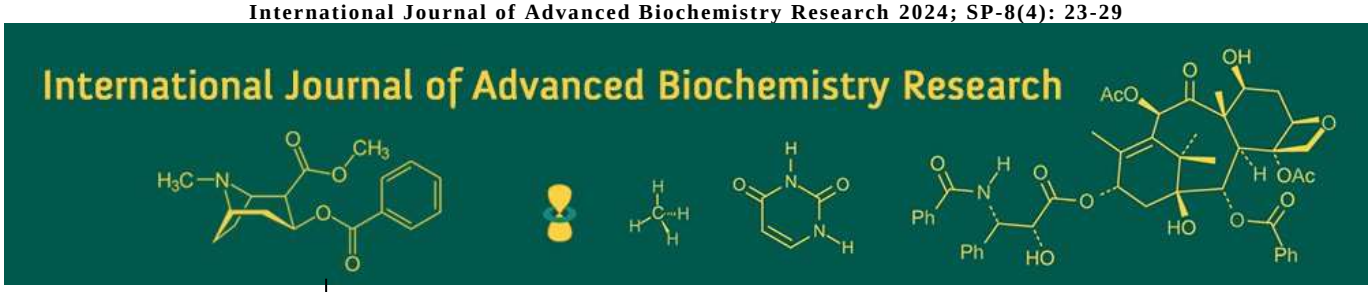

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Effect of phytohormones and plant growth promoting micro-organisms on seedling growth of Karna Khatta (*Citrus karna*)

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Abstract
An experiment was conducted at Department of Horticulture, SHUATS, Prayagraj, Uttar Pradesh with an objective to evaluate the influence of different concentration of phytohormones on seedling growth of Karna Khatta. The experiment was laid in Randomized Block Design with fourteen treatments replicated thrice. Seeds are treated with phytohormones and plant growth promoting micro - organism over night before sowing in polybags. The various concentration of phytohormones *viz.* GA_3 and NAA, plant growth promoting micro -organisms *viz.* Aspergillus, Pseudomonas and Photosynthetic Bacteria and there combination were used to treat the seeds and further observation were taken for 120 Days. The maximum results indicated that the shoot length (85.23 cm), seedling girth (15.33 mm), number of leaves (57.66), seedling length (18.70 cm), seedling vigor index (1,663.73), leaf area (38.56 cm^2) recorded in seeds which are treated with GA_3 80 ppm for 24 hours. Therefore, it is evident that the GA_3 at 80 ppm was found best in terms of vegetative growth.

Keywords: Phytohormones, plant growth promoting micro- organisms, seedling growth, Karna Khatta

Introduction
Among citrus rootstocks, Karna Khatta (*Citrus karna*) is widely used as rootstock for mandarin orange in many parts of India. Karna Khatta is grown in home as well as gardens. It was first introduced by Late B.C. Basu, formerly Deputy Director of Agriculture and Land Records of the East Bengal and Assam, sometimes in the year 1904 - 1906 when he started a tropical fruit plantation in the Wahjain near Cherrapunji (Khasi Hills). The karna is probably indigenous to India. Citrus is one among the most utilized fruits cultivating in tropical and sub-tropical regions. Citrus can be used for fresh as well as canned juice preparation.
The Karna (*Citrus karna* Rafinesque) is commercially propagated through seeds in India as it comes true to type, because of high degree (39-60%) of nucellar embryonic. In seed propagated plants better and quicker germination of seeds and production of the maximum number of the seedling is highly essential to meet the increasing demand of the cultivators in shortest possible time. But in Karna khatta germination percentage is low and it varies between 27 to 58%.
The most serious problem in Karna khatta propagation is heavy mortality with the seedlings in primary nursery stage. The seed coat of citrus acts as a barrier because it interferes with early germination of seed due to the presence of certain inhibitory substance. The growth regulators like GA_3 and NAA have been widely used for pre-sowing seed treatment to increase germination and to accelerate vegetative seedling growth in the genus citrus. Application of bio-fertilizers will help in safeguarding the soil health and also the quality of crop products. Bio-fertilizers are the natural fertilizers that are microbial inoculants of bacteria, algae or fungi alone or in combination.
Recently, growth regulators and plant growth promoting micro - organisms have gained much attention for their role in growth and development of plants as well as seed germination. Plant hormones have most important functions in controlling and coordinating cell division, growth and differentiation. Application of different plant growth regulators and plant growth promoting micro - organisms has shown significant effect on seed germination and seedling growth in various researches. Based on these facts, the present investigation

was undertaken to improve better seedling growth and quality seedling of Karna Khatta through certain pre - sowing seed treatments.

