	13.3
150	16.3
200	18

3.4. Estimation of chlorophyll contents

The amount of chlorophyll was found to increase with the increase in the concentration of treatment of the azolla. Effect of azolla on chlorophyll content is observed, as we can see that 150g azolla treated plant has highest chlorophyll content and control has the least chlorophyll content. The 200g azolla treated plant has fewer chlorophyll contents compared to 150g azolla treated plants, so we studied all the facts of the experiment and came to the knowledge that the 200g treated azolla plants were kept in shade and there was no direct sunlight falling to it (Fig. 5). Chlorophyll fluorescence parameters were performed in fully expanded okra leaves analyzed by using Plant Efficiency Analyzer (Pravisya et al, 2019). In their study, chlorophyll (1.06 mg) was predominantly enhanced in plants supplemented with *B. sonorensis* and then controlled after 60 days of treatment (Harinathan et al, 2021).

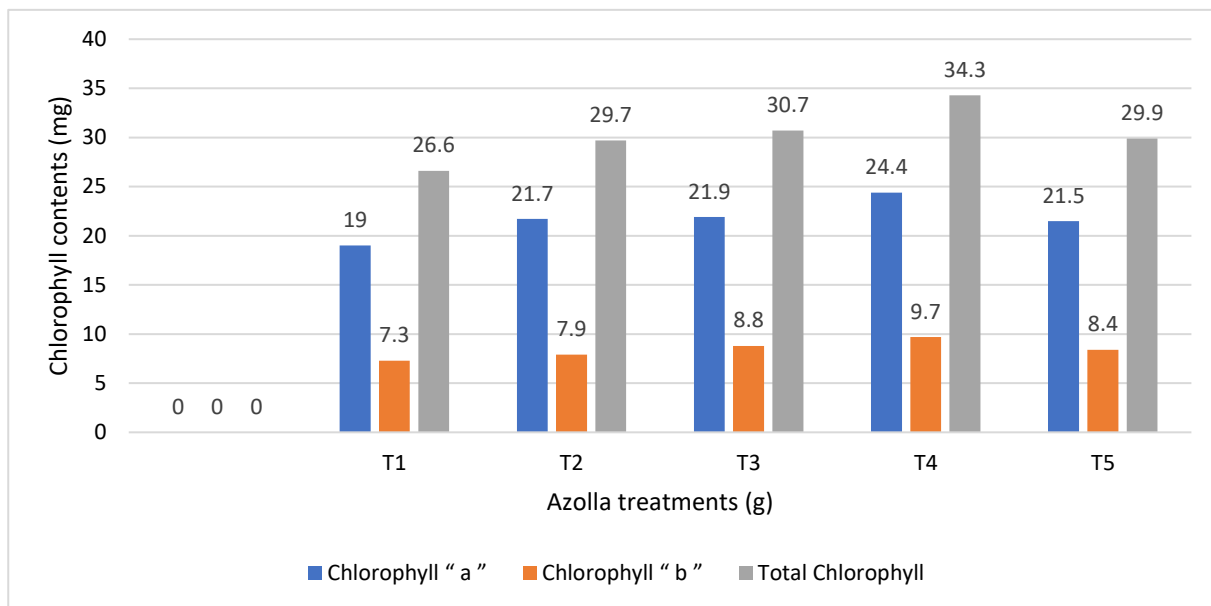


Figure 5. A graph showing the effect of azolla treatments on chlorophyll content present in okra plants

IV. Conclusion

The study results suggest that azolla treatments can effectively enhance the growth performance and yields of okra plants. This implies that the fern could suitably substitute inorganic fertilizers as a nutrient source which would obviously offer a number of benefits such as being non-toxic, harmless, cheaper, non-flammable, more accessible, and eco-friendly compared to others. Therefore, any efforts to advance the use of azolla fern to manage soil fertility in terrestrial crops would be of great economic gain in terms of reducing the cost of inorganic fertilizers as well as minimizing the environmental concerns associated with their use and it is obvious that the use of azolla in agriculture as an organic compost can be a boon to the Indian agriculture industry.

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