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Influence of ethrel and nutrients on growth, earliness, yield and quality parameters in snap melon (*Cucumis melo* var. *momordica*)

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ABSTRACT

An investigation was carried out on "Influence of ethrel and nutrients on growth, yield and quality parameters of snap melon (Cucumis melo var. momordica)" at the Department of Vegetable Science experimental block, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India, during Rabi 2022. The main challenge of the study was to determine the optimal combination and concentration of Ethrel, boron, and calcium that could effectively enhance growth, yield and quality parameters in snap melon. Balancing these treatments to achieve maximum productivity without negatively affecting plant growth or fruit quality required precise experimentation and analysis under varied treatment interactions. The experiment was laid out in RCBD with sixteen treatments and 3 replications. Treatment includes Ethrel at 3 different concentrations, i.e., 150, 200, and 250 ppm, combined with boron and calcium at 0.5 and 1% each, along with a control, which includes a spray of distilled water. The imposition of treatment of Ethrel was carried out at 2 and 4 leaf stages, while calcium and boron were applied at 30 and 45 days after transplanting. The studies revealed that, foliar application of Ethrel at 250 ppm: Boron at 1% recorded the highest number of branches per vine (5.01), minimum vine length (173.40 cm) at 50 DAT and inter nodal length (7.44 cm), least sex ratio (5.25), higher fruit weight (1261 g /fruit), yield (13.96 kg/ vine) and cost benefit ratio (4.35), fruit firmness (3.88 kg/cm^2) and shelf life (5.66 days). Whereas, days to first male and female flower appeared of 25.02 and 27.02 days respectively, a higher number of female flowers per vine (33/plant), maximum number of fruits (14.00/plant) and minimum number of days to first harvest (61.67 days) was recorded with foliar application of Ethrel at 250 ppm: Boron at 0.5 per cent treatment. However, Ethrel at 250 ppm: Calcium at 1% application showed first female flower appearance at 2.96th node. The results of the investigation finally inferred that, foliar application of Ethrel at 250 ppm and Boron at 1 per cent was the most effective in improving female flowers, increasing the marketable fruits and yield.

Keywords: *Ethrel, Boron, Calcium, Snap melon, Foliar application, Nutrients.*

Introduction

Snap melon (*Cucumis melo* var. *momordica)* is a vegetable, commonly called phoot, in the family Cucurbitaceae with a diploid chromosome number of 2n=2x=24. Snap melon is an annual, generally cultivated in arid and semi-arid regions for mature and immature fruits. It is native to India. The name snap means split. When it comes to harvest, it automatically splits so the name snap given, and it is the maturity indices of snap melon. It is a high-nutrient-rich cucurbit, which is rich in sugars, minerals, dietary fibres, and vitamin C (Bates, 1995). It contains 3 % CHO, 0.3 % protein, 0.1% fat, 95.7 % moisture, 265 IU Vitamin A per 100 g, Vitamin C, and 10 mg/100 g (Peter and Hazara, 2012) with edible oil of 39.1%.

Being monoecious in nature, it bears a large number of staminate flowers with comparatively a smaller number of female flowers. Normally, the sex ratio in cucurbits is 15:1 or 25:1. In general, male flowers outnumber female flowers in terms of fruit production. A good variety has a higher female-to-male flower ratio. Changing sex expression leads to increased production of pistillate flowers with a reduced number of staminate flowers, which leads to a decrease in sex ratio. Exogenous application of plant growth regulators alters the sequence of male and female flowers. If applied at the 2nd to 4th leaf stage, the critical stage at which suppression or promotion of either sex is possible.

Ethylene mainly controls fruit ripening, leaf and petal elongation, cell division, and cell elongation and sex determination in some plants (Pandey and Pandey, 2016). In monoecious species, especially some cucurbits like cucumber, pumpkin, squash, and melon, ethylene strongly promotes the formation of female flowers, thereby suppressing the number of male flowers considerably (Seshadri and More, 2015).

