Effect of foliar application of plant growth regulators on Growth, Yield and Fruit Quality of Watermelon (*Citrullus lanatus* Thunb.)

ABSTRACT

The present investigation entitled **"Effect of foliar application of Plant Growth Regulators on Growth, Yield and Fruit Quality of Watermelon (*Citrullus lanatus* T.)"** was conducted at Horticulture Research farm, Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj during *Zaid season* 2021 on watermelon with plant growth regulators viz., NAA (45,60ppm) GA_3 (25,50 ppm) and Control (water spray). The experiment was laid out in Factorial Randomized Block Design (FRBD) consisting of 10 treatments with 3 replications. The results concluded that in variety TMWH-2786 with treatments T_5(GA_3@50ppm) performed superior in the following parameters viz., days to germination (6-7 days) survival percentage (99.5%), vine length (5.77 m), days to the appearance of the first pistillate flower in 50% of plants (44.7 days), days to first harvest (93.73 days), fruit size in longitudinal shape (28.6 cm), maximum fruit weight (2.26 kg), number of marketable fruits per plant (2.11 fruits), maximum yield per hectare (31.78 tons), fruit diameter (30 cm) and TSS (10.5^{o}Brix) was recorded

Key words: *Watermelon, NAA, GA_3, Growth, Yield, Quality.*

Introduction

Watermelon (*Citrullus lanatus* Thunb.), a polar desert fruit in the tropics is an important crop throughout India. It is commonly known by various names tarbuj or paniphal, mathan, palampanna and kalingaddi in different parts of the country (Mahala 2014). Watermelon is an important annual vegetable crop and belongs to the Cucurbitaceae family having 22 chromosomes. It is grown throughout India, particularly in hot and dry North-Western parts of the country both under irrigated river beds and rainfed conditions during the summer season. It is native to central Africa where it is served as a source of water and a staple animal feed. In India, watermelon is a major crop in various riverbeds in Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh. Watermelon is monoecious or andromonoecious annual sprawling over the ground

Watermelon (Citrullus lanatus) a fruit crop, is herbaceous creeping plant. It is mainly propagated by seeds and thrives best in warm areas. It is a tropical plant and requires a lot of sunshine and high temperature of over 25°C for optimum growth. Watermelon thrives best in a drained fertile soil of fairly acidic nature. It can be grown along the coastal areas of Ghana, the forest zone and especially along river beds in the Northern Savannah areas. (Gupta, 2018)

Plant growth regulators are known to be modifying growth and sex expression, improve fruit set and ultimately increase yield in a number of cucurbits. Exogenous application of plant growth regulators can alter the sequence of male and female flowers, if applied at 2 or 4 leaf stages, the critical stage at which the suppression or promotion of either sex is possible. (Hossain et al., 2006). Hence, by proper manipulation, the sequence of flowering with the application of exogenous plant growth regulators, the yield of cucurbits can be increased. A relationship between growth substances and sex expression probably exists in these plants. (Paramar 2003).

Naphthalene acetic acid (NAA) helps in growth promotion, stimulates cell division, cell elongation, cell wall plasticity and permeability of cell membranes, RNA synthesis, induction of hydrolytic enzymes and increases plant height, increased mobilization and translocation of reserve food material**.**

Gibberellic acid (GA_3) helps in growth promotion, stimulates cell division, cell elongation, elongation of the shoot, photosynthesis, RNA synthesis, membrane permeability to water uptake, and prevents abscission of leaves, flowers and fruits, enhances leaf area index, leaf chlorophyll content and fruit yield increased. (Deepthi, 2008)

Materials and methods.

