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Effect of Different Levels of Gibberellic Acid (GA3) on Seed Germination and Seedling Growth of Sweet Orange (*Citrus sinensis* L.) cv. Malta

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ABSTRACT: The sweet orange, scientifically labeled as *Citrus sinensis* L. and belonging to the Rutaceae family, holds significant global importance as a fruit. While its origins trace back to Southeast Asia, it is now cultivated in various regions across the world. Its pulp and the juice extracted from it are essential components of diets, rich in vitamin C, liminoids, synephrine, hesperidin, polyphenols, pectins, calcium, potassium, thiamine, niacin, and magnesium. A systematic study was carried out to investigate the Effect of Different Levels Gibberellic acid on Seed Germination and Seedling Growth of Sweet Orange (*Citrus sinensis* L.) cv. Malta. The experiment was allocated with three replication and each replication contained 15 seeds under a randomized complete block design with 11 different treatment combinations of GA3. The best results in terms of minimum days taken for germination, maximum germination per cent, survival per cent, shoot length, shoot diameter, number of leaves, leaf area, shoot fresh weight, shoot dry weight, root length, root diameter, total number of roots, root fresh weight, root dry weight, total fresh weight, total dry weight and cost benefit ratio were obtained with T11 (GA3 @ 200 ppm). The goal of this study was to determine how Gibberellic acid influences seed germination with different concentrations and which concentration is best or suitable for further future applications to grow seedlings easily and quickly.

Keywords: Germination, GA3, Sweet Orange, Growth.

INTRODUCTION

Citrus is one of the important fruits among fruit crops. Belongs to family Rutaceae with the Chromosome number is 2n=2x = 18. Sweet orange (*Citrus sinensis* L.) is second largest fruit in cultivation among all other citrus groups. It is a succulent fruit and the fruit type of citrus is hesperidium. Juicy sacs develop from placental hair of endocarp is present in locules (Singh, 2018). Sweet Orange cv. Maltais grown as a shrub and tree with white flowers and takes up-to 5-6 years to reach the reproductive phase from the time of planting. Flowering on this tree occurs from March to May and the fruits are harvested in November - December. Malta is commonly grown in home-gardens in hilly areas of Uttarakhand. In hilly regions of Uttarakhand, people can be seen consuming the slices of Malta fruit marinated with homemade salt, sugar, honey or sometimes cream during the sunny winters (Goswami *et al*., 2020). Malta contains minerals like potassium and calcium which enhance the immune system by enhancing the resistance against infections caused in blood. Malta also helps in rejuvenating the tissues and cells of the body.Malta fruit is distributed in Himalayan region of India like- Jammu & Kashmir, Himachal Pradesh, Arunachal Pradesh, Uttarakhand and Sikkim (Shah, 2014). In Uttarakhand major Malta producing area are Chamoli, Pauri, Tehri, Almora, Pithoragarh, Rudraprayag. Malta fruit act as an important cash crop in the mountain state of Uttarakhand (Pandey *et al.*, 2011). The seed treatment of citrus species with Gibberellic acid improves the germination of seeds, growth and uniformity of seedlings both in rootstock and commercial varieties (Srivastava and Singh 1965; Burns and Coggins 1969; Shant and Rao 1973). Use of gibberellic acid have been force on a large scale in the recent years in enlarging seed germination, stimulating the growth of various parts of plants and amplify the rate of elongation of young seedlings. Protective cultivation like poly house and net house are found effective for retarding temperature.

MATERIALS AND METHODS

A. Description of experimental area

A field experiment was conducted at college of Horticulture, VCSG, UUHF, Bharsar, Pauri Garhwal, Uttarakhand, India during 2021-21. The experimental site is located at an altitude of 1900 meters above mean sea level at a longitude of 78.990 E and Latitude of 30.0560 N. Bharsar boasts of a temperate climate with mild summer, higher precipitation during rainy season and severe cold prolonged winter with occasional snowfall.

