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Impact of Bioagent and botanicals on growth and yield of Okra

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Abstract
The present experiment was carried out during Feb to May 2023 in quantum university Roorkee. The experiment was conducted with three treatment, replicated thrice with Karishma variety of Okra, the seed were treated with turmeric extract with different concentration of 5%,10% and 15% along with control was maintained for this plant with no treatment. Soil was treated with biofertilizer *Trichoderma vride* and Vermi-compost. Garlic and neem oil spray used for plant protection. Various morphological parameters were used for the observation of plant growth in various physiological attributes i.e., Germination%, Plant Height, Pod Length and pod weight. All three treatments were significant as compared with control. 15% Turmeric treatment (T_3) seed treatment showed maximum result and lowest result was recorded in T_0 (Control).

Keywords: Organic farming, trichoderma, turmeric extract, neem oil, garlic extract

Introduction
Okra (*Abelmoschus esculentus* (L.) Moench belongs to malvaceae family, is a native from tropical Africa. It is often referred to as "a perfect villager's vegetable" because of its hardiness, nutritional fibres, and unique seed protein that is balanced in both tryptophan and lysine amino acids (Kumar *et al.,* 2010) [17]. It is a popular summer vegetable in Nepal that may be eaten raw, steamed, cooked, or fried. It is mostly grown for its delicate pods (Farinde *et al.,* 2007; Maurya *et al.,* 2013) [18, 19]. Okra offers therapeutic and nutritional benefits. Vitamins A, B, and C are present in the green, delicate pod along with oxalic acid, thiamine, riboflavin, and nicotinic acid. Approximately 66 mg of calcium per 100 g makes this vegetable far higher in calcium content than other vegetables. The okra pod is a great source of iodine, which is needed to fend off throat ailments like goiter.

With an area of 509 thousand hectares, an annual production of 6094.9 thousand tonnes, and a yield of 12 million tonnes/ha, India leads the world in okra production. The crop is cultivated all across India, but Gujarat is the state that produces the most, with an output of about 921.72 thousand tonnes from 75.27 thousand hectares and a productivity of 12.25 tonnes/ha.

Living microorganisms included in biofertilizer have the ability to enhance soil nutrients, physical and chemical characteristics, encourage plant development, and suppress diseases (Kumar, 2016; Ren *et al.,* 2020) [20, 21]. Biofertilizers are essential for enhancing the soil environment and promoting plant development since they are thought to be a safe, nontoxic substitute for synthetic agrochemicals.

Trichoderma species are effective biological control agents that can stop soil-borne illnesses and promote plant growth, claim Carrera Huerga *et al.* (2020) and Sallam *et al.* (2019) [22]. Numerous secondary metabolites produced by Trichoderma species directly prevent the growth of dangerous bacteria (Mironenka *et al.,* 2021) [23]. However, they also indirectly improve plant resistance to disease and promote plant development by changing the makeup of the soil microbial community and increasing the number of beneficial soil microbes. Consequently, biological management has been the main focus of Trichoderma strain research in recent years.

The stiff seed coat that causes low germination in okra plants can be fixed by seed priming. The process of carefully hydrating seeds to possibly promote faster and more reliable seed germination and subsequent plant development is known as "seed priming" (Sharma *et al.,*

2014) [24]. In order to overcome the okra seed germination obstacle, the experiment sought to determine how bio-priming treatments affected okra seed germination.

Materials and Methodology

This experiment was conducted in Hasanpur, Roorkee Uttarakhand India. Its latitude and longitude location are approximately 30.0083°N 77.7636°E respectively. This location receives about 98.16 millimeters (3.86 inches) of precipitation and has 97.82 rainy days (26.8% of the time) annually. Its average rainfall is 11.3 inches. The hot season lasts for nearly 2.6 months, from middle of April to starting of July, with an average daily high temperature above 35 °C. The hottest month of the year is June, with an average high of 38 °C and low of 27 °C. The cool season lasts for nearly 2.4 months, from starting of December to end of February, with an average daily high temperature below 23 °C. The coldest month of the year is January, with an average low of 10 °C and high of 20 °C.

The experiment variety of Karishma was a one factor analysis with cropping system, Biofertilizer (*Trichoderma viride*) and turmeric application as treatment factors. Plots measuring 9m^2 (3×3 m) were planted. Treatments were arranged within field with three replicates with one control. We were prepared% solution of Turmeric solution i.e. 5% 10% and 15%. Soil was treated with 25 kg/m^2 FYM and 400 gm *Trichoderma viride*. Seed were treated with turmeric solution in different percent solution 5%, 10% and 15% for 24hrs and control which was not treated with solution. For all treatment including control, 12 plots were prepared. Line sowing method was used with spacing 60*40 cm. Time to time weeding and irrigation operation was done in the field. Blister beetle, Shoot and fruit borer pest and Wilt and Blight disease found in the okra, Garlic and neem oil regular spray was used for their management. Garlic spray and neem oil spray has done in every 10 days interval for better plant protection. When the fruit was fully matured harvesting was done. Data was carried out by two to three times.

