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Response of ideal combination of biofertilizers on germination of Karna Khatta (*Citrus karna*)

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Abstract
This study investigated the response of different combinations of biofertilizers on seed germination of karna khatta species of citrus. An experiment was carried out at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh with an aim to evaluate the effect of different combination of plant growth promoting micro- organism on germination of citrus seeds. The experiment comprised of fourteen treatments replicated thrice. The result showed that the application of various combination of biofertilizers significantly improved the germination and survival percentage. The treatment included (*Aspergillus* + Photosynthetic Bacteria (7.5 ml each in 100 ml of water) took less days to start germination whereas Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water) showed high germination percentage and combination *Aspergillus* + Photosynthetic Bacteria+ *Pseudomonas* (5 ml each in 100 ml of water) reported great survival percentage and less mortality of seeds compared to other treatments.

Keywords: Bio-fertilizers, germination, *Aspergillus*, photosynthetic bacteria, *Pseudomonas*

Introduction
Karna khatta is edible. In fact it is the rind which is liked. It tastes mildly sweet. To eat a Karna Khatta fruit, it is thinly peeled with a sharp knife and the yellow part of the peel is removed. Then the fruit is cored and most vesicles are taken out. Karna khatta is also used as a rootstock for mandarins in some parts of North India A thorny spreading tree, 4.5-6 m in height; leaves ovate or ovate oblong, 6.5-9.5 cm long and 4.5-5.5 cm broad; margin serrulate, articulated, petioles prominently winged; flowers tinged with red or purple. Fruits variable, large ovate oblong, broadly mamillate, occasionally almost obtuse, 9-12 cm long, 8-11 cm in diameter, orange coloured, rind rough and irregular, thick, brittle, sweet, strongly adhering, core open at maturity, vesicles orange coloured, very juicy, sour, melting; seeds many, cotyledons white, moderately polyembryonic. This is widely used as a rootstock for mandarin orange in many parts of India. Karna khatta is grown in home as well as gardens.
The Karna (*Citrus karna* Rafinesque) has a high degree (39–60%) of nucellar embryonic development, it is commercially propagated through seeds in India. To meet the growing demand of the nursery growers in the shortest amount of time, greater and faster seed germination and the production of the highest number of seedlings are of the utmost importance in seed-propagated plants. However, the germination rate of Karna Khatta is poor, ranging from 27 to 58 percent. The most significant problem with Karna khatta propagation is high seedling mortality during the initial nursery stage. Citrus seed coat function as barriers because their seed coat contain substances that prevent early germination of the seed. Applying bio-fertilizers to seeds will help improve the quality of produced crops. Natural fertilizers known as "bio-fertilizers" are made of microbial inoculants, either alone or in combination, of bacteria, algae, or fungi. Numerous studies have demonstrated a considerable impact on seed germination when different combinations of bio-fertilizers are applied. Based on these facts, the present investigation was undertaken to improve better seed germination and quality seed production of Karna Khatta through certain pre – sowing seed treatments with biofertilizers.

Materials and Methods
The present study entitled “Response of ideal combination of biofertilizers on germination of Karna Khatta (*Citrus karna*)” was carried out at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experiment was laid out in Randomized Block Design with fourteen treatments which consisted of T_0 - Control, T_1 - GA_3 60 ppm, T_2 - GA_3 80 ppm, T_3 – GA_3 100 ppm, T_4 - NAA 60

ppm, T_5- NAA 80 ppm, T_6 - 100 ppm, T_7 – *Aspergillus* (10 ml/ 100 ml of water), T_8 – *Pseudomonas*(20 ml /100 ml of water), T_9 – VAM (15 g / kg of seed), T_{10} – Photosynthetic Bacteria (10 ml/ 100 ml of water), T_{11} – *Aspergillus* + *Pseudomonas* (7.5 ml each in 100 ml of water) and T_{12} – *Aspergillus* + Photosynthetic Bacteria (7.5 ml each in 100 ml of water), T_{13}- *Aspergillus* + Photosynthetic Bacteria + *Pseudomonas* (5ml each in 100 ml of water), T_{14}- Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water). Thirty seeds were used in each treatment. For preparation of biofertilizers *Aspergillus* (10 ml) is dissolved in 100 ml of distill water, *Pseudomonas* (20 ml) is dissolved in 100 ml of distill water, Photosynthetic bacteria (10 ml) in 100 ml of distill water, *Aspergillus* + *Pseudomonas* (7.5 ml each) is dissolved in 100 ml of distill water, *Aspergillus* + Photosynthetic bacteria (7.5ml each) is dissolved in 100 ml of distil water, *Aspergillus* +*Pseudomonas* +Photosynthetic bacteria (5 ml each) dissolved in 100 ml of water and Photosynthetic Bacteria +*Pseudomonas* (5 ml each) dissolved in 100 ml of water.

The seeds were pre-soaked in biofertilizers and their combination for twenty four hours and then sown polybags. Double seed was sowed at about 1 cm depth in polybags. There were 840 seeds sown two in each polybags. All the polythene bags filled with soil were uniformly watered by watering cane. The number of days required for initiation of germination was calculated as day on which first germination of seed was initiated from the date of sowing considered as days required for initiation of germination. After completion of entire germination the percentage of germination was calculated. The germinated seeds in each treatment were counted at an interval of two days and after completion of germination, the total numbers of germinated seeds were subtracted from total number of seeds sown and percentage of germination was calculated.