B. Experimental material and design

The seeds of Malta were collected from local places of Bharsar, Pauri Garhwal district of Uttarakhand. The experiment was allocated with three replications and each replication contains 15 seeds under arandomized complete block design with 11 different treatments of GA_3. The required concentrations of GA_3 (at 20, 40, 60, 80, 100, 120, 140, 160, 180 and 200 ppm) were prepared by weighing 5mg, 10mg, 15mg, 20mg, 25mg, 30 mg, 35mg, 40mg, 45mg and 50mg respectively and dissolve it in a small amount of ethyl alcohol and then adding distilled water to make up the volume. Seeds were soaked in GA_3 solutions for 24 hours and only the settled seeds were sown in polythene bags. One seed per polythene bag was sown at 2-2.5 cm depth in each replication below the prepared media of FYM and soil under poly house condition. Manual irrigation was applied on alternate days and hand weeding was done as and when needed.

RESULT AND DISCUSSION

A. Days taken for initial germination and germination per cent

The result of the present investigation indicated that days taken to initial germination and germination per cent were significantly influenced by GA_3. The germination per cent was found maximum (64.440%) in treatment T_{11} GA_3 @ 200 ppm. Highest germination per cent in GA_3 @ 200 ppm might be due to fact that the synthesis of amino acids in plants is accelerated, which is indirectly exhibited by enhanced growth of citrus plants and their parts. These results are in conformity with Misra and Verma (1979) in Kinnow mandarin; Misra and Singh (1982) in Malta common seedlings. Furthermore, GA3 contributes to the stimulation of protein synthesis, which results in the manufacture of mRNA, increasing DNA replication and stimulating the examination of seed endospermic components (Lahuti *et al.*, 2003). The hormone GA3 causes the seed to go through several emergence stages, including the absorption of growth inhibitors and the start of enzymes, both of which are necessary for seed germination.

The minimum numbers of days taken to initial germination (27.067) was recorded in T_{11} (GA_3 @ 200 ppm). This might be due to the fact that, GA_3 might have acted on the embryo and caused de novo synthesis of hydrolyzing enzymes particularly amylase and protease and this hydrolyzed food may have been utilized for growth of embryo and thereby improved the germination.GA_3 play an important role in two stages of germination, one at initial enzyme induction and other in activation of reserve food mobilizing system which help in enhancement of germination (Jha *et al.*, 1997).

B. Shoot growth characteristics

The growth of shoot increased with the different Gibberellic acid concentrations. The highest shoot length (21.933 cm), shoot diameter (2.213 mm), number of leaves (24.700) and leaf area (7.983 cm^2). The enhancement in seedling height with GA_3 treatment might have occurred due to increased osmotic uptake of nutrients by this hormone which caused cell elongation (Shanmugavelu, 1966). The Maximum shoot diameter could be due the fact that gibberellic acid promoted cell division and cell elongation in the collar region. The results are in conformity with Misra and Singh (1982) in Malta common seedlings; Chaudhari and Chakrawar (1982) in Rangpur lime; Harshavardhan and Rajasekhar (2012) in jackfruit.

Increase in number of leaves might be due to the maximum height of seedlings under treatment T_{11} (GA_3 @ 200 ppm) and GA3 possibly due to the induced cell division and cell growth by the movement of GA3 to the shoot apex which increase the young leaves (Salisbury and Ross 1988). This aids in the stimulation of the plants physiological process and chemical stimulatory action which form new leaves at faster rate as suggested by Shaban (2010). The maximum Leaf area might be due increased in leaf length and width, which ultimately increased in leaf area of the plant. Present findings are supported by Sharma (2016) in Chironji.

C. Root growth characteristics

Among different gibberellic acid concentrations, maximum root length (18.633cm), root diameter (1.733mm), maximum total number of roots (68.467) was recorded in treatment T_{11}(GA_3 @ 200 ppm). The increase in root length could be due to GA_3 which causes cell division and elongation of already existing cells by enlargement of the vacuoles which in turn increase the root length or it might be due to more production of photosynthesis and their translocation through phloem to the root zone which is responsible for improving root length and root diameter. This finding is supported by findings of Ramteke *et al*. (2015) in papaya. The GA_3 also accelerates the assimilation and translocation of auxins which imparts better root growth and vegetative characters of the plant as reported by Pandey *et al*. (2011). These results are in close agreement with Patel *et al*. (2017) in mango and Vachhani *et al*. (2014) in Khirni. Maximum number of total roots might be due to the vigorous root growth. Hence, result in more number of roots per seedling.