The present investigation was carried out to study the "effect of foliar application of plant growth regulators on the growth, yield and fruit quality of watermelon (*Citrullus lanatus* T.). The experiment was carried out in Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom, University of Agriculture, Technology and Sciences, Prayagraj (UP), India during *Zaid season* 2021. Prayagraj is situated at an elevation of 78 meters above sea level at 25.87^{o}North latitude and 81.15^{o}East longitudes. This region has a sub-tropical climate prevailing in the South-East part of UP with both the extremes in temperature, i.e., the winter and the summer. In cold winters, the temperature sometimes is as low as 32°F from December – January and very hot summer with the temperature reaching up to 115°F in May and June (AMOU, SHUATS, 2021). The experiment was conducted from February to May 2021 with plot size of 2 m x 2 m, planting distance of 1.5 m x 0.9 m, 6 plants per plot, direct sown crop and its an irrigated crop. The experiment material consists of hybrid varieties of seeds namely TMWH-2786 (AASMA) and TMWH-704

(Kaalia Gold), Trimurti Watermelon Hybrid Seeds. The plant growth regulators consisted of Gibberellic Acid (GA_3), Naphthalene Acetic Acid (NAA), while water spray served as untreated control plots. A total of ten treatments were tried including control in FRBD design by using WASP software and replicated thrice. The treatment details consists of V_1T_0 (TMWH-2786) control, V_1T_1 (TMWH2786+NAA ,45ppm), V_1T_2 (TMWH2786+NAA, 60 ppm), V_1T_3 (TMWH-2786+GA_3, 25 ppm), V_1T_4 (TMWH2786+GA_3, 50 ppm), V_2T_0 (TMWH-704) control, V_2T_1 (TMWH-704+NAA, 45 ppm), V_2T_2 (TMWH-704+NAA, 60 ppm), V_2T_3 (TMWH-704+GA_3, 25 ppm), V_2T_4 (TMWH-704+ GA_3, 50 ppm). The solutions were prepared from their respective stock solution using distilled water. Plant growth regulators were sprayed at 2 and 4 leaf stages. Five plants were randomly selected for recording observation on emergence, growth, yield and quality parameters.

Results and Discussion:

Germination parameters

The germination parameters such as days to germination and survival percentage were mentioned in Table 1.

Effect of plant growth regulators on days to emergence of watermelon (*Citrullus lanatus* Thunb.): The changes in the germination parameters of watermelon were not affected by plant growth regulators because the seeds of the watermelon hybrid were already treated by seed treatment methods. All the seeds took almost 6.22-7.28 days for germination.

Effect of plant growth regulators on survival percentage of watermelon (*Citrullus lanatus* Thunb.): Survival percentage among the seeds sown and the seedlings germinated, the mortality rate of the seedlings rate was very less that may be due to favorable climatic conditions. The survival rate of the seedlings was 99%.

Table 1: Effect of foliar application of plant growth regulators on growth, yield and fruit quality of Watermelon.

S.no	Treatment details	Days to germination	Survival percentage	Vine length(cm) 60DAS	Appearance of first pistillate flower	Days to first harvest	Fruit size in longitudinal shape (cm)	Fruit weight (kg)	Number of marketable fruits per plant	Fruit diameter (cm)	Yield per hectare (tons)	TSS(°Brix)	Flesh colour	Rind colour
1	V_1T_0 (TMWH-2786) Control	6.22	99.50	3.22	50.06	100.00	21.96	1.86	1.61	27.00	19.96	9.56	41	137
2	V_1T_1 (TMWH-2786+NAA@45ppm)	7.22	99.26	3.67	48.73	98.93	22.73	1.98	1.78	28.53	23.49	9.71	42	138
3	V_1T_2(TMWH2786+NAA@60ppm)	6.94	99.30	3.91	47.53	97.93	23.03	2.05	1.89	28.70	25.82	9.79	42	138
4	V_1T_3(TMWH-2786+ GA_3@25ppm)	6.72	99.40	4.85	46.20	95.93	25.23	2.16	2.06	29.16	29.66	10.2	41	138
5	V_1T_4(TMWH2786+ GA_3@50ppm)	7.06	99.20	5.77	44.70	93.73	28.60	2.26	2.11	30.00	31.78	10.5	43	139
6	V_2T_0(TMWH-704) control	6.39	99.30	3.12	50.16	103.00	21.73	1.81	1.56	27.70	18.82	9.56	41	137
7	V_2T_1(TMWH-704+NAA@45ppm)	7.28	99.20	3.49	48.26	99.90	22.40	1.94	1.67	28.00	21.59	9.78	42	138
8	V_2T_2(TMWH-704+NAA@60ppm)	6.52	99.36	3.86	47.66	98.46	23.26	2.04	1.83	28.40	24.85	9.88	42	138
9	V_2T_3(TMWH-704+ GA_3@25ppm)	6.78	99.13	4.81	46.33	97.76	24.93	2.13	1.94	29.53	27.54	10.3	42	139
10	V_2T_4(TMWH-704+ GA_3@50ppm)	6.72	99.36	5.73	44.16	94.86	28.06	2.20	2.06	30.10	30.21	10.5	43	139