Cracking or splitting of fruit is a physical process that involves a mechanical break in the fruit cover due to an imbalance between the internal tension of the flesh and tension of the external tissue of the cover (Lopez *et al.*, 2020). Cracking of mature fruits is a serious problem in the case of snap melon, which reduces the commercial value of the fruit and also acts as a site of entry for infections by fungi and insects, leading to decreased resource use and economic losses.

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Foliar application of calcium reduces the cracking, which delays the ripening process by decreasing the respiration rate and ethylene production. In addition, it also decreases the incidence of cracking in melons by increasing diameter, skin thickness, and firmness. Being a nutrient, boron is essential for the proper growth and development of plants. In horticulture, boron is applied in the form of borax or boric acid, mainly to reduce fruit cracking, which considerably increases fruit appearance quality and shape (Choudary, 2014). There is a need to standardize the amount of Ethrel required to promote the formation of pistillate flowers, there by suppressing the number of staminate flowers in monoecious flowers. The objective of this study is to know the influence of Ethrel, calcium, and boron on vegetative growth, yield, quality, and post-harvest life of snap melon.

Material and Methods

The experiment was carried out in the field of the Department of Vegetable Science experimental block at College of Horticulture, University of Horticultural Sciences, Bagalkot, during the *Rabi* season of 2022. The experimental material for the present study consists of snap melon genotype (HUB-25), which is a local collection collected from Mannur, Sindagi, Vijayapura, Karnataka, India. The experiment was laid out in a randomized complete block design with 16 treatments and 3 replications. Treatment includes Ethrel at 3 different concentrations, *i.e.,* 150, 200, and 250 ppm, combined with boron and calcium at 0.5 and 1 per cent each, along with a control which includes a spray of distilled water. The imposition of treatment of Ethrel was carried out at 2 and 4 leaf stages, while calcium and boron were applied at 30 and 45 days after transplanting. Ethrel (39% SL), boric acid (H_3BO_3, 99.5% B), and calcium nitrate ($CaNO_3$, 18.5% Ca) are the sources of ethylene, boron, and calcium, respectively. Five vines were selected randomly from each plot to record the observations on growth, flowering, sex expression, yield and quality attributes. The fruits were harvested when they attained the full slip stage. TSS (Total soluble solids) was measured by a digital hand refractometer, and ascorbic acid content was estimated according to the methodology suggested by Sadasivam and Theymoli (1987) and expressed in mg/FW 100g. The shelf life of fruits was decided based on the appearance and marketability of the fruits. When the fruits attained beyond edible ripe, then those fruits were considered to have reached the end of their shelf life (Turner, 1997) and expressed in number of days.

Results and Discussion

1. Vegetative growth parameters

The results from Table 1 revealed that there is a substantial difference among various treatments for vine length at 50 DAT ; the least vine length was recorded in T_{15} (173.40). While the maximum vine length was recorded in control (233.00 cm), which was *on par* with T_1 (229.33 cm), T_2 (232.90 cm), T_3 (229.80 cm), and T_4 (215.19 cm). Maximum and minimum inter nodal length at harvest were recorded in control (9.79 cm) and T_{15} (7.44 cm), respectively.

In accordance with Hayashi *et al*. (2001), ethylene's anti-gibberellic property results in mitotic cell division cessation in the meristematic tissues of root and shoot, affecting plant length and possibly explaining why plants are shorter. On the other side, ethylene inhibits the transport of IAA in plant systems, causing the elongation process to be slowed (Morgan and Gausman, 1966; Malloch and Osborne, 1976). Based on the data presented above, it is possible to conclude that as the dose of ethephon increases, plant height decreases proportionately. Calcium plays an important role in the growth and development of plants, due to which the vine length was increased. These results are in agreement with Murwira and Kirchman (1993), who reported that the spray of calcium can significantly increase the vegetative growth of cucumber. Significantly higher number of branches per plant was recorded for foliar application of Ethrel 250 ppm: B 1% (5.01), which was *on par* with T_{13} and T_{12}, followed by T_{10} (4.38) while the minimum branches recorded in the control (3.56). This is possible because, as the dose of ethephon increased, the number of branches increased as well, but as the dose of ethephon increased again, the number of branches decreased.