D. Biomass

The results also revealed that shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, total fresh and dry weight was markedly increased by gibberellic acid. Among different gibberellic acid concentrations, maximum shoot fresh weight (2.967 g), shoot dry weight (1.210 g), root fresh weight (1.063g), root dry weight (0.450 g), total fresh weight (4.030 g) and total dry weight (1.660 g) were obtained under T_{11} treatment (GA_3 200 ppm). This seems to be the effect of mobilization of water and nutrients transported at higher rate which might have promoted more production of photosynthetic product and translocated them to various plant parts which might have resulted in better growth of the seedlings and hence, more fresh and dry weight of shoot (Brain, 1954 ; Shanmugavelu, 1966).

The promising effect of GA_3 on fresh weight of roots might be due to the acceleration in the translocation and assimilation of auxins, the assimilation and redistribution of materials in plants cause better growth and vegetative characters which enhance the growth attributes (Pandey *et al.*, 2011). GA_3 might have also increased the auxin level in the roots which induces tap root length and number of secondary and fibrous roots through stimulation of more root initiation, more nutrient uptake and root cell elongation which results in more fresh and dry weight.

E. Survival per cent

Maximum survival percent was recorded in T_{11}(GA_3 200 ppm) treatment i.e. 86.437 % which might be due to early germination and favourable growing conditions under GA_3 @ 200 ppm of Sweet orange (*Citrus sinensis* L.) cv. Malta" seeds which helped in successful acclimatization and establishment of seedling.

F. Economic parameter

The maximum gross return (₹1002.6), net return (₹840.188) and cost benefit ratio (1:1.573) was found in treatment T_{11} (GA_3 200 ppm) which might be due to higher germination per cent, better survival per cent of seedling, minimum days taken for initial germination and the rate of selling plant was also high which leads to increase in cost benefit ratio.

Table 1: Effect of Gibberellic acid on days taken to initial germination, germination per cent, Survival per cent.

Treatments	Days taken to initial germination	Germination percent	Survival percent
T1 Control	48.86	31.10	43.33
T2 GA3 @ 20ppm	45.46	33.33	52.22
T3 GA3 @ 40 ppm	41.86	35.55	61.10
T4 GA3 @ 60ppm	39.53	39.99	66.02
T5 GA3 @ 80ppm	37.80	42.22	68.25
T6 GA3 @ 100ppm	35.40	44.44	70.63
T7 GA3 @ 120ppm	33.80	48.88	72.61
T8 GA3 @ 140ppm	32.06	51.10	78.57
T9 GA3 @ 160 ppm	30.66	55.55	80.09
T10 GA3 @180 ppm	29.20	59.99	85.46
T11 GA3 @ 200ppm	27.06	64.44	86.43
SE (d)	0.470	4.709	6.451
C.D. $_{(0.05)}$	0.987	9.892	13.551

Table 2: Effect of Gibberellic acid on Shoot Characters.

Treatments	Total no. of leaves	leaf area (cm^2)	shoot length (cm)	shoot diameter (mm)	shoot fresh weight (g)	shoot dry weight (g)
T1 Control	7.90	2.83	9.03	0.80	0.27	0.08
T2 GA3 @ 20ppm	10.43	3.57	11.83	1.09	0.60	0.32
T3 GA3 @ 40 ppm	11.50	4.12	12.70	1.14	0.90	0.49
T4 GA3 @ 60ppm	12.63	4.62	13.83	1.17	1.23	0.57
T5 GA3 @ 80ppm	14.46	5.22	14.67	1.24	1.30	0.68
T6 GA3 @ 100ppm	16.43	5.72	16.01	1.33	1.54	0.78
T7 GA3 @ 120ppm	18.50	6.29	17.73	1.48	1.60	0.84
T8 GA3 @ 140ppm	19.83	6.75	18.81	1.62	1.72	0.95
T9 GA3 @ 160 ppm	21.30	7.26	19.93	1.87	1.83	1.05
T10 GA3 @180 ppm	23.63	7.49	20.56	2.06	2.10	1.13
T11 GA3 @ 200ppm	24.70	7.98	21.93	2.21	2.96	1.21
SE (d)	0.257	0.144	0.293	0.036	0.148	0.039
C.D. $_{(0.05)}$	0.539	0.302	0.616	0.076	0.311	0.082

Table 3: Effect of Gibberellic acid on Root Characters and Total fresh and dry weight.