Materials and Methods

The present investigation entitled Effect of Phytohormones and Plant growth promoting micro-organisms on seedling growth of Karna Khatta (*Citrus karna*) was conducted at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experiment was carried out following Randomized Block Design with fourteen treatments *viz*. 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 (5ml each in 100 ml of water). The treatments replicated trice using 30 seeds in each treatment of a replication. The seeds were soaked for 24 hours and sown in polythene bags. The seedlings were allowed to grow for four month. After four months, five representative seedlings from each replication of a treatment were selected for measuring growth parameters; Number of leaves, Shoot Length, Seedling Length (cm), girth of seedling (mm), seedling vigour index, and Leaf Area Index (cm^2).

Result and Discussion

Number of Leaves

It is evident that the number of leaves was influenced by different treatments at all successive stage of growth. There was significant difference between the treatments at 30, 60, and 90 days among the treatment applied T_2 (GA_3 80 ppm), with (6.93, 9.13,12.30 and 57.66) increase significantly better number of leaves followed by T_5 (NAA 80 ppm) with (6.53, 8.73 11.87 and 55.33) which was significantly superior over T_0 (control) with number of leaves (2.53, 4.60, 7.70 and 28.33).The maximum number of leaves was recorded in T_2 (GA_3 80 ppm) with (57.66) followed by T_5 (NAA 80 ppm) with (55.33) and the minimum was recorded in T_0 control with (28.33).The data is presented in Table 1 and graphically presented in Fig 1.

Shoot length

It is evident that the shoot length was influenced by different treatments at all successive stage of growth. There was significant difference between the treatments at 30, 60,90 and 120 days among the treatment applied T_2 (GA_3 80 ppm), with (9.33, 11.40,14.30,85.23 cm) increase significantly better shoot length followed by T_5 (NAA 80 ppm) with 8.93, 10.93, 13.73,82.70 cm) which was significantly superior over T_0 (control) with shoot length 3.40, 5.47, 10.46,30.30 cm).The maximum shoot length was recorded in T_2 (GA_3 80 ppm) with (85.23 cm) followed by T_5 (NAA 80 ppm) with (82.70 cm) and the minimum was recorded in T_0 control with (30.30 cm). The data is presented in Table 2 and graphically presented in Fig 2.

Seedling length

It is evident that the seedling length was influenced by different treatments at all successive stage of growth. There was significant difference between the treatments, among the treatment applied T_2 (GA_3 80 ppm), with (18.70 cm) increase significantly better seedling length followed by T_5 (NAA 80 ppm) with (18.27 cm) which was significantly superior over T_0 (control) with seedling length (14.46 cm).The maximum seedling length was recorded in T_2 (GA_3 80 ppm) with (18.70 cm) followed by T_5 (NAA 80 ppm) with (18.27 cm) and the minimum was recorded in T_0 control with (14.46 cm). The data is presented in Table 3 and graphically presented in Fig 3.

Seedling girth

It is evident that the seedling girth was influenced by different treatments at all successive stage of growth. There was significant difference between the treatments at 30, 60,90 and 120 days among the treatment applied T_2 (GA_3 80 ppm), with (4.70, 6.70,8.70 and 15.33 mm) increase significantly better seedling girth followed by T_5 (NAA 80 ppm) with 4.13, 6.13, 8.16 and 14.93 mm) which was significantly superior over T0 (control) with seedling girth 1.63, 3.63 5.63 and 10.36 mm).The maximum seedling girth was recorded in T_2 (GA_3 80 ppm) with (15.33 mm) followed by T_5 (NAA 80 ppm) with (14.93 mm) and the minimum was recorded in T_0 control with (10.36 mm). The data is presented in Table 4 and graphically presented in Fig 4.

