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**To study effect of biocontrol agents on growth of
okra *Abelmoschus esculentus* (L.) Moench**

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Harshit Gupta**

Abstract

Biocontrol can also be defined as utilization of one living organism to restrict another. These biological control agents are environment friendly and cause no side effect. It is cheaper than any other method, these agents does not cause toxicity to plants. It cause no effect in the soil and leave no residual problems. It increases crop yield and are easy to manage and apply to the target. To reduce the deleterious effect of agrochemicals an experiment was conducted to study the effect of biocontrol agents on okra for the selection of putative strain at the Department of Seed Science & Technology, Chauras campus, H.N.B Garhwal University, Srinagar (Garhwal), Uttarakhand, India. To evaluate different parameters with biocontrol agents in both laboratory and field condition Biocontrol agents including *Bacillus*-218, *Pseudomonas* strain FP37 and S90 singly and in combinations were used for seed treatment in Okra. Effects were examined by observing Germination, Root length, Shoot length, Dry weight, Fresh weight, Seedling length. The laboratory results are presented in Table 1 and the field results are presented in Table 2 and Table 3 Fig.1-3. In both laboratory and field condition treatments shows better result over control.

Keywords: Biocontrol agents, Okra, Environment friendly, Organic farming

Introduction

Okra (*Abelmoschus esculentus* Monech) known as Bhindi or lady's finger or gumboo, okra belongs to the family malvaceae having chromosome no. $2n=130$. There are 38 species under the genus *Abelmoschus* and is a warm season vegetable grown in the tropical and subtropical countries of the world. The origin of okra is somewhere in African continent. It is one of the most popular because of its easy cultivation quick growing habit short duration dependable yield and its adaptability to various conditions for its tender green pods used as vegetables though sometimes canned and dehydrated,

At present, in India the annual production of okra is 6350.3 thousand million tonnes from an area of about 530785 hectares with the productivity of 12.0 MT/ha. Leading Okra producing states in India are Andhra Pradesh, West Bengal, Bihar, Gujarat, Orissa, Maharashtra, Assam, and Uttar Pradesh.

The edible part of Okra is capsule, dehiscent, elongated, straight or curved which is up to 10-30 centimeter long per 1-4 centimeter wide, green yellow or green sometimes purple or white. It is used as an ingredient in soups, stews and various creole dishes. The dried seeds roasted and ground are used as coffee additive or substitute. Okra leaves, buds, flowers, can be eaten cooked, boiled, steamed and curries. Seeds contain up to 22% edible oil, so they can be used for extracting oil. Greenish-yellow edible okra has pleasant taste and it is high in unsaturated fats such as linoleic acid. Okra is also well known for its medicinal properties.

Common Okra growing problems are seeds do not germinate if soil is not warm enough with temperature at least 70° F. Too cool and dry temperature lead to drop of flowers and bud before pods set. Pollination will be poor if temperature rise above 90° F or drop below 55° F. Plants stunted leaves yellow and curl and become deformed due to fungal disease that favors warm soil prevalent in humid region. These effects can be reduced to some extent by using biological control agent.

Plant growth promoting rhizobacteria (PGPR) are the soil bacteria inhabiting around/on the root surface and are directly or indirectly involved in promoting plant growth and development via production and secretion of various regulatory chemicals in the vicinity of rhizosphere. Generally, plant growth promoting rhizobacteria facilitate the plant growth directly by either assisting in resource acquisition (nitrogen, phosphorus and essential minerals) or modulating plant hormone levels, or directly by decreasing the inhibitory effects of various pathogens on plant growth and development in the forms of bio control agents. Various studies have documented the increased health and productivity of different plant species by the application of plant growth promoting rhizobacteria under both normal and stressed conditions.