Factor A	F test	NS	NS	S	S	S	S	S	S	S	S	S	S	S
	CD at5%	0.30	0.16	0.15	1.00	0.66	0.42	0.16	0.13	0.56	2.70	0.14	0.72	0.64
	SE(d)±	0.14	0.08	0.05	0.48	0.31	0.20	0.07	0.06	0.26	1.28	0.06	0.34	0.30
Factor B	F test	NS	NS	S	S	S	S	S	S	S	S	S	S	S
	CD at5%	0.48	0.26	0.24	1.59	1.05	0.67	0.25	0.21	0.87	4.27	0.22	1.41	1.02
	SE(d)±	0.23	0.13	0.11	0.75	0.50	0.32	0.12	0.10	0.41	2.03	0.10	0.54	0.48
Factor A X B	F test	NS	NS	S	S	S	S	S	S	S	S	S	S	S
	CD at5%	0.08	0.37	0.34	2.25	1.49	0.36	0.36	0.29	1.24	6.04	0.31	1.61	1.44
	SE(d)±	0.32	0.19	0.16	1.07	0.71	0.17	0.17	0.14	0.59	2.87	0.15	0.76	0.68

NS- Non significant*, S- Significant*.

Effect of plant growth regulators on growth parameters of watermelon

All the growth parameters such as vine length at 60 DAS, appearance of first pistillate flower in 50% plants and days to first harvest. were variably affected by plant growth regulators i.e., GA_3 and NAA were mentioned in Table 1. The experimental results revealed that all the growth parameters were significantly improved by using lower to higher concentrations. GA_3@50ppm was found to be superior over the control and other treatments during the experimentation.

Vine length:

In reference to the vine length of 60 DAS for variety TMWH-2786, the maximum vine length 5.77 m plant^{-1} was recorded with the application of GA_3@50ppm, and the minimum vine length 3.22 m plant^{-1} was recorded in the control (Table 1). In variety TMWH-704, the maximum vine length of 5.73 m plant^{-1} was recorded with the application of GA_3@50ppm, and the minimum vine length of 3.12 m plant^{-1}was recorded in the control. It might be due to their stimulatory effect on plant growth by cell elongation and rapid cell division in apical parts of the plants. Chovatia et al., (2010)

The Appearance of the first pistillate flower in 50% of plants:

In reference to the appearance of first pistillate flower in 50% of plants in variety TMWH-2786, appearance of the pistillate flower was recorded at 44.87 days with the application of gibberellic acid GA_3@50ppm compared to the control 50 days (Table 1). In reference to the appearance of the first pistillate flower in 50% the plants in variety TMWH-704, the appearance of the pistillate flower was recorded 44.1 days with application of gibberellic acid GA_3@50ppm compared to the control 50.1 days. This may be due to gibberellins induce early flowering when compared to NAA delayed the flowering with lower doses when compared to higher doses of NAA i.e., it enhances the cell division. Similar results were recorded by Dalai et al., (2020)