Seedling vigor index

The effect of phyto-hormone and plant growth promoting micro-organism on Seedling Vigor Index of Karna Khatta is very obvious and consistent. There was significant difference among the different treatments applied, among the treatment applied the maximum Seedling Vigor Index was recorded in T_2 (GA_3 (80 ppm) with 1,663.73 Seedling Vigor Index followed by T_5 (NAA (80 ppm)) with 1,569.33 of Seedling Vigor Index and the minimum Seedling Vigor Index was recorded in T_0 (Control) with 863.267 Seedling Vigor Index. The maximum Seedling Vigor Index was recorded in T_2 (GA_3 (80 ppm) with 1,663.73 Seedling Vigor Index followed by T_5 (NAA (80 ppm)) with 1,569.33 of Seedling Vigor Index and the minimum Seedling Vigor Index was recorded in T0 (Control) with 863.267 Seedling Vigor Index. The data is presented in Table 5 and graphically presented in Fig 5.

Leaf area

It is evident that the leaf area was influenced by different treatments at all successive stage of growth. There was significant difference between the treatments, among the treatment applied T_2 (GA_3 80 ppm), with (38.56 cm^2) had significantly more leaf area followed by T_5 (NAA 80 ppm) with (36.93 cm^2) which was significantly superior over T_0 (control) with leaf area (19.06 cm2).The maximum leaf area was recorded in T_2 (GA_3 80 ppm) with (38.56 cm^2) followed by T_5 (NAA 80 ppm) with (36.93 cm^2) and the minimum was recorded in T_0 control with (19.06 cm^2). The data is presented in Table 6 and graphically presented in Fig 6.

Table 1: Effect of phyto-hormones and plant growth promoting micro-organism on number of leaves of Karna Khatta seedlings

Notion	Treatment	30 Days	60 Days	90 Days	120 Days
T_0	Control	2.53	4.60	7.70	28.333
T_1	GA3 (60 ppm)	3.33	5.40	8.46	44.667
T_2	GA3 (80 ppm)	6.93	9.13	12.30	57.667
T_3	GA3 (100 ppm)	4.33	6.40	9.56	53.667
T_4	NAA (60 ppm)	4.73	6.80	9.90	50.667
T_5	NAA (80 ppm)	6.53	8.73	11.87	55.333
T_6	NAA (100 ppm)	4.76	6.90	9.93	35.667
T_7	Aspergillus(10 ml/100 ml of water)	6.33	8.13	11.23	32.667
T_8	Pseudomonas(20 ml/100 ml of water)	5.43	7.53	10.60	41.333
T_9	VAM (15g/kg of seed)	4.93	7.03	10.16	43.333
T_{10}	Photosynthetic Bacteria (10 ml/100 ml of water)	4.66	6.77	9.90	47.667
T_{11}	Aspergillus + Pseudomonas (7.5 ml each in 100 ml of water)	5.36	7.46	10.63	47.333
T_{12}	Aspergillus + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	5.13	7.23	10.33	51.667
T_{13}	Aspergillus + Photosynthetic Bacteria+ Pseudomonas (5 ml each in 100 ml of water)	6.20	8.33	11.23	37.333
T_{14}	Photosynthetic bacteria + Pseudomonas (5 ml each in 100 ml of water)	4.83	6.87	9.967	53.667
SEd		1.48	1.505	1.555	1.458
CD (5%)		0.791	0.731	0.736	0.708