2. Flowering parameters

The appearance of the node at the first staminate flower was remarkably influenced by the various levels of Ethrel and nutrients. Lower node at first staminate flower appearance was recorded in control (2.98), while higher was in T_3 (Ethrel 150 ppm: Ca 0.5%). On the other side node at first pistillate flower was differed significantly due to various levels of Ethrel, calcium and boron. Lower node at first pistillate flower appearance was in T_{13} (2.96) (Figure 1) and was *on par* with T_{15}, T_{11} and T_{14} and higher node at pistillate flower appearance was in control (9.21). Early flowering of treated plants with Ethrel because of induction of tendency of femaleness in the plant and increased levels of auxins might have resulted in the early induction of female flowers. Analogous findings were reported by Verma *et al*. (1986), Mishra *et al.* (1976), Patil *et al.* (1983), Singh and Singh (1984), Singh and Choudhary (1988) and Asghar *et al*. (1990) in cucumber.

Least days required to first male flower was observed in T_{14} (25.02 days) and was *on par* with T_{15}. Whereas, maximum days was noticed in T_{16} (42.03 days). The results of days taken to first flowering of female flower revealed that significantly the minimum number of days was recorded for foliar application of Ethrel 250 ppm: B 0.5% (27.02 days) and was *on par* with T_{12} (28.03 days), T_{11} & T_{13} (28.06 days) and T_{10} (28.08 days). Maximum number of days to flowering was recorded in T_{16} (34.19 days). Because of exogenous application of Ethrel which lead to higher amount of ethylene in leaf primordial cells, these cells will decide the sex of flower. In general, higher ethylene in leaf primordial cells results in pistillate flowers, cucurbits specially melons except watermelon behaves positively with Ethrel to induce femaleness Mainly ethylene sprayed at 2 or 4 leaf stage results in sex reversal, because this stage of cell division decides the sex of upcoming flowers.

Table 1: Effect of various levels of ethrel, boron and calcium on growth and flowering attributes in HUB- 25 (snap melon)

