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Effect of time of spray and plant growth regulators on yield, quality and economics of muskmelon (*Cucumis melo* L.)

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Abstract
An investigation was carried out on "Effect of time of spray and plant growth regulators on muskmelon (*Cucumis melo* L.)" at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan, Gujarat, India during Summer 2021. The experiment was laid out in Factorial Randomized Block Design with eighteen treatment combinations involving three levels of time of spray *i.e.*, t_1 (2 leaf stage), t_2 (4 leaf stage) and t_3 (2 and 4 leaf stage) and plant growth regulators in six levels *i.e.*, p_1 (NAA @ 100 ppm), p_2 (NAA @ 150 ppm), p_3(Ethrel @ 100 ppm), p_4 (Ethrel @ 150 ppm), p_5 (GA_3 @ 10 ppm) and p_6(GA_3 @ 20 ppm) in Gujarat Muskmelon 3 variety. T_{16} (Spray at 2 and 4 leaf stage + Ethrel@ 150 ppm) found superior on yield and quality parameters *viz*., [number of fruits per vine, weight of fruit (g), fruit yield per vine (kg), fruit yield per plot (kg), total yield (kg/ha) and [TSS (ºBrix), reducing sugar (%), non-reducing sugar (%), total sugar (%) and volume of fruit (cm^3)], respectively and economics as well, as compared to the other treatments.

Keywords: 2 and 4 leaf stage, PGR, Sex expression

Introduction
Cucumis melo L. commonly known as Cantaloupe or muskmelon is a member of Cucurbitaceae family. It is known by various names *viz.*, Bachang, Sweet melon, Kalinga, Chira, Kharbuj and Sakkarteti in different parts of India. The ripe fruits are edible while green fruits are used as vegetable. The fruits are extensively used as dessert fruits and are highly popular in hotter months. Melons grown in dry regions are sweeter and tastier than those of awet situation. Muskmelon is gaining a lot of importance due to its short duration, high production potential with high nutritive value, taste, delicacy and also its suitability for the cultivation under rainfed and irrigated conditions throughout the year. In India, cucurbits occupy the prime place among the various vegetables, which are popular and available in all parts of India. The growing area and production of muskmelon in India were 61 ('000 ha) and 1368 ('000 MT), respectively. (Annon., 2019-20) [1].
Plant growth regulators (PGRs) are organic compounds other than the nutrients that modify plant physiological processes. PGRs, called bio stimulants or bio inhibitors act inside the plant cells to stimulate or inhibit specific enzymes or enzyme systems and thus, regulate the plant metabolism. Normally, they are active in low concentrations in the plants. Growth regulators include both growth promoters and retardants which have shown to modify the canopy structure and other yield attributes (Ansari and Chowdhary, 2018) [2]. Exogenous application of growth regulators has shifted the sex expression by increasing the production of female flower and suppressing that of male flower in cucurbits. Exogenous application of plant regulators altered sex ratio and sequence, when applied at 2 or 4 leaf stage, the critical stage at which the suppression or promotion of either sex is possible. Hence, modification of sex to desired direction was manipulated by exogenous application of plant growth regulators once, twice or even thrice at different intervals (Hossain *et al*., 2006) [5].

Materials and Methods
A field experiment on muskmelon var. GMM3 was conducted at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan, Gujarat, India during Summer 2021. The experiment was laid out in Factorial Randomized Block Design with total eighteen treatments comprising of two factors *viz*., time of spray (t) *viz*., t_1 (2 leaf stage), t_2 (4 leaf stage) and t_3 (2 and 4 leaf stage) and plant growth regulators (p) *viz*., p_1 (NAA @ 100 ppm), p_2 (NAA @ 150

ppm), p_3 (Ethrel @ 100 ppm), p_4 (Ethrel @ 150 ppm), p_5 (GA_3 @ 10 ppm) and p_6(GA_3 @ 20 ppm).

