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Effect of seed inoculants on growth, germination percentage and seed vigour of okra [*Abelmoschus esculentus* (L.) Moench]

Charan Singh Choudhary, Manju Netwal, Raj Kumar Jakhar and Deepti Prabha

Abstract
Experiments were conducted in *kharif* season 2019 at the experimental farm of regional seed science research center, chauras campus Srinagar Garhwal, District Pauri Garhwal (Uttrakhand) H.N.B. Garhwal University Srinagar Garhwal Uttarakhand. Experiments laid out in RBD having Eight treatments with three replications. The treatment consisted of (control, *Pseudomonas*, *Azotobactor*, Neem cake, *Pseudomonas* + *Azotobactor*, *Pseudomonas* + Neem cake, *Azotobactor* + Neem cake and *Pseudomonas* + *Azotobactor* + Neem cake). The results indicated that seed inoculation of *Azotobacter* along with neem cake to the okra significantly increased growth, germination percentage and seed vigour of okra *i.e.* germination percentage, plant height 30 days after sowing, days to 50% flowering, seedling root length, seedling shoot length, seedling length, plant height after 60 days sowing and seedling vigour index. However, treatment T_7 (*Pseudomonas* + *Azotobactor* + Neem cake) and T_5 (*Pseudomonas* + Neem) was found statistically at par to T_6 (*Azotobactor* + Neem cake) in all the parameters.

Keywords: *Azotobactor*, growth, neem cake, okra and *Pseudomonas*

Introduction
Okra contains proteins, carbohydrates and vitamin C (Dilruba *et al*., 2009) [2] and play a vital role in human diet (Saifullah and Rabbani 2009) [12]. The consumption of okra fruits per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 gm, energy 144.00 kJ (36 Kcal), protein 2.10 gm, carbohydrate 8.20 gm, fat 0.20 gm, fibre 1.70 gm, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, Beta-carotene 185.00 µg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. PGPR promote plant growth directly by either modulating plant hormone levels. Or facilitating resource acquisition (nitrogen phosphorous and essential minerals) or indirectly by decreasing the inhibitory effects of various pathogens on plant growth and development in the forms of bio-controls agents (Glick, 2012) [5].
Azotobacter beneficial effects on plant yields, due to their ability of fixing nitrogen (Tejera *et al*., 2005) [15], solubilizing phosphates (Hayat *et al*., 2010) [6] and Farajzadeh *et al*. (2012) [3] and to the microbial secretion of stimulating phytohormones, like gibberellins, auxins and cytokinins. *Azotobacter* also produces antifungal antibiotics i.e. fungistatic substances with a board active spectrum and inhibits the growth of *fusarium*, *Aspergillus*, *Helminthosporium*, *Alterneria*, *cephalosporium*, *Rhizoctonia* and *sclerotium rolfsii*.
Pseudomonas fluorescens encompasses a group of common, nonpathogenic saprophytes that colonize soil, water and plant surface environments. As its name implies, it secretes a soluble greenish fluorescent pigment called fluorescein, particularly under conditions of low iron availability. It is an obligate aerobe, except for some strains that can utilize NO_3 as an electron acceptor in place of O_2. *Pseudomonas fluorescens* belongs to Plant Growth Promoting *Rhizobacteria* (PGPR), the important group of bacteria that play a major role in the plant growth promotion, induced systemic resistance, biological control of pathogens etc. Many strains of *Pseudomonas fluorescens* are known to enhance plant growth promotion and reduce severity of various diseases, (Ganeshan and Kumar, 2006) [4].
The use of neem seed cake, which is a form of organic manure, has become imperative. Neem (*Azadirachta indica*) seed cake (residue of neem seed after oil extraction), when added to the soil, not only improves the soil with organic matter, but also lowers nitrogen losses by inhibiting nitrification. It increases the yield of crops on the long term, an excellent soil conditioner and has no negative effect on the environment (Lokanadhan *et al*., 2012) [8].

Keeping these in view, the present investigation was conducted to know the effect of seed inoculants on growth, germination percentage and seed vigour of okra.