Treatments	Root length (cm)	Root diameter (mm)	Total No.of Roots	Root fresh weight (g)	Root dry weight (g)	Total fresh weight (g)	Total dry weight (g)
T1 Control	3.20	0.64	17.56	0.09	0.03	0.37	0.11
T2 GA3 @ 20ppm	6.18	0.81	24.33	0.14	0.05	0.74	0.38
T3 GA3 @ 40 ppm	7.42	1.02	30.50	0.18	0.06	1.08	0.55
T4 GA3 @ 60ppm	9.30	1.06	36.33	0.19	0.07	1.42	0.65
T5 GA3 @ 80ppm	11.38	1.12	42.43	0.21	0.09	1.52	0.78
T6 GA3 @ 100ppm	13.10	1.28	46.67	0.37	0.15	1.91	0.93
T7 GA3 @ 120ppm	14.30	1.34	52.40	0.43	0.18	2.03	1.02
T8 GA3 @ 140ppm	15.60	1.43	57.16	0.53	0.23	2.25	1.19
T9 GA3 @ 160 ppm	16.03	1.55	61.50	0.67	0.27	2.50	1.32
T10 GA3 @180 ppm	17.16	1.66	65.03	0.84	0.32	2.94	1.46
T11 GA3 @ 200ppm	18.63	1.73	68.46	1.06	0.45	4.03	1.66
SE (d)	0.277	0.033	0.426	0.064	0.019	0.137	0.042
C.D. $_{(0.05)}$	0.581	0.070	0.896	0.134	0.041	0.288	0.088

Table 4: Effect of Seed treatment on cost benefit ratio.

Treatments	Cost of cultivation (₹/Treatment)	Gross return (₹/Treatment)	Net return (₹/Treatment)	C:B
T1 Control	126.53	242.6	125.06	1:0.91
T2 GA3 @ 20ppm	130.12	313.24	183.12	1:1.40
T3 GA3 @ 40 ppm	133.70	391.00	257.29	1:1.92
T4 GA3 @ 60ppm	137.29	475.32	338.02	1:2.46
T5 GA3 @ 80ppm	140.88	518.72	377.83	1:2.68
T6 GA3 @ 100ppm	144.47	564.72	420.48	1:2.91
T7 GA3 @ 120ppm	148.06	638.88	490.82	1:3.31
T8 GA3 @ 140ppm	151.64	722.76	571.11	1:3.76
T9 GA3 @ 160 ppm	155.23	800.80	645.56	1:4.15
T10 GA3 @180 ppm	158.82	922.88	764.05	1:4.81
T11 GA3 @ 200ppm	162.41	1002.60	840.18	1:5.17

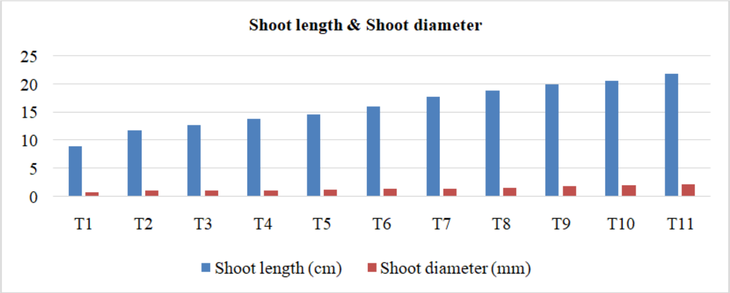

Fig. 1. Effect of gibberellic acid on Shoot length (cm) & Shoot diameter (mm).

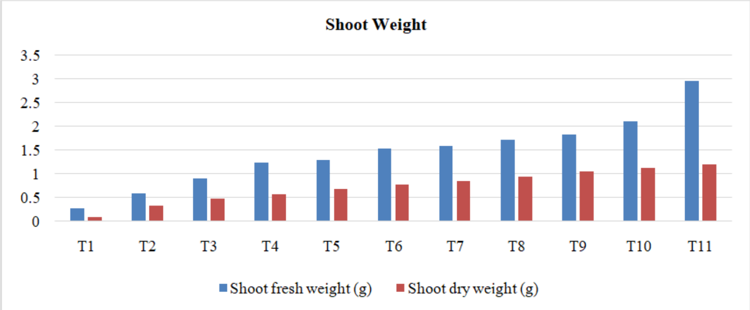

Fig. 2. Effect of gibberellic acid on Shoot Weight (g).

