Effect of plant growth regulators on Growth, Yield and Quality of Watermelon (*Citrullus lanatus* T.)

ABSTRACT

The present investigation entitled **"Effect of Plant Growth Regulators on Growth, Yield and 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* 2020-2021. The experiment was laid out in Factorial Randomized Block Design (FRBD) consisting of 10 treatments with 3 replications. The results concluded that the gGermination parameters viz., dDays to germination (6-7 days), sSurvival percentage (-99.5%), -gGrowth parameters viz., vVine length (5.77 m), dDays to the appearance of the first pistillate flower in 50% of plants (44.7 days), dDays to first harvest (93.73 days), and yYield parameters viz., fFruit size in longitudinal shape (28.6 cm), mMaximum fruit weight (2.26 kg), nNumber of marketable fruits per plant (2.11 fruits), maximum yield per hectare (31.78 tons), fruit diameter (30 cm) and qQuality parameters viz., TSS (10.5 ° Brix) was recorded in variety TMWH-2786 with treatments T_5 (GA_3@50ppm).

Key words: *(Watermelon, PGR's (NAA, GA_3). Growth, Yield, Quality.)*

Comment [TCH1]: Why only report the plant performance of TMWH-2786? How about TMWH-704?

Comment [TCH2]: I can not find the description of T5 treatment in the method section. Please clarify.

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 ~~number~~. 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 ~~of~~ in various riverbeds in Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh. Watermelon is monoecious or andromonoecious annual spawling over the ground

Comment [TCH3]: Citations needed for this sentence.

Watermelon (*Citrullus lanatus* Thunb.), is believed to have originated from Africa and spread to other parts of the world. In India, Uttar Pradesh is the first in area and production. Seeds germinate~~s~~ well and the crop thrives best when the temperature is 25-30 ℃–. Fruits mature best at 30℃. Cool weather below 16 ℃ adversely affects the growth and development of the crop.

Comment [TCH4]: Citations needed for these sentences.

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~~es~~ 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).

NAA (Naphthalene acetic acid) helps in g~~G~~rowth ~~promoting~~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 promoting~~promotes plant growth, 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, increased yield of fruit.

Comment [TCH5]: Citations needed for this sentence.

Comment [TCH6]: Citations needed for this sentence.

Comment [TCH7]: Citations needed for this sentence.

Materials and methods.

The present investigation was carried out ~~-~~to study the e~~"E~~ffect of plant growth regulators on the g~~G~~rowth, y~~Y~~ield and q~~Q~~uality of w~~W~~atermelon (*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 – 2022. Prayagraj is situated at an elevation of 78 meters above sea level at 25.87° North latitude and 81.15° East longitudes. This region has a sub-tropical climate prevailing in the South-East part of U.P~~.~~ 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 ~~in~~ from December – January and very hot summer with the temperature reaching up to 115°F in ~~the months of~~ May and June. During winter, frosts and ~~during~~ summer, hot scorching winds are also not uncommon. The average rainfall is around 1013.4 ~~(~~cm~~)~~ with maximum concentration during July to September months with

occasional showers in winter. The experiment was conducted from February to May 2021 and the experiment material consists of hybrid varieties of seeds namely TMWH-2786 and TMWH-704. Total A total of ten treatments were tried to including control in FRBD design and replicated thrice. The treatments were consisting of Gibberellic Acid (GA_3), and Naphthalene Acetic Acid (NAA) and control (water spray). The treatment details consists of V_1T_0 (TMWH-2786) Control, V_1T_1 (TMWH2786+NAA@45ppm), V_1T_2 (TMWH2786+NAA@60ppm), V_1T_3 (TMWH-2786+ GA_3@25ppm), V_1T_4 (TMWH2786+ GA_3@50ppm), V_2T_0 (TMWH-704) control, V_2T_1 (TMWH-704+NAA@45ppm), V_2T_2 (TMWH-704+NAA60ppm), V_2T_3 (TMWH-704+GA_3@25ppm), V_2T_4 (TMWH-704+ GA_3@50ppm). These plant growth regulators are sprayed at 2 and 4 leaf stages. The solutions were prepared from their respective stock solution using distilled water. Five plants were randomly selected for recording observation on germination, growth, yield and quality attributing parameters

Comment [TCH8]: Please provide the trait advantage or difference of these two varieties.

Results and Discussions:

Germination parameters

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

Effect of plant growth regulators on days to germination of watermelon (*Citrullus lanatus* T.): The changes in the germination parameters of watermelon was 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.