Results and Discussion

Days of Germination

The observations which were recorded during the experiment period on the effect of different biofertilizer combination on Day of Germination of karna khatta seed is depicted in Table 1. The response of different combination of biofertilizers on Day of germination of karna khatta is very obvious and consistent. There was significant difference among the different treatments applied T_{12} (*Aspergillus* + Photosynthetic Bacteria (7.5 ml each in 100 ml of water took less days i.e. 24.00 days of germination followed by T_{13} (*Aspergillus* + Photosynthetic Bacteria+ *Pseudomonas* (5 ml each in 100 ml of water) with 25.00 days of germination and the maximum day was recorded in T_0 (Control) with 28.00 days of germination.

Table 1: Response of different combination of biofertilizers on Day of Germination of Karna Khatta seed

Notion	Treatment	Days for germination
T_0	Control	28.00
T_1	GA_3 (60 ppm)	20.34
T_2	GA_3 (80 ppm)	16.00
T_3	GA_3 (100 ppm)	19.33
T_4	NAA (60 ppm)	23.33
T_5	NAA (80 ppm)	17.67
T_6	NAA (100 ppm)	22.34
T_7	*Aspergillus*(10 ml/100 ml of water)	25.67
T_8	*Pseudomonas*(20 ml/100 ml of water)	21.33
T_9	VAM (15g/kg of seed)	24.33
T_{10}	Photosynthetic Bacteria(10 ml/100 ml of water)	21.33
T_{11}	*Aspergillus* + *Pseudomonas*(7.5 ml each in 100 ml of water)	25.33
T_{12}	*Aspergillus* + Photosynthetic Bacteria(7.5 ml each in 100 ml of water	24.00
T_{13}	*Aspergillus* + Photosynthetic Bacteria+ *Pseudomonas*(5 ml each in 100 ml of water)	25.00
T_{14}	Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water)	26.00
SEd		2.572
CD (5%)		5.296

Germination Percentage

The observations which were recorded during the experiment period on the effect of different biofertilizer combination on Germiantion percentage of karna khatta seed is depicted in Table 2. The response of different combination of biofertilizers on Germination percentage of karna khatta is very obvious and consistent. The maximum germination percentage was recorded in T_{14} (Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water) with 77.00% germination percentage followed by T_{11} (*Aspergillus* + *Pseudomonas* (7.5 ml each in 100 ml of water) with 74.00 germination percentage and the minimum germination percentage was recorded in T_0 (Control) with 60.00 percent germination.

Survival Percentage

The observations which were recorded during the experiment period on the effect of different biofertilizer combination on survival percentage of karna khatta seed is depicted in Table 3. The response of different combination of biofertilizers on Germination percentage of karna khatta is very obvious and consistent. The maximum survival percentage was recorded in T_{13} (*Aspergillus* + Photosynthetic Bacteria + *Pseudomonas* (5 ml each in 100 ml of water) with 75.33% followed by T_{14} (Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water) with 70.67 survival percentage and the minimum survival percentage was recorded in T_0 (Control) with 57.00 percent survival.

Table 2: Response of different combination of biofertilizers on Germination percentage of Karna Khatta seed

Notion	Treatment	Germination Percentage
T_0	Control	60.00
T_1	GA3 (60 ppm)	67.67
T_2	GA3 (80 ppm)	89.00
T_3	GA3 (100 ppm)	74.67
T_4	NAA (60 ppm)	72.00
T_5	NAA (80 ppm)	86.00
T_6	NAA (100 ppm)	75.34
T_7	*Aspergillus* (10 ml/100 ml of water)	69.30
T_8	*Pseudomonas* (20 ml/100 ml of water)	70.33
T_9	VAM (15g/kg of seed)	77.67
T_{10}	Photosynthetic Bacteria (10 ml/100 ml of water)	71.33
T_{11}	*Aspergillus* + *Pseudomonas* (7.5 ml each in 100 ml of water)	74.00
T_{12}	*Aspergillus* + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	70.00
T_{13}	*Aspergillus* + Photosynthetic Bacteria+ *Pseudomonas* (5 ml each in 100 ml of water)	72.67
T_{14}	Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water)	77.00
SEd		6.818
CD (5%)		14.037

Table 3: Response of different combination of biofertilizera on Survival percentage of Karna Khatta seed

Notion	Treatment	Survival Percentage
T_0	Control	57.00
T_1	GA3 (60 ppm)	62.33
T_2	GA3 (80 ppm)	84.34
T_3	GA3 (100 ppm)	72.67
T_4	NAA (60 ppm)	68.66
T_5	NAA (80 ppm)	82.67
T_6	NAA (100 ppm)	71.33
T_7	*Aspergillus*(10 ml/100 ml of water)	64.67
T_8	*Pseudomonas*(20 ml/100 ml of water)	75.33
T_9	VAM (15g/kg of seed)	70.33
T_{10}	Photosynthetic Bacteria(10 ml/100 ml of water)	66.33
T_{11}	*Aspergillus* + *Pseudomonas*(7.5 ml each in 100 ml of water)	69.33
T_{12}	*Aspergillus* + Photosynthetic Bacteria(7.5 ml each in 100 ml of water	65.67
T_{13}	*Aspergillus* + Photosynthetic Bacteria+ *Pseudomonas*(5 ml each in 100 ml of water)	76.33
T_{14}	Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water)	70.67
SEd		5.464
CD (5%)		11.25

Conclusion

Biofertilizers in different combinations can be recommended to the nursery growers for better quality seed production and to decrease the increasing problem of mortality of seed in the nursery of citrus. The inability to seed to grow can be reduced with the help of pre – soaking treatments with various biofertilizer combination. The treatment combinations that can be advised are (*Aspergillus* + Photosynthetic Bacteria (7.5 ml each in 100 ml of water) for shortening days to start germination whereas Photosynthetic bacteria + *Pseudomonas* (5 ml each in 100 ml of water) for high germination percentage and *Aspergillus* + Photosynthetic Bacteria+ *Pseudomonas* (5 ml each in 100 ml of water) for survival percentage and less mortality of seeds.

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