

Establishment and Effect of Foliar Application of Brassinosteroids and Salicylic Acid on Vegetative Growth of Nagpur Orange (*Citrus reticulata* Blanco)

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(Received 03 June 2021, Accepted 12 August, 2021)

(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: A field experiment was carried out during 2020-2021 at Horticulture Research Farm, SHUATS, Prayagraj and the aim of investigation was to determine the effect of foliar application of brassinosteroids and salicylic acid on vegetative growth of Nagpur Orange. This experiment was conducted in Randomized Block Design (RBD) with nine treatments viz. T₀ Control, T₁ Brassinosteriod @ 0.5ppm, T₂ Brassinosteriod @ 1.0ppm, T₃ Brassinosteriod @ 1.5ppm, T₄ Brassinosteriod @ 2ppm, T₅ Salicylic acid @ 50ppm, T₆ Salicylic acid @ 100ppm, T₇ Salicylic acid @ 150ppm and T₈ Salicylic acid @ 200ppm were applied during the research work on Nagpur Orange. The treatment was done at vegetative growth stage at 30, 60, 90, 120, 150 and 180 DAT was calculated in each treatments which were selected in each plant. Spray of T₄ Brassinosteriod @ 2ppm resulted in highest survival percentage and vegetative growth parameters like survival percentage (100%), Mortality percentage (0.00%), plant height (69.60cm), number of leaves per plant (129.24), number of branches per plant (17.75), stem girth (3.37cm), plant spread (67.19), leaf area (13.98cm²) and Chlorophyll SPAD (75.06). Therefore, application of Brassinosteriod @ 2ppm will improve vegetative growth of newly planted Nagpur Orange plants and the growers will be economically benefited.

Keywords: Orange, Salicylic acid, Brassinosteriod, chlorophyll concentration.

INTRODUCTION

Mandarin (*Citrus reticulata* Blanco) is considered to be one of the most important cultivated species among citrus and is being commercially grown in certain specific region of the country like Nagpur mandarin in Central India. Nagpur Santra is the finest variety and very popular in India as well as in world for its good quality fruits. Fruit size big, sub globose, average weight 110-125 g, rind medium thick, fairly loosely adherent, surface is also relatively smooth but, segment found in 10-15 number and number of seeds 1-2 per segment, colour of peel pale orange yellow (Choudhary *et al.*, 2013).

Mandarin orange, a world famous cultivar popularly known as Nagpur Santra is the main cash and fruit crop is grown on a large scale in Amravati and Nagpur division of Maharashtra and famous for its taste and quality (Bhargavaramireddy and Balakrishnan, 2014). A single orange is said to have about 170 phyto-nutrients and over 60 flavonoids with anti-cancer, anti-tumor, anti-inflammatory, blood clot inhibiting and antioxidant properties. These properties are due to the phyto-vitamins and nutrients present in the citrus fruits (Aslin, 2014). Nagpur mandarin orange is the most

important commercial cultivars containing abundant juice, 4 to 11 seed (Chattopadhyay, 2007). Presently, 95 per cent of the production goes for fresh fruit market. It is notable that due to poor post-harvest infrastructure, wastage of mandarin is around 25-30 per cent and that only 5 per cent of the total production is processed presently (Anonymous, 2015).

Salicylic acid (SA), a naturally occurring plant hormone, acts as an important signaling molecule and enhances tolerance of treated plants against biotic stresses (Matwally *et al.*, 2003). Salicylic acid also has a vital role in plant growth, ion uptake, and nutrient transport within the plant. It also plays an important role in induction of plant defense against a variety of biotic and abiotic stresses through morphological, physiological and biochemical mechanisms.

The 'Brassins' are the most active growth-promoting extracts isolated from Brassica napus pollen. Subsequently, another extract was identified as a steroidal lactone, and named brassinolide (BL). Recently, many BL-like compounds, as animal hormone steroids, have been found throughout the plant kingdom and thus named brassinosteroids.

It plays an important role in plant growth and development, regulating diverse processes such as cell elongation, cell division, photomorphogenesis, xylem differentiation and reproduction as well as both biotic and abiotic stress responses.