Comment [TCH9]: I don't think the authors can claim the germination of the seeds were not affected by the application of NAA and GA3. The growth performance in Table showed that application of both NAA and GA3 resulted in seed germination delay. The authors need to provide statistical support evidence to justify this claim.

Comment [TCH10]: This method was not provided in the method section. Please add the method.

Comment [TCH11]: Please cite the Table where this information is listed. Table 1?

Effect of plant growth regulators on survival percentage of watermelon (*Citrullus lanatus* T.)–: 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 change in climatic conditions. T~~and t~~he survival rate of the seedlings was 99%.

Comment [TCH12]: The author can not make this claim as the entire study was conducted under the same condition.

Comment [TCH13]: Please provide the Table where this info is listed.

Table 1: Effect of plant growth regulators on ~~G~~growth, y~~Y~~ield and g~~Q~~uality of w~~W~~atermelon.

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	99.5	3.22	50.0	100	21.9	1.86	1.61	27	19.96	9.56	41	137
2	V_1T_1 (TMWH-2786+NAA@45ppm)	7.22	99.3	3.67	48.7	98.93	22.7	1.98	1.78	28.5	23.49	9.71	42	138
3	V_1T_2(TMWH2786+NAA@60ppm)	6.94	99.3	3.91	47.5	97.93	23.1	2.05	1.89	28.7	25.82	9.79	42	138
4	V_1T_3(TMWH-2786+-GA_3@25ppm)	6.72	99.4	4.85	46.2	95.93	25.2	2.16	2.06	29.2	29.66	10.2	41	138
5	V_1T_4(TMWH2786+-GA_3@50ppm)	7.06	99.2	5.77	44.7	93.73	28.6	2.26	2.11	30	31.78	10.5	43	139
6	V_2T_0(TMWH-704) control	6.39	99.3	3.12	50.1	103	21.7	1.81	1.56	27.7	18.82	9.56	41	137
7	V_2T_1(TMWH-704+NAA@45ppm)	7.28	99.2	3.49	48.2	99.90	22.4	1.94	1.67	28	21.59	9.78	42	138
8	V_2T_2(TMWH-704+NAA@60ppm)	6.5	99.4	3.86	47.6	98.46	23.3	2.04	1.83	28.4	24.85	9.88	42	138
9	V_2T_3(TMWH-704+-GA_3@25ppm)	6.78	99.2	4.81	46.3	97.76	24.9	2.13	1.94	29.5	27.54	10.3	42	139
10	V_2T_4(TMWH-704+-GA_3@50ppm)	6.72	99.4	5.73	44.1	94.86	28.1	2.20	2.06	30.1	30.21	10.5	43	139

Table 2: Table 2 showing Different growth factor

Factor A	F test	-	-	S	S	S	S	S	S	S	S	S	S	S
	CD at5%	0.305	0.167	0.153	1.00	0.66	0.429	0.16	0.134	0.566	2.702	0.141	0.722	0.647
	SE(d)±	0.145	0.085	0.052	0.480	0.318	0.204	0.078	0.064	0.265	1.286	0.067	0.344	0.308
Factor B	F test	-	-	S	S	S	S	S	S	S	S	S	S	S
	CD at5%	0.482	0.264	0.243	1.59	1.05	0.679	0.25	0.211	0.879	4.272	0.223	1.411	1.023
	SE(d)±	0.230	0.134	0.116	0.759	0.503	0.323	0.123	0.101	0.419	2.033	0.106	0.543	0.487
Factor A X B	F test	-	-	S	S	S	S	S	S	S	S	S	S	S
	CD at5%	0.082	0.373	0.343	2.25	1.49	0.36	0.36	0.299	1.243	6.041	0.315	1.614	1.447

Comment [TCH14]: Statistical analysis method was not described in method section. Please provide the method in detail.

	SE(d)±	0.325	0.190	0.163	1.073	0.711	0.174	0.174	0.142	0.592	2.87	0.150	0.768	0.689