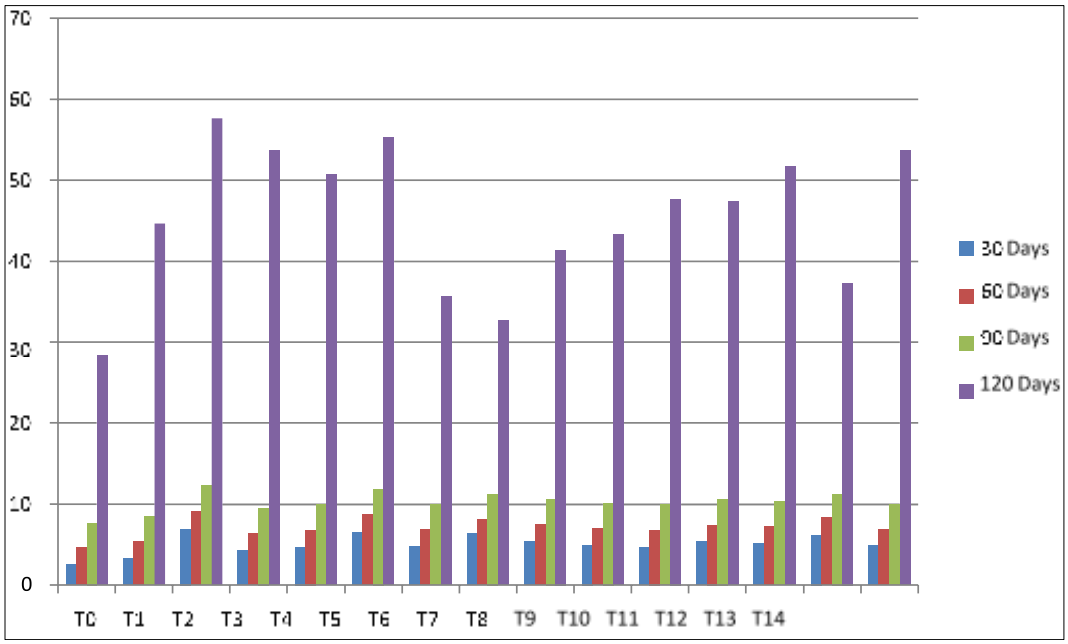

Fig 1: Effect of phyto-hormones and plant growth promoting micro-organism on Number of leaves of Karna Khatta seedling

Table 2: Effect of phyto-hormones and plant growth promoting micro-organism on Shoot Length of Karna Khatta seedling

Notion	Treatment	30 Days	60 Days	90 Days	120 Days
T_0	Control	3.40	5.47	10.46	30.30
T_1	GA3 (60 ppm)	4.40	6.50	11.73	75.23
T_2	GA3 (80 ppm)	9.33	11.40	14.30	85.23
T_3	GA3 (100 ppm)	6.80	8.93	12.26	72.333
T_4	NAA (60 ppm)	6.96	9.06	12.06	74.96
T_5	NAA (80 ppm)	8.93	10.93	13.73	82.70
T_6	NAA (100 ppm)	6.30	8.30	11.16	65.23
T_7	Aspergillus(10 ml/100 ml of water)	7.86	9.83	12.93	70.96
T_8	Pseudomonas(20 ml/100 ml of water)	8.73	10.87	14.20	55.23
T_9	VAM (15g/kg of seed)	7.73	9.67	12.90	54.50
T_{10}	Photosynthetic Bacteria (10 ml/100 mlof water)	8.00	9.97	12.93	58.56
T_{11}	Aspergillus + Pseudomonas (7.5 ml each in 100 ml of water)	6.50	8.57	11.53	68.16
T_{12}	Aspergillus + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	7.30	8.73	12.10	57.33
T_{13}	Aspergillus + Photosynthetic Bacteria+ Pseudomonas (5 ml each in 100 ml of water)	7.40	9.47	12.63	68.06
T_{14}	Photosynthetic bacteria + Pseudomonas (5 ml each in 100 ml of water)	7.90	10.03	13.50	59.76
SEd		0.802	0.731	0.936	0.481
CD (5%)		1.651	1.504	1.927	30.300