MATERIALS AND METHODS

The experiment has been laid out in Randomized Block Design (RBD) with nine treatments and three replications and it was carried out at the experimental orchard of Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences-Prayagraj, during the year 2020-2021. All the facilities necessary for cultivation, including labour were made available in the department. Orange (*Citrus reticulata* Blanco) Nagpur Orange seedlings were collected from Pandey Pudasala Gauhania Nursery, Prayagraj. The experiment was laid out in a Randomized Block Design with nine treatment combinations viz. T₀ Control, T₁ Brassinosteroid @ 0.5ppm, T₂ Brassinosteroid @ 1.0ppm, T₃ Brassinosteroid @ 1.5ppm, T₄ Brassinosteroid @ 2ppm, T₅ Salicylic acid @ 50ppm, T₆ Salicylic acid @ 100ppm, T₇ Salicylic acid @ 150ppm and T₈ Salicylic acid @ 200ppm.

RESULTS AND DISCUSSION

The results obtained from present investigation have been summarized as below:

Survival percentage: The perusal of the data in (Table 1) and (Fig. 1) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on survival percentage of Nagpur Orange as compared to control (T₀). The maximum survival percentage (100%) were recorded under application of T₄ Brassinosteroid @ 2ppm, T₁ Brassinosteroid @ 0.5ppm, T₂ Brassinosteroid @ 1.0ppm, T₃ Brassinosteroid @ 1.5ppm, T₅ Salicylic acid @ 50ppm, T₆ Salicylic acid @ 100ppm, T₇ Salicylic acid @ 150ppm and T₈ Salicylic acid @ 200ppm and the minimum survival percentage (66.67) were recorded under T₀ Control. The findings of the present investigation

showed that maximum survival percentage of Nagpur Orange was recorded in T₁, T₂, T₃, T₄ (100%) which were significantly superior over the minimum values viz. T₅, T₆, T₇, and T₈. The minimum mortality percentage in T₁, T₂, T₃, T₄ may be due to involvement hormones in cell division and translocation of nutrients. These results are consistent with the findings of Campbell *et al.* (2004); Cubero *et al.* (2010); Serna *et al.*, (2013).

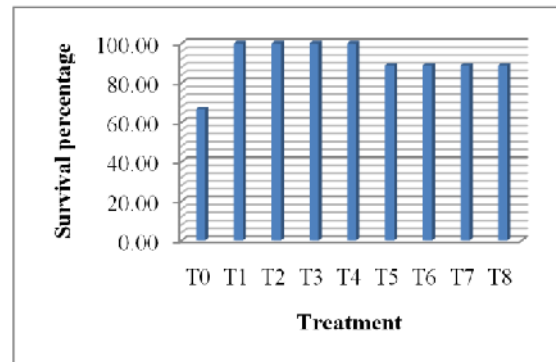


Fig. 1. Survival percentage.

Mortality percentage: The perusal of the data in (Table 1) and (Fig. 2) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on mortality percentage of Nagpur Orange as compared to control (T₀). The minimum mortality percentage (0.00%) were recorded under application of T₄ Brassinosteroid @ 2ppm, T₁ Brassinosteroid @ 0.5ppm, T₂ Brassinosteroid @ 1.0ppm and T₃ Brassinosteroid @ 1.5ppm followed by T₅ Salicylic acid @ 50ppm, T₆ Salicylic acid @ 100ppm, T₇ Salicylic acid @ 150ppm and T₈ Salicylic acid @ 200ppm and the maximum mortality percentage (33.33) were recorded under T₀ Control. The minimum mortality percentage in T₁, T₂, T₃, T₄ may be due to involvement hormones in cell division and translocation of nutrients. These results are consistent with the findings of Bishop and Koncz (2002); Jain and Dashora (2007); Kumar *et al.*, (2020).

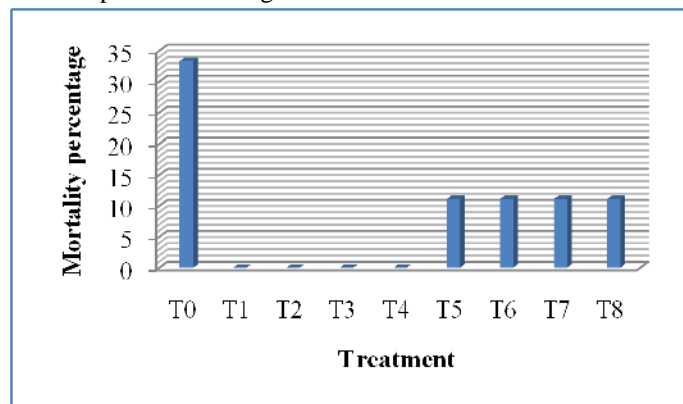


Fig. 2. Mortality percentage.