Days to first harvest:

In reference to days to first harvest in varietyTMWH-2786, first picking was recorded significantly least number of days i.e., 93.73 days with application of gibberellic acid GA_3@50 ppm whereas, for the control, the first picking recorded at 100days. In reference to days to first harvest in variety TMWH-704, the first picking was recorded at 94.86 days with the application of gibberellic acid GA_3@50 ppm whereas first picking for the control was recorded at 103days. The treated plants are more physiologically active in translocating food to develop fruits which results in early maturity of fruits to harvest. Similar results were recorded by Dinesh et al., (2019).

Effect of plant growth regulators on yield parameters of watermelon

The yield parameters such as fruit size in longitudinal shape, fruit weight, number of marketable fruits, fruit diameter and fruit yield were mentioned in Table 1. The experimental results revealed that all the yield parameters were significantly improved by using lower to higher concentrations. GA_3@50ppm was found to be superior over the control and other treatments during the experimentation.

Fruit size in longitudinal shape:

In reference to the fruit size in longitudinal shape in variety TMWH-2786, the largest fruit size recorded is 28.6 cm with the application of GA_3@50ppm, and the minimum fruit size was observed in the control 21.9 cm (Table 1). In reference to the fruit size in variety TMWH-704, the largest fruit size was recorded at 28.1 cm with application of GA_3@50ppm and the minimum fruit size was recorded in the control 21.7 cm (Table 1). Similar observations were reported by Prabhu and Natarajan (2006)

Fruit weight:

In reference to fruit weight, in variety TMWH-2786, the highest weight of fruit was found at 2.26 kg with the spray of GA_3@50ppm, and the least fruit weight was found in control (water spray) at 1.86 kg (Table 1). In reference to fruit weight, in variety TMWH-704, the highest weight of fruit was found at 2.20 kg with the spray of GA_3@50ppm and the least fruit weight was found in control (water spray) at 1.81 kg. During the early stages of fruit development, GA_3 and NAA directly or indirectly influences the cell number, size and density. These may promote cell elongation and cell expansion thereby the mesocarp of the fruit becomes larger, and increases its weight. The results obtained in this investigation are similar to the results of Chaudari et al., (2016) and Prasad et al., (2003)

Number of marketable fruits:

In reference to the number of marketable fruits per plant, in variety TMWH-2786, the highest number of marketable fruits 2.11 fruits was recorded with the spray of GA_3@50ppm, and the least fruit weight was found in control 1.61 fruits. In reference to the number of marketable fruits per plant, in variety TMWH-704, the highest number of marketable fruits 2.06 fruits was found with the spray of GA_3@50ppm, and the least fruit weight was found in control 1.56 fruits. NAA and GA_3 suppress the male flower production and increase the female flowers thereby resulting in more number of fruits set which also increases more number of fruits. Similar results were also found in accordance with Thappa et al., (2015).

Fruit diameter

In reference to fruit diameter, in variety TMWH-2786, the highest fruit diameter was found 30cm with the application of GA_3@50 ppm, and the least fruit diameter was found in control (water spray) at 27 cm. In reference to fruit diameter, in variety TMWH-704, the highest fruit diameter 30.1 cm was found with the application of GA_3@50ppm, whereas the least fruit diameter was found in control 27.7 cm. The function of fertilized ovule or the seed in relation to growth of the fruits is to synthesize hormones which initiate to

maintain a metabolic gradient along with translocation of food towards fruits. The results were similar to Ingale et al., (2000).

Fruit yield:

In reference to fruit yield in variety TMWH-2786, the highest fruit yield was found (31.78tons/ha) with the spray of GA_3@50ppm, and the least fruit yield was found in control 19.96tons. In reference to fruit yield in variety TMWH-704., the highest fruit yield was found 30.21tons with the spray of GA_3@50ppm, and the least fruit yield was found in control 18.82 tons. Sure et al., (2012) reported that increasing the yield in treated plants may be attributed to the plants remaining physiologically active to build sufficient food for the developing flowers and fruits. Thereby increasing the yield. The results were similar to that of Aisha et al., (2006), Marbhal et al., (2005).