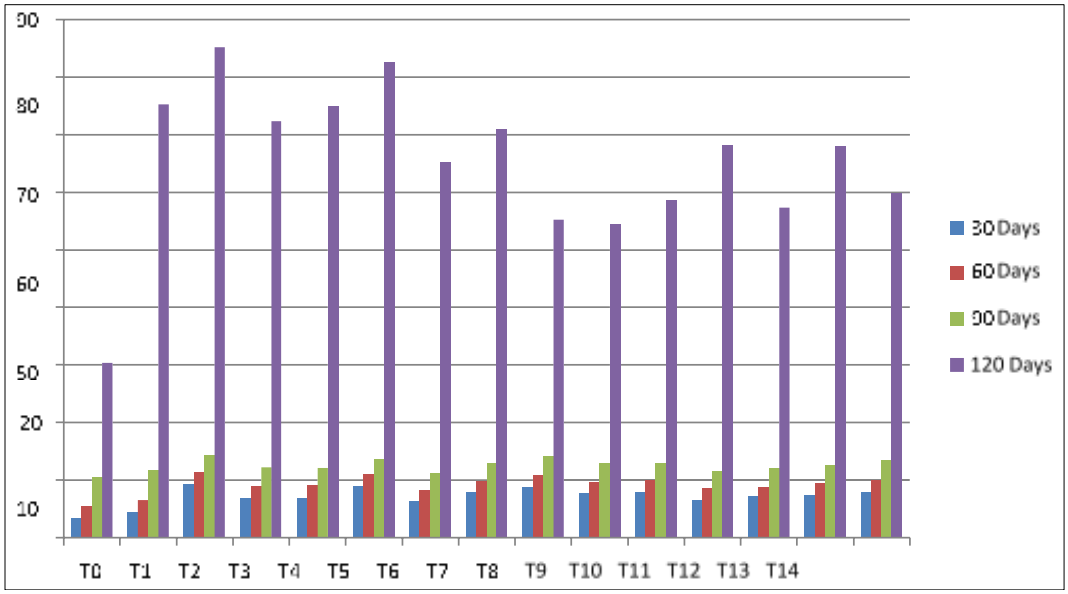

Fig 2: Effect of phyto-hormones and plant growth promoting micro-organism on Shoot Length of Karna Khatta seedling

Table 3: Effect of phyto-hormones and plant growth promoting micro-organism on Seedling Length of Karna Khatta seedling

Notion	Treatment	Seedling length
T_0	Control	14.46
T_1	GA3 (60 ppm)	15.70
T_2	GA3 (80 ppm)	18.70
T_3	GA3 (100 ppm)	16.90
T_4	NAA (60 ppm)	16.47
T_5	NAA (80 ppm)	18.27
T_6	NAA (100 ppm)	15.40
T_7	Aspergillus(10 ml/100 ml of water)	17.00
T_8	Pseudomonas(20 ml/100 ml of water)	17.90
T_9	VAM (15g/kg of seed)	16.63
T_{10}	Photosynthetic Bacteria (10 ml/100 ml of water)	17.23
T_{11}	Aspergillus + Pseudomonas (7.5 ml each in 100 ml of water)	15.66
T_{12}	Aspergillus + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	16.20
T_{13}	Aspergillus + Photosynthetic Bacteria+ Pseudomonas (5 ml each in 100 ml of water)	16.83
T_{14}	Photosynthetic bacteria + Pseudomonas (5 ml each in 100 ml of water)	17.63
SEd		0.919
CD (5%)		1.892