Table 1: Effect of foliar spray of Brassinosteroids and salicylic acid on vegetative growth of Nagpur Orange.

Treatments	Survival percentage	Mortality percentage	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Stem girth (cm)	Plant spread (cm)	Leaf area (cm ²)	Chlorophyll SPAD
T ₀ Control	66.67	33.33	51.26	80.22	10.94	2.12	49.00	8.73	43.63
T ₁ Brassinosteriod @ 0.5ppm	100.00	0.00	64.22	106.14	13.74	3.07	56.49	11.16	65.40
T ₂ Brassinosteriod @ 1.0ppm	100.00	0.00	62.90	113.13	13.82	3.15	55.26	11.82	67.81
T ₃ Brassinosteriod @ 1.5ppm	100.00	0.00	61.16	109.40	15.15	3.24	62.24	12.47	71.74
T ₄ Brassinosteriod @ 2ppm	100.00	0.00	69.60	129.24	17.75	3.37	67.19	13.98	75.06
T ₅ Salicylic acid @ 50ppm	100.00	0.00	59.49	103.44	14.75	2.39	63.27	10.56	59.18
T ₆ Salicylic acid @ 100ppm	88.89	11.11	59.63	96.25	13.43	2.52	58.49	10.55	57.48
T ₇ Salicylic acid @ 150ppm	88.89	11.11	58.77	104.94	13.79	2.63	56.90	10.42	56.14
T ₈ Salicylic acid @ 200ppm	88.89	11.11	60.77	104.10	13.50	2.78	54.28	10.27	50.11
F-Test	S	S	S	S	S	S	S	S	S
S.Ed(±)	9.072	6.82	0.706	3.970	1.132	0.059	1.535	0.502	1.720
CD at 5%	19.232	17.22	1.497	8.415	2.401	0.126	3.253	1.065	3.156

Plant height (cm): The perusal of the data in (Table 1) and (Fig. 3) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on plant height of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum plant height (43.95, 48.17, 56.33, 60.77, 64.97 and 69.60cm) at 30, 60, 90, 120, 150 and 180 DAT were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₁ Brassinosteriod @ 0.5ppm, T₂ Brassinosteriod @ 1.0 ppm and T₃ Brassinosteriod @ 1.5ppm and where as the minimum plant height (34.50, 36.68, 40.60, 43.64,

48.69 and 51.26cm) were recorded under T₀ Control. The finding of the present investigation showed that maximum plant height was recorded under T₄ Brassinosteriod @ 2ppm followed by T₁ Brassinosteriod @ 0.5ppm and T₂ Brassinosteriod @ 1.0ppm were found statistically at par with each other and was significantly superior over rest of the treatment. The maximum plant height in T₄ may be due to cell division and promotion of cell elongation. Similar, results were obtained by Choudhary *et al.*, (2013); Bhargavamireddy and Balakrishnan, (2014); Chumpookam *et al.*, (2017); Reetika *et al.*, (2020).

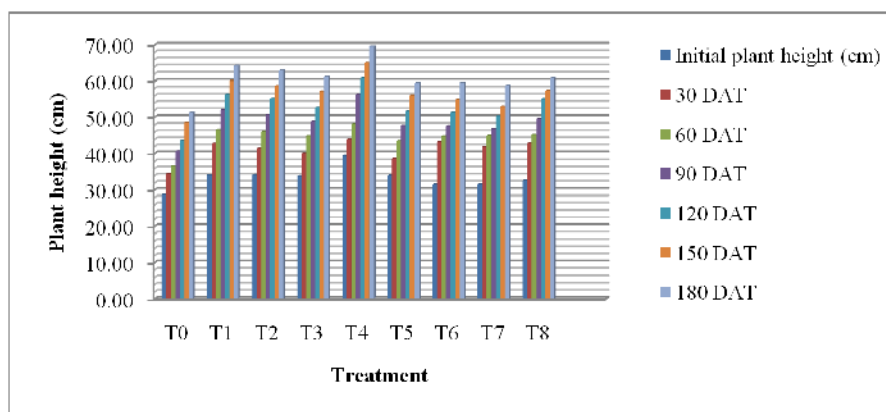


Fig. 3. Plant height (cm).