The combination of treatments comprised of Spray at 2 leaf stage + NAA @ 100 ppm (T_1), Spray at 2 leaf stage + NAA @ 150 ppm (T_2), Spray at 2 leaf stage + Ethrel @ 100 ppm (T_3), Spray at 2 leaf stage + Ethrel @ 150 ppm (T_4), Spray at 2 leaf stage + GA_3 @ 10 ppm (T_5), Spray at 2 leaf stage + GA_3 @ 20 ppm (T_6), Spray at 4 leaf stage + NAA @ 100 ppm (T_7), Spray at 4 leaf stage + NAA @ 150 ppm (T_8), Spray at 4 leaf stage + Ethrel @ 100 ppm (T_9), Spray at 4 leaf stage + Ethrel @ 150 ppm (T_{10}), Spray at 4 leaf stage + GA_3 @ 10 ppm (T_{11}), Spray at 4 leaf stage + GA_3 @ 20 ppm (T_{12}), Spray at 2 and 4 leaf stage + NAA @ 100 ppm (T_{13}),Spray at 2 and 4 leaf stage + NAA @ 150 ppm (T_{14}), Spray at 2 and 4 leaf stage + Ethrel @ 100 ppm (T_{15}), Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm (T_{16}), Spray at 2 and 4 leaf stage + GA_3 @ 10 ppm (T_{17}), Spray at 2 and 4 leaf stage + GA_3 @ 20 ppm (T_{18}) replicated thrice.

The experimental soil was loamy sand, with good drainage condition. As per recommended dose, whole quantity of well decomposed FYM (20 t ha^{-1}) was applied to the experiment field before sowing and mixed thoroughly with the soil and dose of N:P:K (100:50:60 kg ha^{-1}) out of which half dose of the nitrogen (N) and full dose of phosphorus (P_2O_5) and potassium (K_2O) were applied as basal dose in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The remaining half dose of nitrogen was applied as top dressing in the form of urea at thirty days after sowing. The planting was done at the spacing of 1.2 m × 1.0 m with plot size 4.0 m × 2.4 m.

The foliar application of plant growth regulators was given as per the treatments. The length of main vine in centimeter was measured at 60 DAS and at final harvest with the help of measure tap from ground level to the tip of the main vine. The number of primary branches was counted at final harvest. All the flowering parameters were noted from the date of sowing and and on the basis of daily observation from each tagged plants except the number of days taken from fruit set to edible maturity. To count the days taken from fruit set to edible maturity, one fruit from each tagged plant was marked separately. Total number of days required from the date of fruit set to the harvesting was recorded. Statistical analysis of the data pertaining to growth and flowering parameters were analysed as per the methods described by Panse and Sukhatme (1985) [8].

Results and Discussion

Yield parameters: The data on yield attributing characters such as number of fruits per vine, weight of fruit (g), fruit yield per vine (kg), fruit yield per plot (kg) and total yield (kg/ha) are depicted in Table 1 and 2.

Number of fruits per vine

Various time of spray, plant growth regulators and their interaction produced significant effect on number of fruits per vine. Significantly maximum number of fruits per vine (5.63) was recorded at 2 and 4 leaf stage (t_3). Among plant growth regulators, significantly maximum number of fruits per vine (5.04) was recorded with the application of Ethrel @ 150 ppm (p_4). The interaction effect of time of spray and plant growth regulators significantly increased number of fruits per vine (6.60) with the treatment combination of t_3p_4 (Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm).

The increased number of fruits per vine with the application of ethrel might be due to the production of more number of branches per plant which is responsible for the production of more number of pistillate flowers and ultimately more fruit set (Sureshkumar *et al.*,2016) [10]. These findings are in accordance with the results of Arora *et al.* (1995) [3] in ridge gourd. Application of plant growth regulators at 2 and 4 leaf stage increase the number of female flowers per vine which ultimately increases the number of fruits per vine.

Weight of fruit (g)

A perusal of the data reveals that the weight of fruit was significantly influenced by time of spray, plant growth regulators and their interaction. Significantly maximum weight of fruit (591.97 g) was recorded at 2 and 4 leaf stage (t_3). Among plant growth regulators, significantly maximum weight of fruit (563.96 g) was observed with the application of Ethrel @ 150 ppm (p_4). The interaction effect of time of spray and plant growth regulators significantly increased weight of fruit (683.87 g) with the treatment combination of t_3p_4 (Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm).

The increased fruit weight with the ethrel application might be due to the sole function of fertilized ovules in relation to the growth of fruits with the help of synthesized one or more hormones which initiate and maintain a metabolic gradient along with the foods and this can be transported from the other parts of the plants towards the fruit (Sureshkumar *et al.*, 2016) [10].