Pseudomonas and *Bacillus* are the well known for their plant growth promotional activity. These soil borne bacteria are emerging as an important tool because of their catabolic activity, root colonizing ability, Capacity to produce a wide range of enzyme and metabolites that help the plant to withstand under various biotic and abiotic conditions. *Pseudomonas* is a genus of Gram-negative, aerobic gamma protein bacteria, belonging to the family Pseudomonadaceae. The consequently are able to colonize a wide range of niches. Their ease of culture in vitro and availability of an increasing number of *Pseudomonas* strain genome sequences has made the genus an excellent focus for scientific research; the best studied species include *P. aeruginosa* in its role as an opportunistic human pathogen, the plant pathogen *P. syringae*, the soil bacterium *P. putida*, and the plant growth-promoting *P. fluorescens* (Madigan *et al.*, 2005). Mishra and Nautiyal in 2009 evaluate the role of *Pseudomonas putida* NBRIC19 in alleviating biotic stress of *Parthenium hysterophorus* (Parthenium) in *Triticum aestivum*. *Bacillus* is a genus of gram-positive, rod-shaped (bacillus) bacteria and a member of phylum Firmicutes. *Bacillus aquimaris* SSC5 isolated from a soil microcosm utilizes m- tyrosine as the sole source of carbon, nitrogen, and energy (Bertin *et al.*, 2007).

There is substantial scope for enhancing yield of Okra to meet the increasing demands by adoption of new techniques such as using proper combination of different biocontrol agents. With this consideration, the present studies entitled "To Study Effect of Biocontrol Agents on Growth of Okra *Abelmoschus Esculentus* (L.) Moench".

Material and Methods

Experimental Site

The present investigation entitled "To Study Effect of Biocontrol Agents on Growth of Okra (*Abelmoschus Esculentus* (L.) Moench" was conducted at Department of seed Science & Technology, Chauras campus, H. N. B Garhwal University, Srinagar (Garhwal), Uttarakhand, India. The material used and methods followed during this investigation have been described as

Collection of Seeds

Okra seed of variety Arka komal was use in the research.

Laboratory Experiment

Biocontrol agents including *Bacillus*-218, *Pseudomonas* strain FP37 and S90 singly and in combinations were used for seed treatment in Okra. Seeds were washed properly with distilled water and leave to dry. Then germination test were carried out by the towel paper method. Moist towel papers were used as a substratum to conduct all the experimental trials. 75 seeds for each treatment with three replications each consist of 25 seeds, and placed in seed germinator at cylindrical position for 10 days at 25 °C and daily observation were taken up to the completion of experiment.

Field trial

There were seven treatments as described in Table-1 with their different combinations was grown in the field. Well decomposed FYM was added in the field before sowing. Design used for the field trial was RBD (Randomized Block Design). Seeds were properly washed with distilled water and leave it to dry. Then the seeds are treated with bioagents containing 90 seeds with three replications each containing thirty seeds. Each replication consists of three rows with ten seeds in every row. The depth of seed sowing was not more than three centimeter. Seeds were sown in full soil moisture and deep ploughed land for thirty days at 25-30 °C and daily observation were taken up to the completion of experiment.

Treatments details

Control- Without any seed treatment.