Number of leaves per plant: The perusal of the data in (Table 1) and (Fig. 4) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on number of leaves per plant of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum number of leaves per plant (31.38, 48.73, 64.71, 79.36, 98.29 and 129.24) at 30, 60, 90, 120, 150 and 180 DAT were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₂ Brassinosteriod @ 1.0ppm, T₃ Brassinosteriod @ 1.5ppm and T₁ Brassinosteriod @ 0.5ppm and where as the minimum number of leaves per plant (16.03, 30.17, 40.06, 48.54, 63.85 and 80.22) were recorded under T₀ Control. The maximum number of leaves per plant in T₄ may be due to cell division and promotion of cell elongation. Similar, results were obtained by Choudhary *et al.* (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.* (2017); Reetika *et al.*, (2020).

2ppm followed by T₂ Brassinosteriod @ 1.0ppm, T₃ Brassinosteriod @ 1.5ppm and T₁ Brassinosteriod @ 0.5ppm and where as the minimum number of leaves per plant (16.03, 30.17, 40.06, 48.54, 63.85 and 80.22) were recorded under T₀ Control. The maximum number of leaves per plant in T₄ may be due to cell division and promotion of cell elongation. Similar, results were obtained by Choudhary *et al.* (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.* (2017); Reetika *et al.*, (2020).

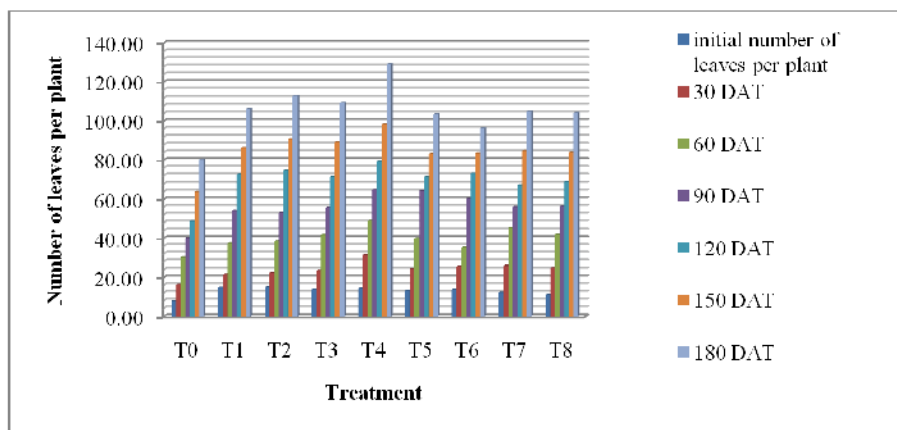


Fig. 4. Number of leaves per plant.

Number of branches per plant: The perusal of the data in (Table 1) and (Fig. 5) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on number of branches per plant of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum number of branches per plant (5.75, 7.88, 9.88, 12.60, 14.22 and 17.75) at 30, 60, 90, 120, 150 and 180 DAT were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm, T₂ Brassinosteriod @ 1.0ppm and T₁ Brassinosteriod @

0.5ppm and where as the minimum number of branches per plant (2.74, 4.31, 5.09, 7.18, 9.444 and 10.94) were recorded under T₀ Control. The finding of the present investigation showed that maximum number of branches per plant was recorded under T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm was found statistically at par with each other and was significantly superior over rest of the treatment. Similar, results were obtained by Choudhary *et al.*, (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.*, (2017); Reetika *et al.*, (2020).