Table 1: Effect of time of spray, plant growth regulators and their interaction on various yield parameters of muskmelon (*Cucumis melo* L.)

Plant growth regulators (p)	Number of fruits per vine				Weight of fruit (g)			
	Time of spray							
	t_1	t_2	t_3	Mean	t_1	t_2	t_3	Mean
p_1 (NAA @ 100 ppm)	4.20	3.73	4.80	4.24	483.00	478.04	522.54	494.53
p_2 (NAA @ 150 ppm)	4.33	3.93	6.00	4.76	494.35	480.24	625.33	533.31
p_3 (Ethrel @ 100 ppm)	4.40	4.00	6.20	4.87	497.09	486.68	657.74	547.17
p_4 (Ethrel @ 150 ppm)	4.47	4.07	6.60	5.04	511.63	496.38	683.87	563.96
p_5 (GA_3 @ 10 ppm)	4.13	3.80	5.87	4.60	486.77	476.95	566.48	510.07
p_6 (GA_3 @ 20 ppm)	4.07	3.60	4.33	4.00	452.01	445.33	495.87	464.40
Mean	4.27	3.86	5.63		487.47	477.27	591.97	
	t	p	t × p		t	p	t × p	
S. Em. ±	0.11	0.15	0.26		9.59	13.57	23.50	
C. D. (5%)	0.30	0.43	0.74		27.57	38.99	67.53	
C. V. %	9.78				7.84			

Note: t_1: 2 leaf stage, t_2: 4 leaf stage, t_3: 2 and 4 leaf stage

Fruit yield per vine (kg)

The data revealed that effect of time of spray, plant growth regulators and their interaction produced significant effect on fruit yield per vine (kg) was found significant. 2 and 4 leaf stage (t_3) recorded significantly maximum fruit yield per vine (3.19 kg).In case of the plant growth regulators, maximum fruit yield per vine (3.04 kg) was found with the application of Ethrel @ 150 ppm (p_4).Significantly maximum fruit yield per vine (3.78 kg) was recorded with the treatment combination of t_3p_4 (Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm).

The probable reason for the increased fruit yield by ethrel application might be due to increased number of female flowers per plant, number of fruits per plant and fruit weight which might have ultimately enhanced the yield. Similar finding was noted by Chaurasiya *et al.* (2016) [4] in muskmelon, Sondarava *et al.* (2016) [9] in ridge gourd, Nayak *et al*. (2018) [7] in cucumber and Kumari *et al.* (2019) [6] in bottle gourd.

Table 2: Effect of time of spray, plant growth regulators and their interaction on various yield parameters of muskmelon (*Cucumis melo* L.)

Plant growth regulators (p)	Fruit yield per vine (kg)				Fruit yield per plot (kg)				Total yield (kg/ha)			
	Time of spray											
	t_1	t_2	t_3	Mean	t_1	t_2	t_3	Mean	t_1	t_2	t_3	Mean
p_1 (NAA @ 100 ppm)	2.47	2.14	2.75	2.45	17.08	11.72	17.51	15.44	17791.67	12208.33	18243.06	16081.02
p_2 (NAA @ 150 ppm)	2.53	2.47	3.62	2.87	17.35	16.93	18.27	17.52	18072.92	17638.89	19027.78	18246.53
p_3 (Ethrel @ 100 ppm)	2.65	2.51	3.66	2.94	17.52	16.96	19.95	18.15	18263.89	17670.14	20784.72	18906.25
p_4 (Ethrel @ 150 ppm)	2.80	2.53	3.78	3.04	17.53	17.00	20.49	18.34	18263.89	17711.80	21347.22	19107.64
p_5 (GA_3 @ 10 ppm)	2.64	2.46	2.84	2.65	17.31	16.77	17.53	17.20	18034.72	17465.28	18256.95	17918.98
p_6 (GA_3 @ 20 ppm)	2.05	1.98	2.48	2.17	11.34	11.09	17.27	13.23	11809.03	11548.61	17993.06	13783.56
Mean	2.52	2.35	3.19		16.36	15.08	18.50		17039.35	15707.18	19275.46	
	t	p	t × p		t	p	t × p		t	p	t × p	
S. Em. ±	0.06	0.09	0.15		0.42	0.60	1.03		439.82	622.00	1077.34	
C. D. (5%)	0.18	0.25	0.43		1.21	1.72	2.94		1263.90	1787.43	3065.92	
C. V. %	9.82				10.76				10.76			