Materials and Methods

The experiments entitled "effect of seed inoculants on growth, germination percentage and seed vigour of okra" (*Abelmoschus esculentus* L.) Moench" was carried out at the experimental farm of regional seed science research center, Chauras campus Srinagar Garhwal, (UK) H.N.B. Garhwal University Srinagar Garhwal Uttarakhand, during *Kharif* season, 2019 to execute the present study. The experiment was laid out in randomized block design with three replications consisting of twenty-four treatments comprising of organic (Farm yard manure & Neem cake) and Bio-fertilizers (*seudomonas* & *Azotobactor*) combinations including control, *Pseudomonas*, *Azotobactor*, Neem cake, *Pseudomonas* + *Azotobactor*, *Pseudomonas* + Neem cake, *Azotobactor* + Neem cake and *Pseudomonas* + *Azotobactor* + Neem cake. The organic (Neem cake) were applied as soil application 15 days before sowing and bio inoculants (*Pseudomonas and Azotobactor*) as seed treatment. The plot size was 4.95 × 3 m^2 and seedlings transplanted at spacing of 45 cm x 20 cm. Observations were recorded for different growth and quality parameters like germination percentage, plant height 30 days after sowing, days to 50% flowering, seedling root length, seedling shoot length, seedling length, plant height after 60 days sowing and seedling vigour index.

Germination percentage was calculated (Association of official Seed Analysis 1983) [1] as follows:

$$\text{Germination percentage} = \frac{\text{Numberofseedsgerminated}}{\textbf{Total}\text{number of seeds}} \times 100$$

The seedling vigour index was calculated as per the following formula:

Standard germination (%) × Seedling length (cm)

The data were analyzed according to the procedure of analysis of randomized block design with three replications (Snedecor and Cochran, 1961) [14].

Results and Discussion

Data pertaining to the effect of seed inoculants on growth, germination percentage and seed vigour of okra revealed that all the treatments significantly influenced the germination percentage, plant height 30 days after sowing, days to 50% flowering, seedling root length, seedling shoot length, seedling length, plant height after 60 days sowing and seedling vigour index of okra (Table 1 and 2). The results indicated that seed inoculation of *Azotobacter* along with neem cake to the okra significantly increased growth, germination percentage and seed vigour of okra *i.e.* germination percentage, plant height 30 days after sowing, days to 50% flowering, seedling root length, seedling shoot length, seedling length, plant height after 60 days sowing and seedling vigour index. However, treatment T_7 (*Pseudomonas* + *Azotobactor* + Neem cake) and T_5 (*Pseudomonas* + Neem) was found statistically at par to T_6 (*Azotobactor* + Neem cake) in all the parameters. In the present study, the application of *Azotobacter* + Neem cake (T_6) resulted in maximum germination percentage (86.92%) respectively. It is possibly due to the regular supply of the biofertilizer and neem cake which increment the germination percentage because *Azotobacter* also produce riboflavin, thiamin, gibberellins and indole acetic acid as earlier cited by Kader *et al*. (2002) [7]. This may be possibly due to the cell elongation and also dipped in inoculum as earlier cited by Sharma and Thakur (2001) [13] and Rawia *et al*. (2009) [11]. This might be due to the microbial inoculants showed effect on seed vigour index also an agreement with the findings of Nezarat *et al*. (2009) [9]. This is all due to the elongation of cells and also due to increases the photosynthetic activity were reported by Sharma and Thakur (2001) [13] and Nuruzzaman *et al*. (2003) [10].

Table 1: Effect of seed inoculants on germination%, Days to 50% flowering, seedling root length, shoot length and Seed vigour index

Treatments	Germination%	Days to 50% flowering	Seedling root length (cm)	Seedling shoot length (cm)	Seedling length (cm)	Seed vigour index
Control	70.51	45.12	15.11	55.14	68.25	2.25
T_1	72.52	47.51	17.64	62.69	75.32	2.32
T_2	80.61	48.65	18.45	66.95	77.12	2.85
T_3	76.69	47.96	17.96	65.32	76.48	2.91
T_4	82.65	48.99	18.97	68.45	77.85	2.99
T_5	83.65	49.12	19.65	69.68	79.64	3.10
T_6	86.92	50.75	20.84	72.75	82.77	3.15
T_7	85.69	49.65	20.11	71.64	80.41	3.19
S.Em±	2.93	1.76	0.76	2.39	2.64	0.10
CD 5%	8.69	5.22	2.25	7.11	7.84	0.31