T1 - Seed Treated with bioagent *Bacillus*-218 @12gm/kg

T2 - Seed Treated with *Pseudomonas*FP-37@12gm/kg

T3 - Seed Treated with bioagent *Pseudomonas*S-90@12gm/kg

T4 - Seed Treated with bioagents *Bacillus*-218 + *Pseudomonas*FP-37@12gm/kg

T5 - Seed Treated with bioagents *Bacillus*-218 + *Pseudomonas*S-90@12gm/kg

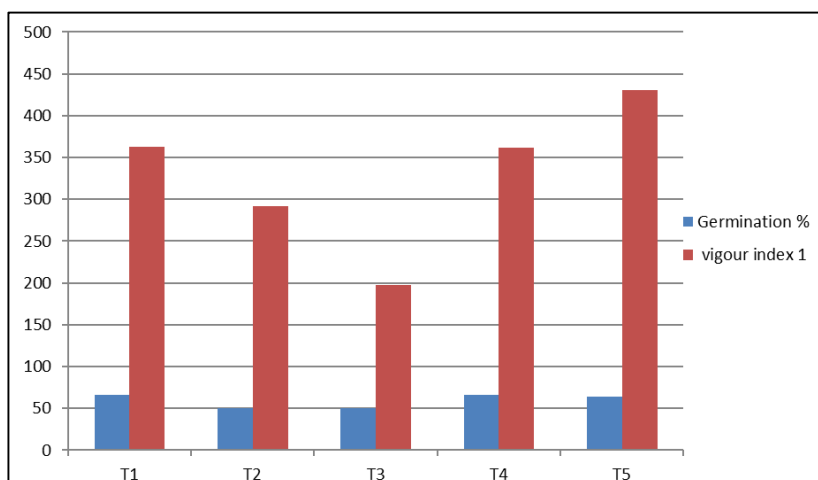
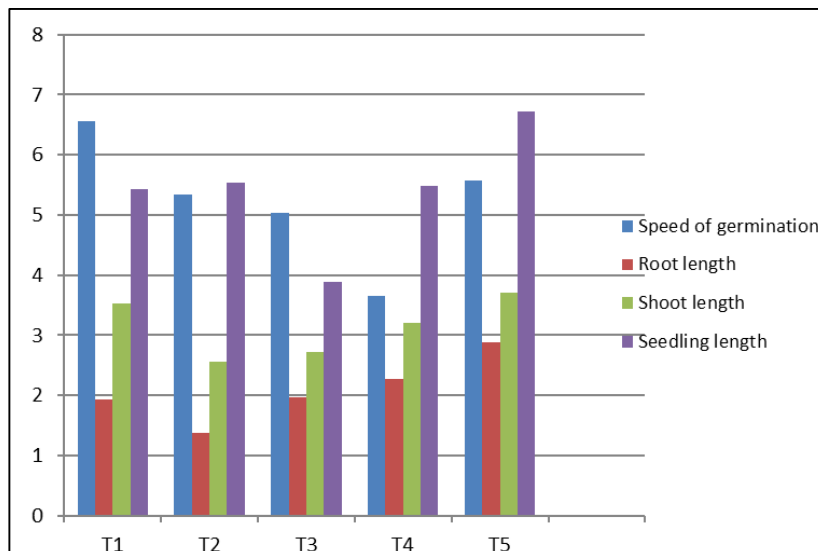
T6 - Seed Treated with bioagents *Pseudomonas* FP-37 + *Pseudomonas*S-90@12gm/kg

T7 - Seed Treated with bioagents *Bacillus*-218 + *Bacillus*-218 + *Pseudomonas*S-90@12gm/kg.

Table 1: Standardization of different strain according to their effect on morphological growth of okra. Finally three strains *Bacillus*-218, *Pseudomonas* strain FP37 and S90 selected on the basis of their performance.

Treatment	Speed of germination	Germination%	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling vigour index I
T1	6.55**	66.00**	1.93**	3.53**	5.43**	362.32**
T2	5.34**	50.00**	1.37**	2.56**	5.53**	291.60**
T3	5.03**	50.00**	1.97**	2.72**	3.88**	197.24**
T4	3.66**	66.00**	2.28**	3.21**	5.49**	361.40**
T5	5.57**	64.00**	2.88**	3.70**	6.72**	430.08**
CD at 1%	1.73**	13.61**	0.39**	2.29**	3.20**	239.54**
CD at 5%	1.19*	9.37*	0.27*	1.58*	2.20*	164.85*

*, ** data are significant at 5% and 1% respectively.



Data analysis

1. Assessment of planting value: Parameters for assessing the planting value as follows.

- a) Germination % = $\frac{\text{No. of seeds germination on final day} \times 100}{\text{Number of seed sown}}$
- b) Speed of Germination: Speed of germination calculated by using the formula given by Maguire 1962, Bradbeer 1988; Wardle *et al.*, 1991.
- $$(N1/1 + N2/2 + \dots + Nn/Nn1)$$
- Where N1= Total Number of seed germinated on day 1; N2= Total Number of seed germinated on day 2 and so on till Nn=Total Number of seed germinated on final day.
- c) Root Length: Length of root from collar to the apical tip (cm) (ISTA Rules 2010).
- d) Shoot Length: Length of shoot from collar to the apical tip (cm).
- e) Seedling Length: Total length of seedling was obtained by adding root and shoot length (cm).
- f) Fresh weight of seedling: Weight of uprooted seedling (gm).
- g) Dry weight of seedling: Weight of dried seedling (gm).
- h) Seedling vigour index 1: Seedling length \times Germination%
- i) Seedling vigour index 2: Seedling dry weight \times Germination%

2. Statistical analysis

The data was analyzed by following analysis of RBD. Analysis of variance (ANOVA) was performed and when significant difference existed (CD at 1% and 5%) was calculated to compare the mean of different treatments.