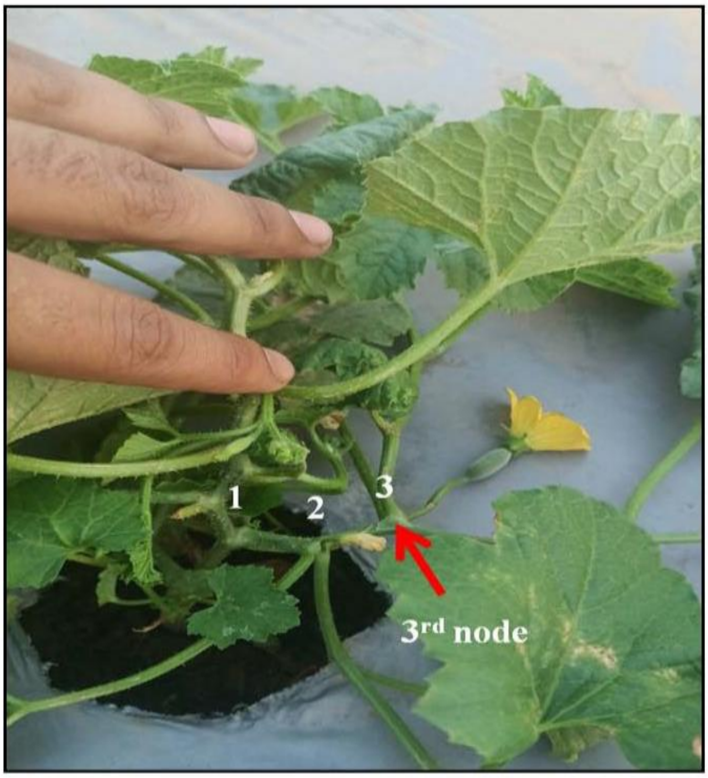
Treatments	Vine length (cm) at 50 DAT	Inter nodal length (cm) at last harvest	No. of branches per plant at last harvest	Node at 1st male flower	Node at 1st female Flower	Days to 1st male flower	Days to 1st female Flower	No. of male flowers per vine	No. of female flowers per vine	Sex ratio
T_1: Ethrel 150 ppm	229.33	9.54	3.73	3.60	4.98	33.07	33.07	174.20	21.00	9..99
T_2: Ethrel 150 ppm: Ca 0.5%	232.90	9.35	3.79	3.40	5.16	32.09	32.09	176.44	21.33	10.26
T_3: Ethrel 150 ppm: Ca 1%	229.80	9.28	3.96	3.65	5.26	31.08	31.08	176.80	22.00	9.85
T_4: Ethrel 150 ppm: B 0.5%	215.19	8.79	3.98	3.48	5.1	31.96	31.96	177.50	23.00	9.16
T_5: Ethrel 150 ppm: B 1%	213.40	8.69	4.01	3.53	4.96	30.44	30.44	178.36	24.00	8.78
T_6: Ethrel 200 ppm	211.80	8.64	4.22	3.31	4.41	30.33	30.33	178.30	26.00	7.12
T_7: Ethrel 200 ppm: Ca 0.5%	206.96	8.61	4.26	3.43	4.16	30.03	30.33	181.00	27.00	6.65
T_8: Ethrel 200 ppm: Ca 1%	204.20	8.58	4.32	3.38	4.32	29.08	29.08	185.22	28.00	6.56
T_9: Ethrel 200 ppm: B 0.5%	202.40	8.42	4.36	3.33	4.23	28.99	28.99	186.23	29.00	6.53
T_{10}: Ethrel 200 ppm: B 1%	200.10	8.36	4.38	3.33	4.06	28.08	28.08	190.33	29.00	6.24
T_{11}: Ethrel 250 ppm	195.13	8.35	4.76	3.26	3.21	28.06	28.06	205.22	30.00	5.93
T_{12}: Ethrel 250 ppm: Ca 0.5%	189.10	7.84	4.81	3.22	3.48	28.03	28.03	210.66	33.00	5.89
T_{13}: Ethrel 250 ppm: Ca 1%	184.56	7.61	4.85	3.21	2.96	28.06	28.06	210.68	31.00	5.57
T_{14}: Ethrel 250 ppm: B 0.5%	17 8.13	7.56	4.86	3.22	3.26	25.02	27.02	216.77	33.00	5.28
T_{15}: Ethrel 250 ppm: B 1%	173.40	7.44	5.01	3.09	3.12	27.08	27.08	213.00	32.00	5.25
T_{16}:.Control (Water only)	233.00	9.79	3.56	2.98	9.21	42.03	34.19	237.33	17.21	17.72
S.Em. $\pm$	6.171	0.193	0.147	0.101	0.146	0.862	1.128	3.508	0.812	0.285
CD @5%	17.822	0.559	0.424	0.291	0.420	2.489	3.259	10.131	2.346	0.823

Table 2: Effect of various levels of ethrel, boron and calcium on yield and quality attributes in HUB- 25 (snap melon)