Note: t_1: 2 leaf stage, t_2: 4 leaf stage, t_3: 2 and 4 leaf stage

Fruit yield per plot (kg)

A perusal of the data reveals that the fruit yield per plot (kg) was significantly influenced by time of spray, plant growth regulators and their interaction. Significantly maximum fruit yield per plot (18.50 kg) was found when plant growth regulators were applied at 2 and 4 leaf stage (t_3). Among plant growth regulators, significantly maximumfruit yield per plot (18.34 kg) found with the application of Ethrel @ 150 ppm(p_4). The interaction effect of time of spray and plant growth regulators significantly increased fruit yield per plot (20.49 kg) was recorded with the treatment combination of t_3p_4 (Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm).

Total yield (kg/ha)

The data revealed that effect of time of spray, plant growth regulators and their interaction produced significant effect on total yield was found significant. 2 and 4 leaf stage (t_3) recorded significantly maximum total yield (19275.46 kg). Among plant growth regulators, significantly maximumtotal yield (19107.64 kg) was found with the application of Ethrel @ 150 ppm (p_4). Significantly maximum total yield (21347.22 kg) was recorded with the treatment combination of t_3p_4 (Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm).

The application of ethrel increased the total yield of fruit. This might be due to the increased number of female flowers per plant, number of fruits per plant, fruit weight and fruit yield per plant which leads to maximized yield. These findings are accordance with Chaurasiya *et al.* (2016) [4] in muskmelon, Sondarava *et al.* (2016) [9] in ridge gourd, Nayak *et al*. (2018) [7] in cucumber and Kumari *et al.* (2019) [6] in bottle gourd.

Quality parameters

The data on quality attributing characters such as TSS (ºBrix), volume of fruit (cm^3), reducing sugar (%), non reducing sugar (%) and total sugar (%) are depicted in Table 3 and 4.

Total soluble solid (˚Brix)

Various time of spray, plant growth regulators and their interaction on total soluble solid was found statistically non significant. Maximum TSS was recorded with 2 and 4 leaf stage (t_3) as well as application of Ethrel @ 150 ppm (p_4) and treatment combination of spray at 2 and 4 leaf stage + Ethrel @ 150 ppm (t_3p_4) (10.79˚Brix, 10.88˚Brix, 11.34˚Brix respectively).

Volume of fruit (cm^3)

An appraisal of the data due to various time of spray, plant growth regulators and their interaction were found significant variation for volume of fruit. The significantly maximum volume of fruit (673.46 cm^3) and (656.63 cm^3) was recorded with 2 and 4 leaf stage (t_3) and Ethrel @ 150 ppm (p_4), respectively. Significantly maximum volume of fruit (765.23 cm^3) was recorded with the treatment combination of t_3p_4 (Spray at 2 and 4 leaf stage + Ethrel @ 150 ppm).

The volume of the fruit was increased due to the application of ethrel. The probable reason behind that might be the increased weight of fruit. Sureshkumar *et al.* (2016)[10] in bitter gourd recorded the similar finding.

Table 3: Effect of time of spray, plant growth regulators and their interaction on various quality parameters of muskmelon (*Cucumis melo* L.)

Plant growth regulators (p)	Total soluble solid (°Brix)				Volume of fruit (cm^3)			
	Time of spray							
	t_1	t_2	t_3	Mean	t_1	t_2	t_3	Mean
p_1 (NAA @ 100 ppm)	10.45	10.14	10.15	10.25	587.42	583.85	607.93	593.07
p_2 (NAA @ 150 ppm)	10.50	10.74	10.19	10.47	594.97	585.36	703.00	627.77
p_3 (Ethrel @ 100 ppm)	10.51	10.79	11.22	10.84	596.84	600.62	717.93	638.46
p_4 (Ethrel @ 150 ppm)	10.48	10.82	11.34	10.88	605.60	599.05	765.23	656.63
p_5 (GA_3 @ 10 ppm)	10.31	10.59	10.95	10.62	592.38	586.30	660.48	613.05
p_6 (GA_3 @ 20 ppm)	10.17	10.40	10.90	10.49	567.66	564.12	586.22	572.67
Mean	10.40	10.58	10.79		590.81	586.55	673.46	
	t	p	t × p		t	p	t × p	
S. Em. ±	0.11	0.16	0.27		6.27	8.87	15.36	
C. D. (5%)	NS	NS	NS		18.01	25.48	44.13	
C. V. %	4.44				4.31			