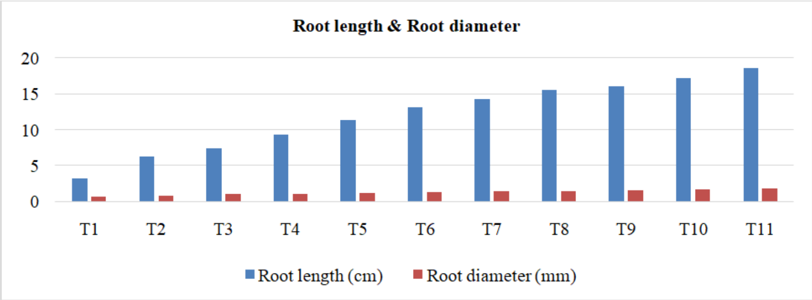

Fig. 3. Effect of gibberellic acid on Root length (cm) & Root diameter (mm).

T_1 Control, T_2 GA_3 20ppm, T_3 GA_3 40ppm, T_4 $GA_3$60ppm, T_5 $GA_3$80ppm, T_6 GA_3 100ppm

Plate 1. Seedling growth at 150DAS of different treatments.

$T_7GA_3$120ppm $T_8GA_3$140ppm $T_9GA_3$160ppm $T_{10}GA_3$180ppm $T_{11}GA_3$200ppm

Plate 2. Seedling growth at 150 DAS of different treatments.

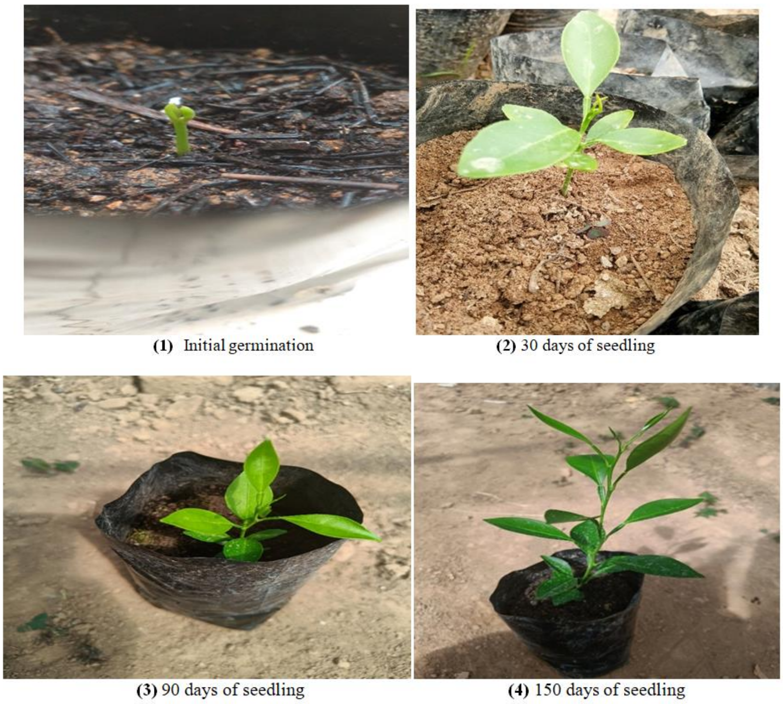

Plate 3. Growth status of seedlings.

CONCLUSIONS

In the present investigation, it was concluded that GA3 @ 200 ppm (T_{11}) was proved superior in respect to germination of Sweet Orange (*Citrus sinensis* L.) cv. Malta seed as well as growth parameter, survival percent, shoot characters, root characters, total fresh weight, total dry weight and maximum cost benefit ratio was also observed in it (1:5.173).Future scope the seed treated with GA3 200ppm identified in this study can be recommended commercially for overall growth of seedlings and Cost benefit ratio for Sweet orange cv. Malta.

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Conflict of Interest. None.

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