Results

In the present study we have found that *Bioagents Pseudomonas and Bacillus increase the growth of okra*. To increase the growth of okra seeds we used different seed treatments of bioagents (*Pseudomonas, Bacillus*) at 12gm/Kg. The experiment was carried in both lab and field.

We found that different treatments of bioagents increased germination and other growth parameters in okra seeds. The laboratory results are presented in Table 1 and the field results are presented in Table 2 and Table 3 Fig.1-3. We have studied different parameters of germination and growth which are given as follows-

Germination Percentage- On the basis of data, Maximum germination percentage in lab 72% was recorded in T1, T2 and T6 as compare to control 56%. Minimum germination percentage 58% with bioagents was recorded in T5.

In field conditions, Maximum germination percentage 72.22% was observed in T6 while Minimum germination percentage 53.33% was observed in control. Minimum germination percentage 55.55% with bioagents was recorded in T3 and T7.

Speed of germination- Maximum speed of germination in lab 21.34 was recorded in T2 as compare to control 8.36. Minimum Speed of germination 9.68 with bioagents was recorded in T7.

In field conditions, Maximum Speed of germination 15.09 was recorded in T1 as compare to control 14.88. Minimum Speed of germination 8.21 with bioagents was recorded in T5.

Root and Shoot length- Maximum root length in lab 2.80 was observed in T6 as compare to control 1.92. Minimum Root length 1.41 with bioagents was recorded in T3.

In field condition Maximum root length 9.00 was observed in T2 as compare to control 6.18. Minimum Root length 6.11 with bioagents was recorded in T5.

Maximum shoot length in lab 3.75cm in was recorded in T2 compare to control 2.98cm. Minimum shoot length 2.58 with bioagents was recorded in T5.

In field conditions, Maximum shoot length 12.70 cm was recorded in T2 as compare to control 10.65cm. Minimum shoot length 8.13 with bioagents was recorded in T3.

Table 1: Effects of biological seed treatment on germination and different growth parameters of okra seeds in laboratory condition

Treatment	Speed of germination	Germination%	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling vigour index 1
T1	12.84**	72.00**	1.44**	3.02**	4.46**	192.35**
T2	21.34**	72.00**	1.66**	3.75**	5.41**	389.52**
T3	13.17**	62.00**	1.41**	3.16**	4.28**	266.76**
T4	13.27**	70.00**	1.52**	3.12**	4.59**	317.88**
T5	12.68**	58.00**	1.48**	2.58**	2.25**	237.96**
T6	15.33**	72.00**	2.80**	3.16**	6.01**	327.00**
T7	9.68**	64.00**	2.42**	2.79**	5.20**	330.88**
Control	8.36**	56.00**	1.92**	2.98**	4.90**	274.40**
CD at 1%	9.58**	20.19**	1.84**	3.07**	4.63**	220.13**
CD at 5%	6.91*	14.55*	0.32*	0.41*	0.52*	158.64*

*, ** data are significant at 5% and 1% respectively.

Table 2: Effects of biological seed treatment on germination and different growth parameters of okra seeds in field condition

Treatment	Speed of germination	Germination%	Root length (cm)	Shoot length (cm)
T1	15.09**	63.33**	8.40**	11.48**
T2	13.01**	59.99**	9.00**	12.70**
T3	12.08**	55.55**	6.80**	8.13**
T4	10.48**	61.21**	8.08**	11.15**
T5	8.21**	67.88**	6.11**	9.55**
T6	14.84**	72.22**	8.23**	12.63**
T7	13.57**	55.55**	8.01**	11.73**
Control	14.88**	53.33**	6.18**	10.65**
CD at 1%	8.23**	29.67**	1.76**	2.99**
CD at 5%	5.93*	21.38*	0.41*	2.16*

*, ** data are significant at 5% and 1% respectively.

Table 3: Effects of biological seed treatment on germination and different growth parameters of okra seeds in field condition.