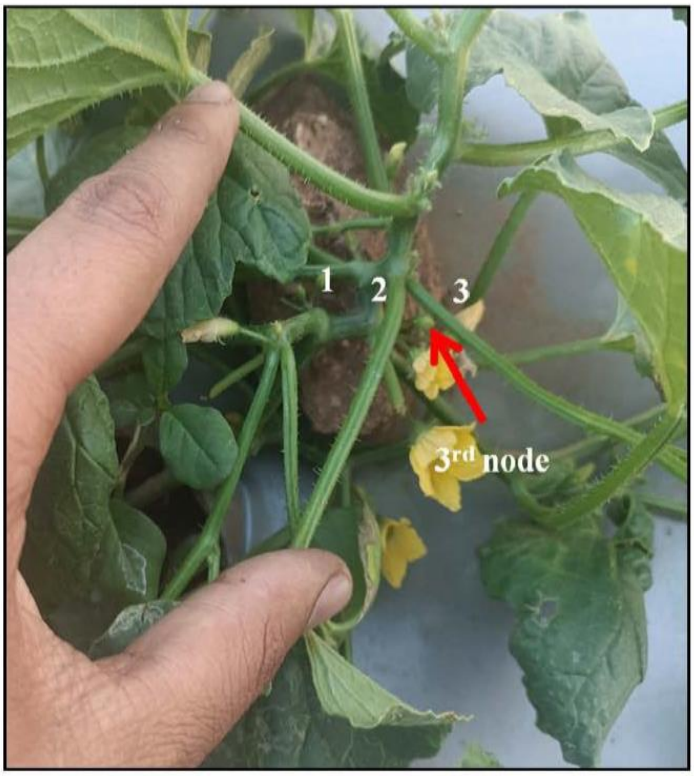
Treatments	Fruit length (cm)	Fruit circumference (cm)	Fruit Weight (g)	Days to 1st harvest	No. of fruits per vine	Fruit yield per vine (kg)	Fruit firmness (kg/cm²)	Total soluble solids (°B)	Vitamin C (mg/100g)	Shelf life (No. of days)
T_1: Ethrel 150 ppm	22.35	23.50	1042.00	78.00	9.20	7.46	3.46	6.33	21.98	3.73
T_2: Ethrel 150 ppm: Ca 0.5%	22.67	25.50	1071.00	77.00	9.73	7.86	3.55	6.16	23.30	3.66
T_3: Ethrel 150 ppm: Ca 1%	22.93	26.49	1086.00	76.00	10.53	8.57	3.66	6.40	21.55	3.86
T_4: Ethrel 150 ppm: B 0.5%	23.27	27.50	1093.00	74.00	10.50	8.89	3.48	6.56	20.57	3.80
T_5: Ethrel 150 ppm: B 1%	23.39	27.80	1098.00	73.00	10.80	8.93	3.58	6.60	24.76	3.79
T_6: Ethrel 200 ppm	23.40	27.90	1127.00	68.00	10.83	9.37	3.42	6.08	26.25	4.01
T_7: Ethrel 200 ppm: Ca 0.5%	23.53	28.50	1136.00	67.00	10.96	9.73	3.79	6.27	24.16	4.09
T_8: Ethrel 200 ppm: Ca 1%	24.87	28.72	1148.00	66.00	11.03	10.16	3.81	6.26	22.95	4.23
T_9: Ethrel 200 ppm: B 0.5%	24.89	29.19	1157.00	65.00	11.46	11.65	3.60	6.32	25.44	4.33
T_{10}: Ethrel 200 ppm: B 1%	24.93	29.50	1162.00	65.00	11.53	11.89	3.65	6.81	21.51	4.46
T_{11}: Ethrel 250 ppm	25.20	34.50	1208.00	64.00	12.03	12.23	3.37	6.06	23.42	4.98
T_{12}: Ethrel 250 ppm: Ca 0.5%	26.60	35.25	1232.00	64.00	12.18	12.58	3.90	6.35	24.46	5.20
T_{13}: Ethrel 250 ppm: Ca 1%	27.53	36.00	1238.00	63.00	12.40	12.96	3.93	6.48	24.34	5.53
T_{14}: Ethrel 250 ppm: B 0.5%	27.67	37.25	1256.00	61.67	14.00	13.03	3.86	6.36	23.45	5.33
T_{15}: Ethrel 250 ppm: B 1%	26.07	36.50	1261.00	62.00	13.50	13.96	3.88	6.08	23.44	5.66
T_{16}: Control (Water only)	21.53	20.50	967.00	81.81	06.01	05.17	3.34	6.03	23.19	3.06
S.Em. $\pm$	0.871	0.951	42.180	2.037	0.513	0.421	0.151	0.051	0.017	0.144
CD @5%	2.514	2.745	121.825	5.884	1.480	1.217	0.437	NS	NS	0.416

In cucurbits, foliar spray of ethephon at 2 or 4 leaf stages delays the production of staminate flowers by higher production of pistillate flowers along with pistillate flower at the earliest node. Similar staminate flower production was reported by Kohinoor and Mian (2005) in snake gourd. Girek *et al.* (2013) and Aishwarya *et al.* (2019) in watermelon and bitter gourd, respectively.