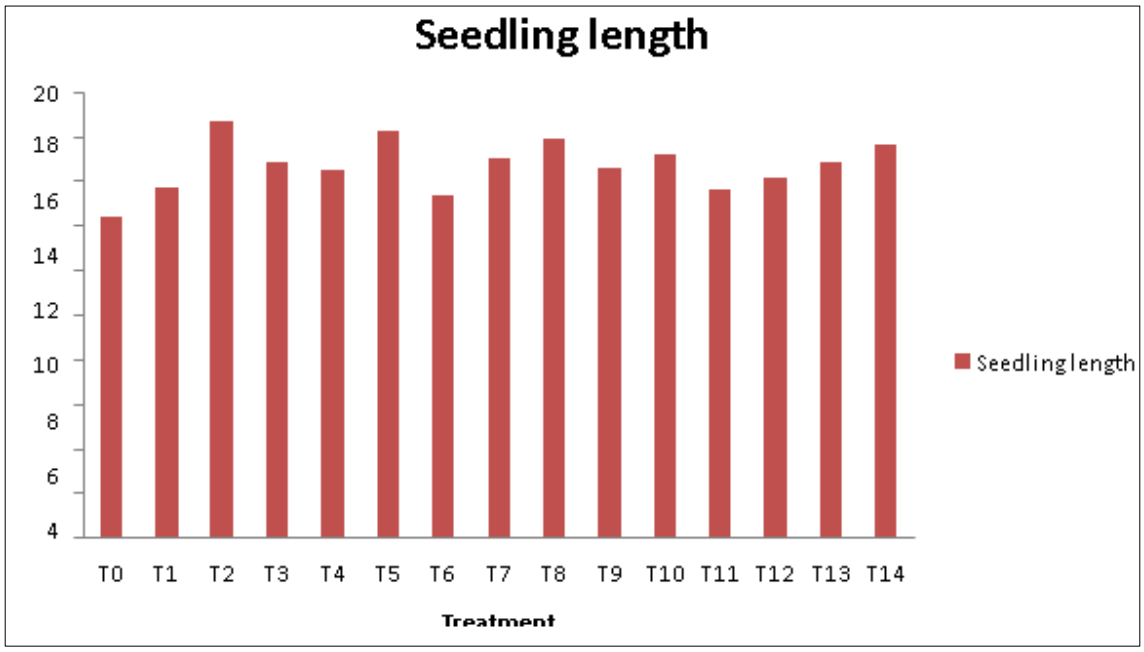

Fig 3: Effect of phyto-hormones and plant growth promoting micro-organism on Seedling Length of Karna Khatta seedling

Table 4: Effect of phyto-hormones and plant growth promoting micro-organism on Girth of Seedling of Karna Khatta seedling

Notion	Treatment	30 Days	60 Days	90 Days	120 Days
T_0	Control	1.63	3.63	5.633	10.367
T_1	GA3 (60 ppm)	3.26	5.26	7.27	14.033
T_2	GA3 (80 ppm)	4.70	6.70	8.70	15.333
T_3	GA3 (100 ppm)	2.60	4.60	6.60	13.433
T_4	NAA (60 ppm)	3.70	5.70	7.70	14.600
T_5	NAA (80 ppm)	4.13	6.13	8.16	14.933
T_6	NAA (100 ppm)	2.36	4.36	6.36	14.633
T_7	Aspergillus(10 ml/100 ml of water)	3.17	4.90	6.90	14.733
T_8	Pseudomonas(20 ml/100 ml of water)	2.83	4.83	6.90	14.433
T_9	VAM (15g/kg of seed)	2.30	4.30	6.30	14.067
T_{10}	Photosynthetic Bacteria (10 ml/100 ml of water)	3.40	5.40	7.40	13.433
T_{11}	Aspergillus + Pseudomonas (7.5 ml each in 100 ml of water)	2.50	4.50	6.50	13.633
T_{12}	Aspergillus + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	3.13	5.13	7.16	14.267
T_{13}	Aspergillus + Photosynthetic Bacteria+ Pseudomonas (5 ml each in 100 ml of water)	3.80	5.80	7.80	12.733
T_{14}	Photosynthetic bacteria + Pseudomonas (5 ml each in 100 ml of water)	3.13	5.13	7.13	13.700
SEd		0.457	0.492	0.488	0.276
CD (5%)		0.94	1.013	1.004	0.569