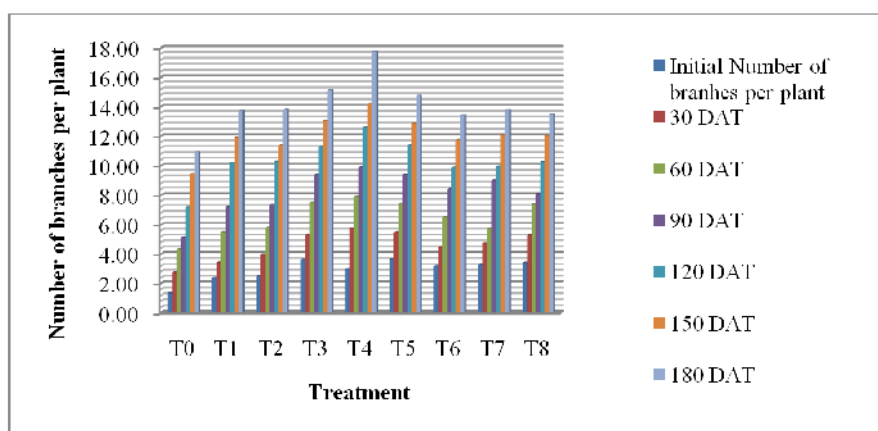


Fig. 5. Number of branches per plant.

Stem girth (cm): The perusal of the data in (Table 1) and (Fig. 6) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on stem girth (cm) of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum stem girth (1.37, 1.58, 1.89, 2.55, 2.86 and 3.37cm) at 30, 60, 90, 120, 150 and 180 DAT were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm, T₂ Brassinosteriod @ 1.0ppm and T₁ Brassinosteriod @ 0.5ppm and where as

the minimum stem girth (0.88, 1.14, 1.27, 1.60, 1.77 and 2.12) were recorded under T₀ Control. The finding of the present investigation showed that maximum stem girth (cm) was recorded under T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm was found statistically at par with each other and was significantly superior over rest of the treatment. The maximum stem girth (cm) in T₄ may be due to cell expansion and promotion of cell elongation. Similar, results were obtained by Choudhary *et al.*, (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.*, (2017); Reetika *et al.* (2020).

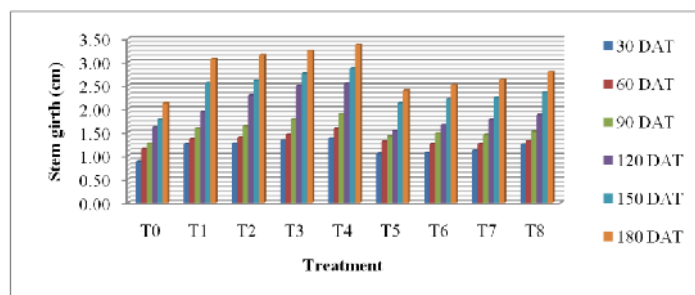


Fig. 6. Stem girth (cm).

Plant spread (cm) (E-W and N-S): The perusal of the data in (Table 1) and (Fig. 7) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on plant spread (cm) (E-W and N-S) of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum plant spread (33.25, 37.51, 48.99, 57.73, 62.00 and 67.19) at 30, 60, 90, 120, 150 and 180 DAT were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm, T₂ Brassinosteriod @ 1.0ppm and T₁ Brassinosteriod @ 0.5ppm and where as the minimum plant spread (20.51,

25.83, 29.62, 36.17, 40.37 and 49.00cm) were recorded under T₀ Control. The finding of the present investigation showed that maximum plant spread (cm) (E-W and N-S) was recorded under T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm was found statistically at par with each other and was significantly superior over rest of the treatment. The maximum plant spread (cm) (E-W and N-S) in T₄ may be due to cell division and promotion of cell elongation. Similar, results were obtained by Choudhary *et al.* (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.* (2017); Reetika *et al.* (2020).

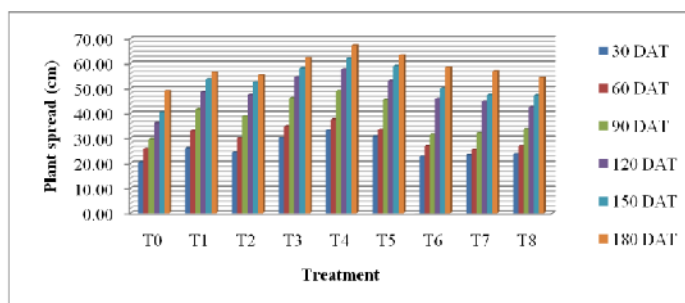


Fig. 7. Plant spread (cm).