Male flowers per vine were lower in T_1 (174.20)and higher in the absolute control (17.21). Earlier studies showed that the reason for the earliest production of pistillate flowers may be attributed to the utmost increase in carbohydrate and starch with treatment of Ethephon (Singh and Singh, 1984). The analogous results were reported by Lippert *et al.* (1972), Shanmugavelu *et.al*. (1973), Mishra *et al.* (1976), Li (1983), Singh and Singh (1984), Ekatpure (1986) and Kshirsagar *et al.* (1995) in cucumber. Ethrel influenced sex ratio significantly.



(a). Female flower at 3rd node in T_{13} (Ethrel 250 ppm: Ca 1%)



b). Male flower at 3rd node in T_{16} (control)

Figure 1: Influence of Ethrel and nutrients on first male and female flower appearance

Sex ratio was minimum in Ethrel 250 ppm: B 1% (5.25) and which was *on par* with T_{14} (5.28), T_{13} (5.57) T_{12} (5.89) and T_{11} (5.93). Sex ratio is higher in control (17.22). These findings are consistent with the findings of (Leopold and Kriedemann, 1975), who reported that, the change in sex modification in cucurbits lies in altering the sequence of flowering and sex ratio. According to Mia *et al.* (2014), this could be attributed to a fall in the total count of male flowers and an increase in female flowers. There was a significant decline in sex ratio recorded in all treatments compared to control, with Ethrel 250 ppm (5.25) proving to be one of the best treatments in this regard.

1. Yield parameters

Data presented Table 2 and Figures 2 a and b reveal that average fruit length significantly differed among different treatments. Ethrel 250 ppm: B 0.5 % recorded significantly maximum fruit length (27.67 cm), and these are *on par* with T_{13} , T_{12} and T_{10}. Whereas, minimum fruit length (21.53 cm) was noticed in the control. Fruit circumference differed significantly by different nutrients (Ca and B) and Ethrel. Maximum diameter of fruit was recorded in Ethrel 250 ppm: B 0.5 % (37.25 cm) and it is *on par* with Ethrel T_{15} (36.50 cm), and the least circumference of fruit was reported in the control (20.50 cm. The highest and lowest fruit weight was recorded in ethrel 250 ppm: B 1.0 % (1261 g) in control (967 g), respectively. The probable reason for the increase in fruit length may be higher respiration and photosynthesis than in the control or untreated one. This is due to higher gathering of carbohydrates driving towards photosynthesis. Similar results were noticed by Patel *et al.* (2010) in sponge gourd for fruit length and diameter or circumference, Vyas *et al.* (2015) in ridge gourd for fruit length and mean fruit weight and Devi and Kumar (2015) in muskmelon for average fruit weight Significantly least number of days was recorded in ethrel 250 ppm: B 0.5 % (61.67 days). The highest number of fruits per vine was noticed in T_{14} (14.00), and the lowest number of fruits per vine was recorded in the control (6.01). T_{15} recorded maximum yield per plant (13.96 kg) which is *on par* with T_{14} (13.03) and T_{13} (12.96). Whereas, T_{16} noticed a minimum yield per plant (5.17 kg). Early flowering of pistillate flowers succeed by fertilization with male flower lead to early fruit set and node at first flower appeared is also least, all these led to early fruit set and early picking of fruits. The increase in total fruit yield in treated plants was attributed by increased physiological activity of treated plants, which results in the building up of a sufficient level of food stock in sink, which aids in proper development of flowers and fruits, which ultimately leads to higher yield. The above results were consonance with those Murthy *et al.* (2007), Patel *et al.* (2010), Arabsalmani *et al*. (2012), Vyas *et al.* (2015) and Dhakal *et al.* (2019) in gherkin, sponge gourd, cantaloupes, ridge gourd and cucumber respectively. Thus, Ethrel played leading role in meeting the needs of the snap melon crop to attain its maximum yield potential.