Treatment	Fresh weight (gm)	Dry weight (gm)	Seedling length (cm)	Seedling vigour index 1	Seedling vigour index 2
T1	32.45**	6.44**	14.28**	1095.93**	414.84**
T2	45.27**	7.98**	21.70**	1303.87**	481.48**
T3	32.22**	6.28**	14.93**	824.24**	358.65**
T4	32.43**	7.94**	19.23**	496.46**	489.99**
T5	32.20**	8.10**	15.66**	1070.20**	543.20**
T6	62.38**	9.82**	20.86**	1572.78**	759.55**
T7	47.51**	8.33**	19.75**	1252.59**	526.08**
Control	15.84**	8.28**	16.75**	867.55**	510.97**
CD at 1%	25.94**	3.90**	3.92**	1563.91**	378.89**
CD at 5%	18.73*	2.81*	2.83*	3721.45*	273.01*

*, ** data are significant at 5% and 1% respectively.

Seedling Length – Maximum seedling length in lab 6.01 in was recorded in T6 compare to control 4.90. Minimum seedling length 2.25 with bioagents was recorded in T1.

In field conditions, Maximum seedling length 21.70 was recorded in T2 as compare to control 16.75. Minimum seedling length 14.28 with bioagents was recorded in T3

Fresh Weight and Dry Weight – Maximum fresh weight in field 62.38gm was observed in T6 as compare to control

15.84gm. Minimum fresh weight 32.20gm with bioagents was recorded in T5. Maximum dry weight 9.82gm was observed in T6 as compare to control 8.28. Minimum dry weight 6.28gm with bioagents was recorded in T3.

Vigour Index 1 and Vigour Index 2:- Maximum vigour index 1 in lab 389.52 was recorded in T2 as compare to control 274.40. Minimum vigour index 1 in 192.35 with bioagents was recorded in T1. Maximum vigour index 1 in

field 1572.78 was recorded in T6 as compare to control 867.55. Minimum vigour index 1 in 496.46 with bioagents was recorded in T4.

Maximum vigour index 2 in field 759.55 was observed in T6 as compare to control 510.97. Minimum vigour index 1 in 358.65 with bioagents was recorded in T3.



Fig: Effect of different combinations of bioagents on seed germination and other parameters of okra



Fig: Effect of different combinations of bioagents on seed germination and other parameters of okra

Summary and Conclusion

The investigation was carried out with an objective of Role of bio agents on growth of okra. Bio agents used were *Bacillus* and *Pseudomonas* strain. Both Field and Laboratory experiments were conducted at 25 °C temperature. We collected okra seeds of variety Arka komal from local seed store Srinagar, Garhwal during 2018. At first selection of putative strain was done in Towel paper test to check its effects in Okra. Best results were observed in *Bacillus* 218 and *Pseudomonas* FP-37, S-90. These three bioagents singly and with their combination were further used in laboratory and field. The planting value parameters assessed were germination percentage, speed of germination, root length, shoot length, seedling length, fresh weight, dry weight, vigour index 1 and vigour index 2.

In laboratory experiment, Biocontrol Agents including *Bacillus*-218, *Pseudomonas* strain FP37 and S90 singly and in combinations were used for seed treatment in Okra. Moist towel papers were used as a substratum to conduct all the experimental trials. 75 seeds for each treatment with three replications each consist of 25 seeds, and placed in seed germinator at cylindrical position for 10 days at 25°C. In field trial, same combinations of treatments were used with design RBD (Randomized Block Design). During the experiment all the parameters were significantly higher than the control.

In Laboratory experiment, highest germination percentage 72% was recorded in T2, T2 and T6. Highest speed of germination 21.34 in T2. In all the bioagents treatments highest root length 2.80 was recorded in T6. Highest shoot

length 3.75 in T2. Highest seedling length 6.01 in T6. Highest vigour index 1 (389.52) found in T2.

In field trial, highest germination percentage 72.22% was recorded in T6. Highest speed of germination 15.09 in T1. In all the bioagents treatments highest root length 9.00 and shoot length 12.70 and seedling length 21.70 was recorded in T2. Maximum fresh weight 62.38gm, dry weight 9.82 gm found in T6. Highest vigour index 1 (1572.78) and highest vigour index 2 (759.55) found in T6.

On the basis of result of above experiment we concluded that okra seeds treated with bioagents gave us positive effect on all the parameters. The result show all the bioagents treatment with their combination enhance growth germination and other parameters of okra seeds.

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