Result and Discussion

The experiment aimed to assess the impact of turmeric extract (5%, 10%, and 15%) in conjunction with biofertilizer (*Trichoderma viride)* and organic constituents (vermicompost, neem oil, and garlic extract) on the growth and production of okra. The measured metrics were germination%, plant height, pod length, and pod weight. The results are provided in Table 1 and explained below:

1. **Germination Percentage (%):** The germination percentage markedly increased with higher concentrations of turmeric extract. The maximum germination percentage of 76% was observed in T_3 (15% turmeric extract), followed by 71% in T_2 (10%), and 67% in T_1 (5%). The control group (T_4) exhibited the lowest germination rate at 59%. This suggests that turmeric seed priming enhances seed vigor and mitigates the hard seed coat barrier in okra. The outcome corresponds with the research of Ashadul *et al.* (2011) on brinjal and K. Mukhopadhyay *et al.* (2019) [16], both of whom documented improved germination using organic priming methods.
2. **Plant Height**: The highest plants were recorded in T_3 (15%) with an average height of 57.33 cm, followed by T_2 at 36.81 cm, and T_1 at 30.10 cm. The control documented the shortest plants at 26.63 cm. The enhanced plant height in the treated plots is likely attributable to the improved soil microbial conditions from *Trichoderma viride* and the augmented seedling vigor from turmeric priming. These findings corroborate prior research by Sallam *et al.* (2019) [22] and Zafra & Cortés Espinosa (2015), which highlighted the plant growth-promoting capabilities of Trichoderma.
3. **Pod Length: -** The pod length was greatest in T_3 (15%) at 12.88 cm, followed by T_2 at 12.53 cm, and T_1 at 11.43 cm. The control exhibited the shortest pods, measuring 9.14 cm.

   The results indicate that elevated turmeric concentrations utilized in seed priming augment reproductive development. Enhanced pod growth may also be ascribed to enhanced nutrient absorption and disease resistance promoted by biofertilizer use.
4. **Pod Weight (g):** The maximum pod weight was seen in T_2 (10%) at 6.97 g, succeeded by T_3 at 6.03 g and T_1 at 5.27 g. The control exhibited the minimal pod weight at 5.03 g.

Notably, although T_3 exhibited superior performance in the majority of attributes, T_2 yielded the greatest pod weight. This indicates that a 10% turmeric extract concentration may offer an optimal equilibrium between vegetative growth and fruit development. Lal *et al.* (2019) [15] also identified analogous findings in investigations with organic amendments and bioagents.

Table 1: Treatment table used in present experiment

Treatment Symbols	Treatment Combination
T_1	5% Turmeric extract
T_2	10% Turmeric extract
T_3	15% Turmeric extract
T4	Control with no treatment

Table 2: Result of organic manure on various growth and quality related traits in Bottle gourd

Treatments	Plant Height (cm)	Pod length (cm)	Pod weight (g)	Germination%
5%	30.10	11.43	5.27	67.00
10%	36.81	12.53	6.97	71.00
15%	57.33	12.88	6.03	76.00
Control	26.63	9.14	5.03	59.00
CV	0.819	3.366	2.577	1.403
CD	0.103	0.242	0.137	1.950
SE(m)	0.029	0.069	0.039	0.553

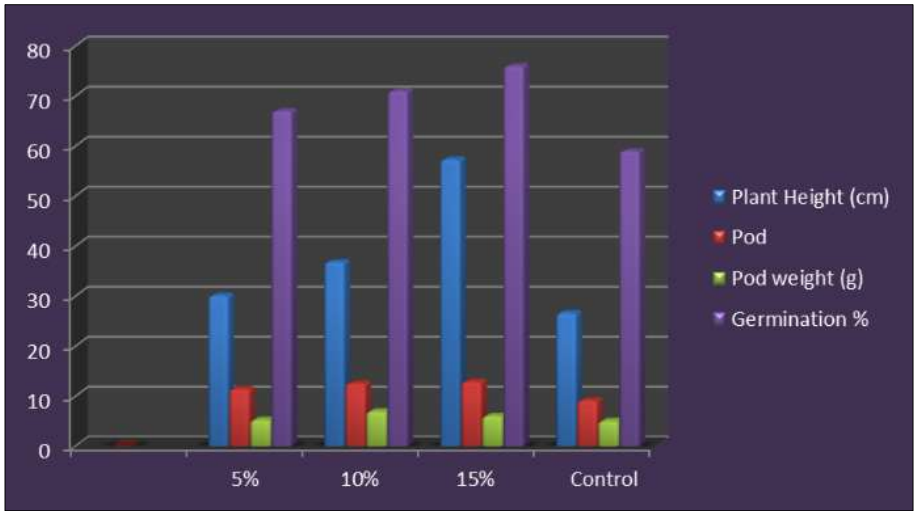

Fig 1: Graphical representation of the growth parameter in Bottle Gourd

Conclusion

This study decisively showed the beneficial effects of bioagents and organic materials on the growth and yield characteristics of okra (*Abelmoschus esculentus* L.). Seed priming with turmeric extract at different doses (5%, 10%, and 15%) alongside soil treatment with Trichoderma viride and vermicompost markedly improved germination percentage, plant height, pod length, and pod weight relative to the untreated control. Treatment T_3 (15% turmeric extract) consistently shown superior results in germination (76%), plant height (57.33 cm), and pod length (12.88 cm), suggesting its efficacy in overcoming seed dormancy and promoting robust seedling development. The 10% turmeric extract (T_2) produced the maximum pod weight (6.97 g), indicating an appropriate concentration for improving fruit quality.

The use of botanical like garlic oil and neem, as well as biofertilizer, improved pest and disease control, resulting in healthier plants and better yield. These results add credence to the increasing amount of research supporting environmentally friendly and organic farming methods that increase crop yield without compromising ecological integrity. A practical, affordable, and environmentally responsible way to increase okra yield is to combine turmeric seed priming with biofertilizer applications. To further validate and enhance these sustainable practices for wider agricultural use, future research may concentrate on analyzing the synergistic effects of various organic extracts and bioagents across a range of agro-climatic conditions.

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