2. Quality parameters

The data pertaining total soluble solids (˚B), fruit firmness (kg/cm^2) and vitamin C content (mg/100g) are given in Table 2. There is no significant difference between various treatments for total soluble solids (TSS). Maximum TSS recorded with foliar spray of ethrel 200 ppm: B 1% (6.81 ˚B) followed by T_5 (6.60 ˚B). While the lowest TSS was recorded in T_{16} (6.03 ˚B). The rise in TSS level of fruits seems probably due to accumulation of metabolites, which stimulated the functioning of various enzymes in physiological process. This turns hydrolysed starch and helped in the metabolic activity during the change of available starch into sugar and TSS. These results agree with the reports of Randhawa (1974) in muskmelon. Combination of boron and calcium may enhance the TSS levels in fruits of tomato (Hasan and Jana, 2000).

Vitamin C levels in fruits differs non significantly among different treatments. Highest level of vitamin C recorded in T_6 (26.25 mg/100 g) which was succeeded by ethrel T_6 (26.25 mg/100 g). Whereas, lowest level of vitamin C in fruit was noticed in T_{14} (23.19 mg/100 g). Significant differences evident between various treatments for fruit firmness. Maximum firmness recorded for Ethrel 250 ppm: Ca 1.0 % (3.93 kg/cm^2) followed by Ethrel 250 ppm: Ca 0.5 % (3.90 kg/cm^2). While minimum firmness was recorded in the control (3.34 kg/cm^2). It may be due to the involvement of boron not only in promoting the metabolism of calcium in cell walls, but it also promotes the integrity of the cell wall, as well it delaying the degradation of the cell wall (Ryden *et al.,* 2003; Lester and Grusak, 2004). The application of both Ca and B may intensify firmness of fruit (Smith and Combrink, 2005).

3. Shelf life of fruits

The results concerning the shelf life of snap melon influence by different treatments of Ethrel and nutrients given in Table 2. Significant difference for the shelf life of snap melon was observed among various treatments of nutrients and Ethrel. Maximum shelf life recorded in Ethrel 250 ppm: B 1.0 % (5.66 days), whereas, minimum shelf life noticed in control (3.06 days). The decrease in physiological loss in weight of fruit might be due to a raised energy requirement at the time of ripening, where the splitting of ATP occurs, resulting in an elevation of ADP level, which accelerates respiration. This increase in respiration might ultimately lead to pronounced loss in weight and a decrease in the shelf life of harvested fruit.

Figure 2: Influence of Ethrel and nutrients on fruits of different treatments

Conclusion

Foliar application of Ethrel at 250 ppm: Boron at 1 per cent recorded the highest number of branches per vine (5.01), minimum vine length (173.40 cm) at 50 DAT and inter nodal length (7.44 cm), least sex ratio (5.25), higher fruit weight (1261 g /fruit), yield (13.96 kg/ vine) and cost benefit ratio (4.35), fruit firmness (3.88 kg/cm^2) and shelf life (5.66 days). Ethrel at 250 ppm: Calcium at 1% application showed the first female flower appearance at 2.96^{th} node. The results of the investigation, indicate that, foliar application of Ethrel at 250 ppm and Boron at 1% was the most effective in improving femaleness, increased the marketable fruits and yield.

Future thrust

Future focus on evaluating various concentrations and combinations of Ethrel, boron, and calcium to understand their effects on sex manipulation, growth, yield, and quality of snap melon across different cultivars and seasons. Additionally, studies on other growth regulators and micronutrients are needed to refine and enhance crop performance.

Author contribution

All authors contributed to the study conception and design. The 1st draft of the manuscript was written by A and all authors commented on previous versions of the manuscript. All authors read and agreed to the published version of manuscript.

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Conflict of Interest Statement
The authors declare that they have no competing interests

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