Effect of plant growth regulators on quality parameters of watermelon

The quality parameters such as total soluble solids, flesh colour and rind colour was mentioned in Table 1. The experimental results revealed that all the quality parameters were significantly improved by using lower to higher concentrations. GA_3@50ppm was found to be superior over the control and other treatments during the experimentation.

TSS (Total Soluble Solids):

In reference to the fruit TSS in variety TMWH-2786, the highest fruit TSS was found 10.5 ^{o} brix with the application of GA_3@50ppm, and the least fruit TSS was found in control (water spray) with 9.56 ^{o} brix (Table1). In reference to the fruit TSS, in variety TMWH-704, The highest fruit TSS was found (10.5 ^{o} brix) was found with the spray of GA_3@50ppm, and the least fruit TSS was found in control (water spray) with 9.56 ^{o} brix (Table 1). The physiological process affect the absorption of nutrients by the plants from the soil which resulted in maximum TSS in treated fruits than in control (Sravika et al., 2021).

Flesh colour :

In reference to flesh color, in variety TMWH-2786, with the spray of GA_3@50ppm the dark colour of the flesh was found indicated with number 43 from Royal Horticultural Colour Chart (Table 1). And the dull colour was found in control (water spray) with the number indicated as 41. In reference to flesh color, in variety TMWH-704, with the spray of GA_3@50ppm the dark colour of the flesh was found indicated with number 43 from Royal Horticultural Colour Chart. And the dull colour was found in the control (water spray) with the number indicated as 41(Table 1).

Rind colour:

In reference to rind color, in variety TMWH-2786, with the spray of GA_3@50ppm the dark colour of the rind was found indicated with number 139 from Royal Horticultural Colour Chart (Table 1). And the dull colour was found in the control (water spray) with the number indicated as 137. In reference to rind color, in

variety TMWH-704, with the spray of GA_3@50ppm the dark colour of the rind was found indicated with number 139 from Royal Horticultural Colour Chart. And the dull colour was found in the control (water spray) with the number indicated as 137 (Table 1).

Conclusion:

Based on the results of the present investigation it was concluded that variety TMWH - 2786 treatment with application of Gibberellic acid (GA_3) @ 50 ppm at 2 and 4 leaf stage was found superior in terms of vine length, the appearance of a first pistillate flower in 50% of plants, fruit weight, fruit diameter, fruit size in longitudinal shape, number of marketable fruits, fruit weight, yield, TSS.

Acknowledgement

The work was supported by Advisor Dr. Devi Singh and all faculty members, Department of Horticulture, Naini Agricultural institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (U.P.) India for providing field and assistance in conducting the research trail.

References

Aisha , S., & Chaudhary, N.Y., 2006. GA_3 improve flower yield in some cucurbits treated with lead and mercury. *African Journal of Agriculture and Biology*,6(2).396-399

Choudary, D.C., Patel, N.M., and Prajapati, B.H., 2016. Effect of various plant growth substances on Economics of Watermelon (*Citrullus lanatus* Thunb Mansf.) cv. Durgapura Lal, *International Journal of Engineering Sciences and Computing* (RW 177-3)

Choudary, D.C., Patel, N.M., Rathva, V.D., and Nurbhanej, M.H, 2016. Effect of growth substances on growth, flowering and yield and quality attributes of Watermelon (*Citrullus lanatus* Thunb (Mansf.)) cv. Durgapura Lal, *International Journal of Agriculture Sciences* 8,(40),p :1825-1828.