Note: t_1: 2 leaf stage, t_2: 4 leaf stage, t_3: 2 and 4 leaf stage

Reducing sugar (%)

Various time of spray, plant growth regulators and their interaction on reducing sugar was found statistically non-significant. Maximum reducing sugar was recorded with 2 and 4 leaf stage (t_3) as well as application of Ethrel @ 150 ppm (p_4) and treatment combination of spray at 2 and 4 leaf stage + Ethrel @ 150 ppm (t_3p_2) (3.19%, 3.22% and 3.33% respectively).

Non reducing sugar (%)

Various time of spray, plant growth regulators and their interaction on non-reducing sugar was found statistically non-significant. Maximum non reducing sugar was recorded with 2 and 4 leaf stage (t_3) as well as application of GA_3 @ 10 ppm (p_5) and treatment combination of spray at 2 and 4 leaf stage + Ethrel @ 150 ppm (t_3p_4) (5.52%, 5.55% and 5.74% respectively).

Total sugar (%)

An appraisal of the data due to various time of spray, plant growth regulators and their interaction on total sugar was found statistically non-significant. Maximum total sugar was recorded with 2 and 4 leaf stage (t_3) as well as application of GA_3 @ 10 ppm (p_5) and treatment combination of spray at 2 and 4 leaf stage + Ethrel @ 150 ppm (t_3p_4) (8.71%, 8.68% and 9.03% respectively).

Table 4: Effect of time of spray, plant growth regulators and their interaction on various quality parameters of muskmelon (*Cucumis melo* L.)

Plant growth regulators (p)	Fruit yield per vine (kg)				Fruit yield per plot (kg)				Total yield (kg/ha)			
	Time of spray											
	t_1	t_2	t_3	Mean	t_1	t_2	t_3	Mean	t_1	t_2	t_3	Mean
p_1 (NAA @ 100 ppm)	3.20	2.84	3.01	3.01	4.98	5.34	5.28	5.20	8.18	8.17	8.29	8.21
p_2 (NAA @ 150 ppm)	3.15	2.89	3.26	3.10	5.24	5.44	5.25	5.31	8.38	8.33	8.52	8.41
p_3 (Ethrel @ 100 ppm)	3.03	2.95	3.28	3.09	5.20	5.68	5.59	5.49	8.23	8.63	8.87	8.58
p_4 (Ethrel @ 150 ppm)	3.18	3.16	3.33	3.22	5.32	5.06	5.74	5.37	8.50	8.22	9.03	8.58
p_5 (GA_3 @ 10 ppm)	2.94	3.23	3.16	3.11	5.68	5.26	5.70	5.55	8.62	8.49	8.90	8.67
p_6 (GA_3 @ 20 ppm)	3.18	3.19	3.08	3.15	5.14	5.48	5.55	5.39	8.32	8.67	8.63	8.54
Mean	3.11	3.04	3.19		5.26	5.38	5.52		8.37	8.42	8.71	
	t	p	t × p		t	p	t × p		t	p	t × p	
S. Em. ±	0.04	0.06	0.10		0.07	0.10	0.18		0.10	0.14	0.24	
C. D. (5%)	NS	NS	NS		NS	NS	NS		NS	NS	NS	
C. V. %	5.50				5.68				4.97			

Note: t_1: 2 leaf stage, t_2: 4 leaf stage, t_3: 2 and 4 leaf stage

Economics

The details of economics *i.e.* gross return, cost of cultivation, net return and BCR on data basis for different treatments have been calculated and presented in Table 5 and graphically depicted in fig. 1. It apparents from Table 5 that the treatment T_{16} (combination of t_3p_4) noted maximum gross return of ₹ 3,20,208 per hectare, net return of ₹ 2,22,037 per hectare and BCR of 3.26.