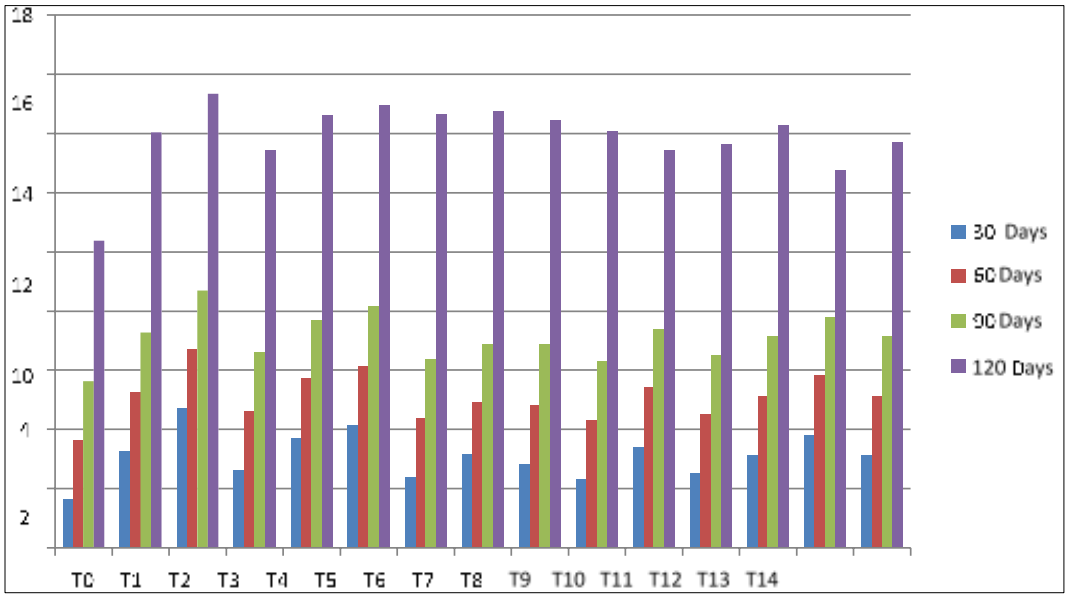

Fig 4: Effect of phyto-hormones and plant growth promoting micro-organism on Girth of Seedling of Karna Khatta seedling.

Table 5: Effect of phyto-hormones and plant growth promoting micro-organism on Seedling vigor index of Karna Khatta seedling

Notion	Treatment	Seedling Vigor Index
T_0	Control	863.267
T_1	GA3 (60 ppm)	1,062.17
T_2	GA3 (80 ppm)	1,663.73
T_3	GA3 (100 ppm)	1,263.53
T_4	NAA (60 ppm)	1,188.13
T_5	NAA (80 ppm)	1,569.33
T_6	NAA (100 ppm)	1,158.93
T_7	Aspergillus(10 ml/100 ml of water)	1,178.80
T_8	Pseudomonas(20 ml/100 ml of water)	1,259.43
T_9	VAM (15g/kg of seed)	1,285.80
T_{10}	Photosynthetic Bacteria(10 ml/100 ml of water)	1,229.93
T_{11}	Aspergillus + Pseudomonas (7.5 ml each in 100 ml of water)	1,162.77
T_{12}	Aspergillus + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	1,137.93
T_{13}	Aspergillus + Photosynthetic Bacteria+ Pseudomonas (5 ml each in 100 ml of water)	1,219.67
T_{14}	Photosynthetic bacteria + Pseudomonas (5 ml each in 100 ml of water)	1,359.67
SEd		132.53
CD (5%)		272.892

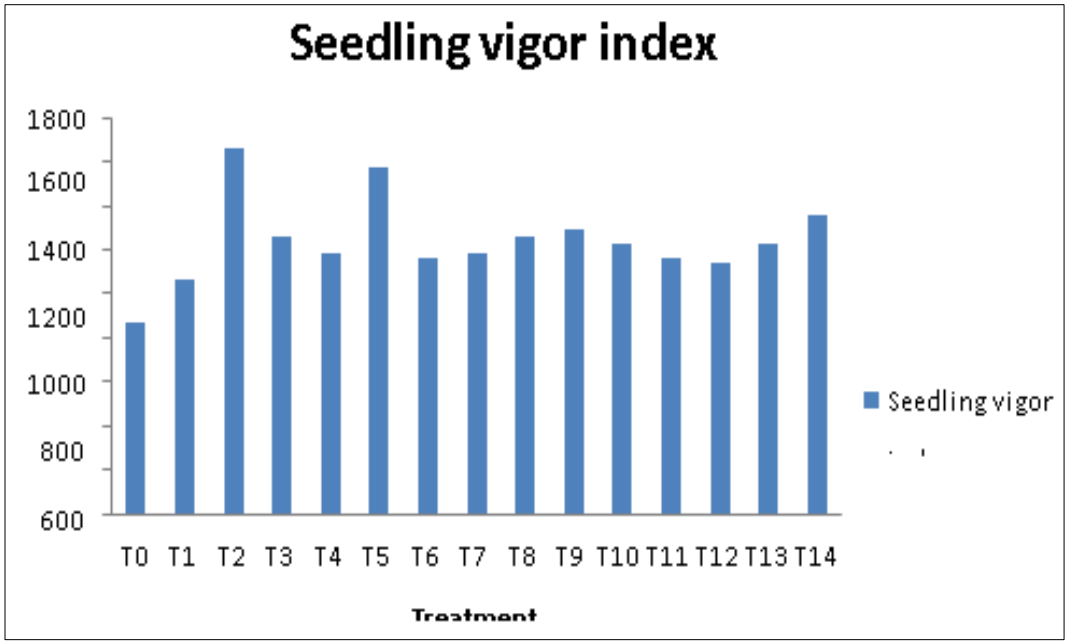

Fig 5: Effect of phyto-hormones and plant growth promoting micro-organism on Seedling vigor index of Karna Khatta seedling

Table 6: Effect of phyto-hormones and plant growth promoting micro-organism on Leaf area of Karna Khatta seedling.