Leaf area (cm²): The perusal of the data in (Table 1) and (Fig. 8) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on leaf area (cm²) of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum leaf area (13.98cm²) were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₃, T₂, T₁, T₅, T₆, T₇, T₈ and where as the minimum leaf area (8.73cm²) were recorded under

T₀ Control. The finding of the present investigation showed that maximum leaf area (cm²) was recorded under T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm was found statistically at par with each other and was significantly superior over rest of the treatment. The maximum leaf area (cm²) in T₄ may be due to higher photosynthetic rate. Similar, results were obtained by Choudhary *et al.*, (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.*, (2017); Reetika *et al.*, (2020).

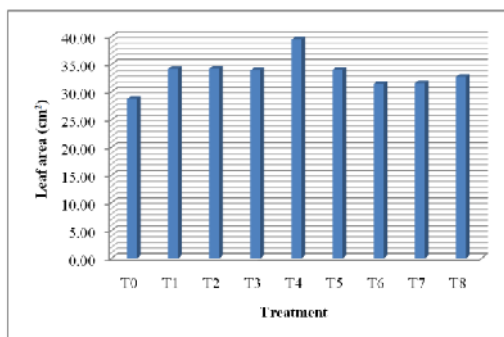


Fig. 8. Leaf area (cm²).

Chlorophyll SPAD: The perusal of the data in (Table 1) and (Fig. 9) revealed the significant effect of foliar application of brassinosteroids @ 0.5, 1, 1.5, and 2 ppm and Salicylic acid @ 50, 100, 150 and 200 ppm have significant effect on chlorophyll SPAD of Nagpur Orange at 30, 60, 90, 120, 150 and 180 DAT as compared to control (T₀). The maximum Chlorophyll SPAD (75.06) were recorded under application of T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm, T₂ Brassinosteriod @ 1.0ppm and T₁ Brassinosteriod @ 0.5ppm and where as the minimum Chlorophyll SPAD (43.63) were

recorded under T₀ Control. The finding of the present investigation showed that maximum chlorophyll SPAD was recorded under T₄ Brassinosteriod @ 2ppm followed by T₃ Brassinosteriod @ 1.5ppm was found statistically at par with each other and was significantly superior over rest of the treatment. The maximum chlorophyll SPAD in T₄ may be due to application of brassinosteriod on the sprayed plant which increases nitrogen metabolism activities. Similar, results were obtained by Choudhary *et al.*, (2013); Bhargavamireddy and Balakrishnan (2014); Chumpookam *et al.*, (2017); Reetika *et al.*, (2020).

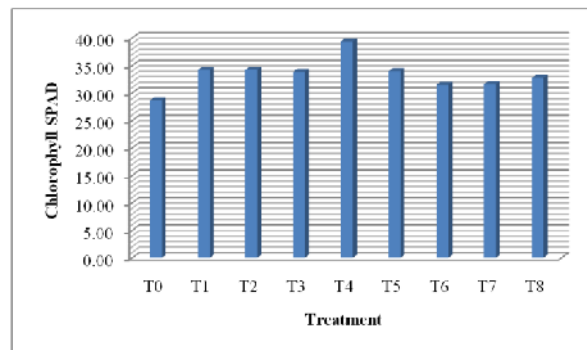


Fig. 9. Chlorophyll SPAD.

CONCLUSION

Thus, it can be concluded from the findings of the present investigation that foliar application of T₄ Brassinosteriod @ 2ppm resulted in highest survival percentage and vegetative growth parameters like survival percentage (100%), Mortality percentage (0.00%), plant height (69.60cm), number of leaves per plant (129.24), number of branches per plant (17.75), stem girth (3.37cm), plant spread (67.19), leaf area (13.98cm²) and Chlorophyll SPAD (75.06). Therefore, application of Brassinosteriod @ 2ppm will improve vegetative growth of newly planted Nagpur Orange plants and the growers will be economically benefited.



Nagpur Orange (*Citrus reticulata*).

Acknowledgement. The author conveys their thanks to the staff of Horticulture department Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (Uttar Pradesh), India for their colossal assistance, without which the trial would not have been successful.

Conflict of Interest. As a corresponding author, I Rikmachi Ch. Marak, confirm that none of the others have any conflicts of interest associated with this publication.

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How to cite this article: Marak, R.Ch., Mishra, S., Bahadur, V., Topno, S.E. and Paul, A. (2021). Establishment and Effect of Foliar Application of Brassinosteroids and Salicylic Acid on Vegetative Growth of Nagpur Orange (*Citrus reticulata* Blanco). *Biological Forum – An International Journal*, 13(3): 550-556.