Chovatia , RS., Ahlawat, T.R., Kavathia , Y., A Javani, L.L., and Kalia, D.C., 2010. Effect of plant growth regulators on vegetative growth, flowering and yield of bitter gourd cv. Priya. *Indian Journal of Horticulture.* 67:254-258.

Dalai, S., Singh, M.K., and Soni, S., 2020. Yield and yield traits of cucumber (*Cucumis sativus* L.) as influenced by foliar application of plant growth regulators. *International Journal of Current Microbiology and Applied Sciences,* 9(3): 121–126,

Dinesh, A.P., Prasanth, D., Laxminarayan, K., Nagaraju., and Gouthami, P., 2019. Efficacy of plant growth regulators on growth and flowering of Cucumber (*Cucumis sativus*. L.), cv. Malini under shade net conditions *International Journal of Current Microbiology and Applied Sciences* 8(09):313-317

Deepthi H.R., Chetti M.B., Aravinda Kumar B. N.,2008. Physiology and quality of muskmelon (*Cucumis melo* L.) as influenced by plant growth regulators. MSc. Thesis, University of Agricultural Sciences, Dharwad,

Gupta Alka, Singh Anamika and Prasad Ranu., 2018. A review on watermelon (Citrullus lanatus) medicinal seeds. *Journal of Pharmacognosy and Phytochemistry* 2018; 7(3): 2222-2225

Hossain, D., Karim, M, A., Rahman, M.H., Pramanik, A.M., and Rahman, S., 2006 Effect of gibberellic acid (GA3) on flowering and fruit Development of Bitter Gourd *(Momordica charantia* L.) *International Journal of Botany* 2(3): pp.329-332

Ingale, V.G., Jadhao, B.J., and Joshi, P.S., 2000. Effect of plant growth regulators on growth, sex ratio and yield of bottle gourd, *Journal of soil and crop* 10(1):101-104

Marbhal, SK., Musmade, AM., Kashi, NV., Kamble, MS., and Kamthe, PV., 2005. Effect of growth regulators and picking sequence on seed yield of bitter gourd, *Haryana Journal of Horticultural Sciences*, 34:323-326

Mahala, P., Choudary, MR., Yadav, TV., Garhwaland, OP., Singh, P., 2014. Effect of plant growth regulators on yield, quality and economics of bottle gourd (*Lagenaria siceraria* (Mol) Standl.). *Annals of Agric-Bio Research*.2014.,19(1):137-139.

Parmar, H.M., 2003. Effect of plant growth regulators on Growth, sex expression and yield of sponge gourd (*Luffa cylindrica* (Linn.) M. Roem,) cv. Pusa chikni M Sc. (Agri.) thesis submitted to Gujarat Agricultural University, Anand.

Prabhu, M., and Natarajan, S., 2006. Effect of growth regulators on fruit characteristics and seediness in ivy gourd (*Coccinea grandis* L.) *Agricultural Sciences Digest*,26:188-190.

Prasad, V. M., Paul, B.B., and Dasrath Yadav., 2003. Effect of plant Harmone (GA_3) on growth and yield of two varieties of cucumber *(Cucumis sativus* L.) Bioved 14(1/2):83-85

Sure, S., Oie, H.A., Azizi, M., 2012 Influence of plant growth regulators and planting method on growthy and yield of Oil Pumpkin (*Cucurbita pepo. var. styriaca). Not Sci Big.*, 4 (2):101-107.

Sravika, B., Kiranpatro, T.S.K.K., Usha kumari, K., Emmanuel, N., and Suneetha, S., 2021. Effect of plant growth regulators on yield and quality parameters of summer squash (*Cucurbita pepo*. L.). *The Pharma Innovation Journal*, 10(8):708-711.

Thappa, M., Satesh kumar., and Ramisa Rafiq., 2015. Influence of plant growth regulators on morphological, floral and yield traits of cucumber (*Cucumis sativus* L.) *Kesetsart Journal. (Nat. Sci)* 45:177-188.