Notion	Treatment	Leaf Area (cm^2)
T_0	Control	19.06
T_1	GA3 (60 ppm)	23.93
T_2	GA3 (80 ppm)	38.56
T_3	GA3 (100 ppm)	31.53
T_4	NAA (60 ppm)	30.23
T_5	NAA (80 ppm)	36.93
T_6	NAA (100 ppm)	25.20
T_7	Aspergillus (10 ml/100 ml of water)	25.16
T_8	Pseudomonas (20 ml/100 ml of water)	21.23
T_9	VAM (15g/kg of seed)	21.30
T_{10}	Photosynthetic Bacteria (10 ml/100 ml of water)	24.83
T_{11}	Aspergillus + Pseudomonas (7.5 ml each in 100 ml of water)	28.30
T_{12}	Aspergillus + Photosynthetic Bacteria (7.5 ml each in 100 ml of water	26.60
T_{13}	Aspergillus + Photosynthetic Bacteria+ Pseudomonas (5 ml each in 100 ml of water)	26.53
T_{14}	Photosynthetic bacteria + Pseudomonas (5 ml each in 100 ml of water)	24.23
SEd		2.506
CD (5%)		5.160

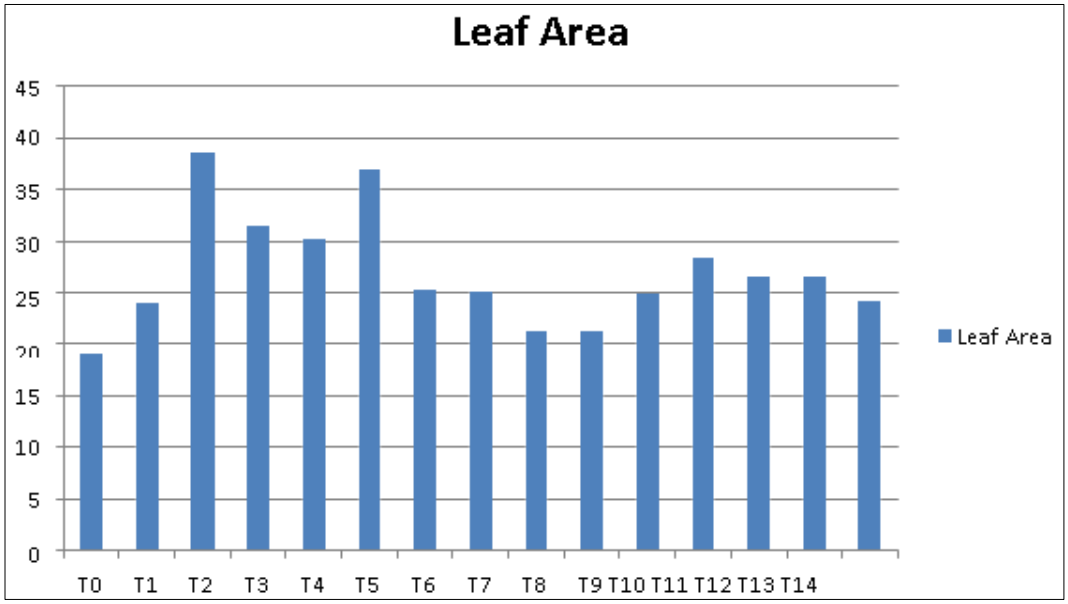

Fig 6: Effect of phyto-hormones and plant growth promoting micro-organism on Leaf area of Karna Khatta seedling.

Conclusion

On the basis of results obtained, It is concluded that the treatment T_2 (GA_3 80 ppm) found to be best in terms of shoot length, seedling length, number of leaves, girth of seedling, Leaf Area and seedling vigor index. Application of plant growth regulators in seedling germination of Karna Khatta proved to be powerful tools to modify several physiological processes in plants which are extensively and profitably used in fruit crops. Treatment of seeds with growth regulators and certain chemicals has been found to break dormancy and hence can be recommended to nursery growers for quality production.

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