Table 5: Effect of time of spray and plant growth regulators on economics and Benefit Cost Ratio

Tr.	Treatment combinations	Yield per hectare (kg/ha)	Gross realization (₹ /ha)	Total cost of cultivation (₹ /ha)	Net returns (₹ /ha)	Benefit Cost Ratio
T_1	t_1p_1	17792	266875	97298	169577	2.74
T_2	t_1p_2	18073	271094	97323	173771	2.79
T_3	t_1p_3	18264	273958	97300	176658	2.82
T_4	t_1p_4	18264	273958	97328	176630	2.81
T_5	t_1p_5	18035	270521	97318	173203	2.78
T_6	t_1p_6	11809	177135	97391	79744	1.82
T_7	t_2p_1	12208	183125	97689	85436	1.87
T_8	t_2p_2	17639	264583	97741	166842	2.71

T_9	t_2p_3	17670	265052	97695	167357	2.71
T_{10}	t_2p_4	17712	265677	97749	167928	2.72
T_{11}	t_2p_5	17465	261979	97731	164248	2.68
T_{12}	t_2p_6	11549	173229	97876	75353	1.77
T_{13}	t_3p_1	18243	273646	98081	175565	2.79
T_{14}	t_3p_2	19028	285417	98158	187259	2.91
T_{15}	t_3p_3	20785	311771	98089	213682	3.18
T_{16}	t_3p_4	21347	320208	98171	222037	3.26
T_{17}	t_3p_5	18257	273854	98143	175711	2.79
T_{18}	t_3p_6	17993	269896	98360	171536	2.74

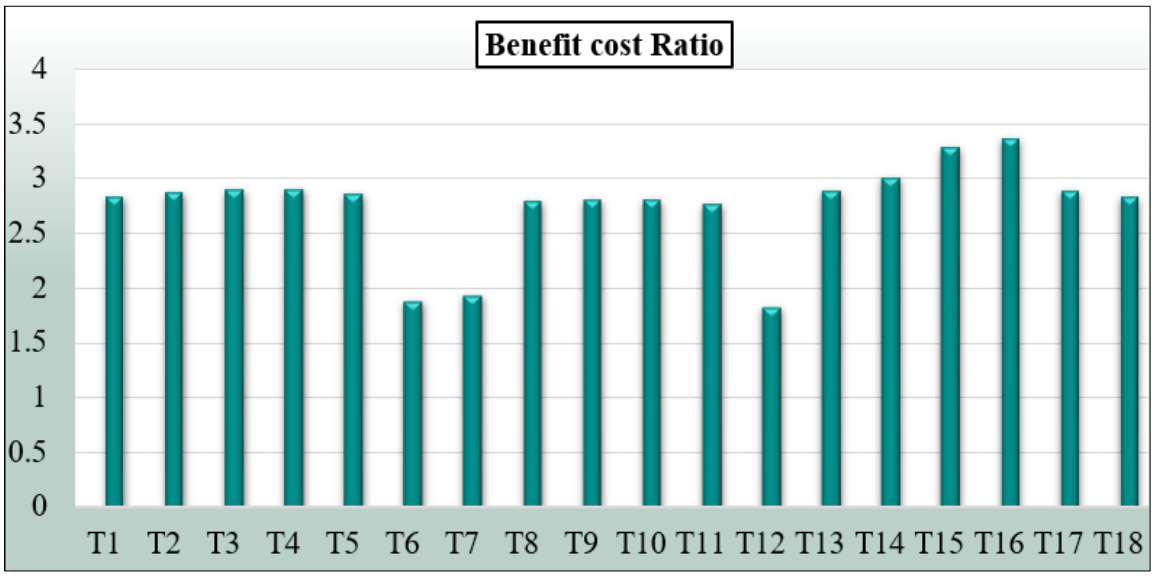

Fig 1: Interaction effect of time of spray and plant growth regulators

Conclusions

On the basis of results obtained from the present investigation, it can be concluded that the application of Ethrel @ 150 ppm at 2 and 4 leaf stage is the best in terms of yield and quality parameters in muskmelon.

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