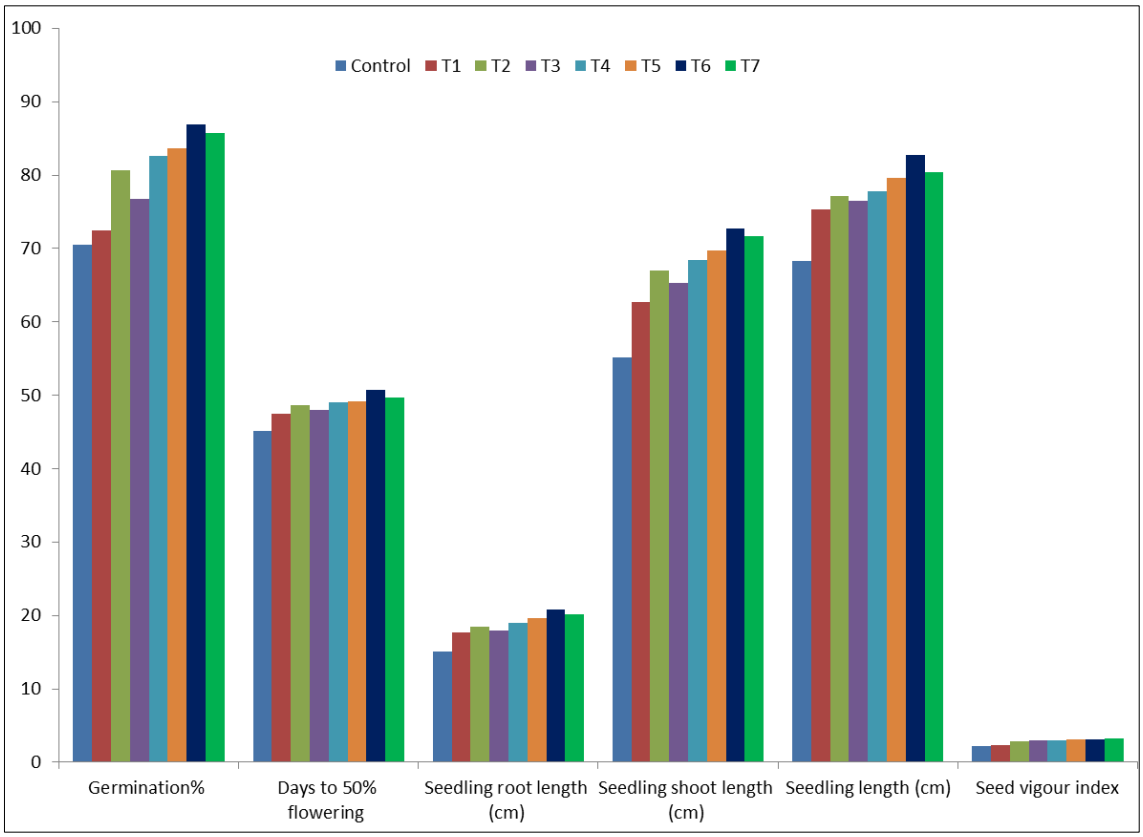

Fig 1: Effect of seed inoculants on growth, germination percentage and seed vigour of okra

Table 2: Effect of seed inoculants on plant height at 30 DAS and 60 DAS

Treatments	Plant height at 30 DAS	Plant height at 60 DAS	Days to first picking
T_0-Control	26.62	79.68	38.65
T_1-Pseudomonas	27.12	85.69	42.65
T_2-*Azotobacter*	27.99	90.29	45.11
T_3-Neem cake	27.86	88.64	44.14
T_4-Pseudomonas + *Azotobacter*	28.45	92.65	45.84
T_5-Pseudomonas + Neem cake	28.97	93.65	46.92
T_6-*Azotobacter* + Neem cake	30.69	97.69	48.66
T_7-Pseudomonas + *Azotobacter* + Neem cake	29.65	94.84	47.85
S.Em±	0.95	3.74	1.64
CD (p=0.05)	2.83	11.11	4.86

Conclusion

On the basis of one year experiment results, it may be concluded that the application of *Azotobactor* + *Neem cake* were better to improve growth, germination percentage and seed vigour of okra.

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