Effect of plant growth regulators on growth parameters of watermelon

All the growth parameters such as vine length at 20, 40 and 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 2. 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 ~~with~~ to the vine length of 20 and~~,~~ 40 DAS~~. In~~ for variety TMWH-2786, t~~T~~he maximum vine length of ~~(~~1.89 m~~)~~ and ~~(~~4.25 m~~)~~ plant^{-1} ~~.~~was recorded with the application of GA_3@50ppm, and the minimum ~~(1.41m)~~ ~~and (2.20m)~~ vine length of 1.41 m and 2.20 m plant^{-1} was recorded in the control. In variety TMWH-704, t~~T~~he maximum vine length of ~~(~~1.9 m~~)~~ and ~~(~~4.13 m~~)~~ plant^{-1} ~~.~~was recorded with the application of GA_3@50ppm, and the minimum ~~(1.25m)~~ ~~and (2.24m)~~ vine length of 1.25 m and 2.24 m plant^{-1} was recorded in the control. ~~was recorded in control~~ NAA induces cell division and cell growth and also improves synthesis and translocation of photosynthates that enhance the vegetative growth of the plant, hence vine length of the plant also increases. GA_3 also helps in cell enlargement, internodal elongation, and the synthesis of RNA and proteins. Thus, it leads to growth and development. The observations were similar to that of findings were done by Sahil et al., (2016) and Pal et al., (2016)

In reference ~~with~~ to the vine length of 60 DAS~~. In~~ for variety TMWH-2786, the maximum vine length ~~(5.77m)~~ of 5.77 m plant^{-1} ~~.~~was recorded with the application of GA_3@50ppm, and the minimum ~~(3.22m)~~ vine length of 3.22m 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 ~~(3.12m)~~ 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)

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

In reference to the appearance of the first pistillate flower in 50% of plants~~.~~ in variety TMWH-2786, ~~the lesser number of days to~~the appearance of the pistillate flower was recorded at 44.87 days with ~~spray~~ the application of gibberellic acid GA_3@50ppm ~~with (44.87 days), and more number of days for appearance of~~

Comment [TCH15]: Table 2 did not show this data. Furthermore, Table 1 only provided the data for 60 DAS. Please clarify.

Comment [TCH16]: I can not find any data for 20 and 40 DAS. Please provide these data.

Comment [TCH17]: The unit for vine length in Table 1 is cm but here the unit used is m. Please clarify.

first pistillate flower was recorded in control with (compared to the control (50 days)(Table 1). In reference to the appearance of the first pistillate flower in 50% of plants. in variety TMWH-704, the lesser number of days to the appearance of the pistillate flower was recorded at 44.1 days with the applicationspray of gibberellic acid GA_3@50ppm with (44.1 days), and more number of days for appearance of first pistillate flower was recorded in control with (compared to the control (50-.1 days). This may be due to Ggibberellins 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 Vedigeri et al., (2001), Das et.al. (2001), **and** Dalai et al., (2020).

Days to first harvest:

In reference to days to first harvest in variety TMWH-2786, the lesser number of days for first picking was recorded at 93.73 days with spray the application of gibberellic acid GA_3@50 ppm with (93.73days), and more number of days to first picking was recorded atwhereas, for the control, the first picking was recorded at with (100 days). In reference to days to first harvest in variety TMWH-704, the lesser number of days for first picking was recorded at 94.86 days with spray the application of gibberellic acid GA_3@50 ppm with (94.86days), and more number of days towhereas first picking for the control was recorded at control with (103 days). The treated plants are more physiologically active in translocate 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 was 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 highest largest fruit size recorded in longitudinal shape was found (is 28.6 cm) with spray the application of GA_3-@50ppm), and the minimum fruit size was found observed in the control (water spray) with (21.9cm)(Table 1). In reference to the fruit size in longitudinal shape, in variety TMWH-704, the highest largest fruit size was recorded at in longitudinal shape was found (28.1cm) with spray

the application of GA_3 @50ppm and the minimum fruit size was found recorded in the control (water spray) with (21.7cm)(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 with (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 with (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. There by the thereby the mesocarp of the fruit becomes larger, and increases its weight. The results obtained in this investigation is 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 was found ((2.11 fruits) was recorded) with the spray of GA_3 @50ppm, and the least fruit weight was found in control (water spray) with (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 (2.06 fruits) with the spray of GA_3 @50ppm, and the least fruit weight was found in control (water spray) with (1.56 fruits)). NAA and GA_3 suppress the male flower production and increase the female flowers there by resulting in more number of fruits set which also increases more number of fruits. The sSimilar 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 spray of GA_3 @50 ppm, and the least fruit diameter was found in control (water spray) at with (27 cm). In reference to fruit diameter, in variety TMWH-704, the highest fruit diameter (30.1cm) was found with the applicationspray of GA_3 @50ppm, whereas the least fruit diameter was found in control (water spray) with (27.7cm) 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) with the spray of GA_3 @50ppm, and the least fruit yield was found in control (water spray) with (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 (water spray) with(18.82 tons). Sure et al., (2012) reported that .Hincreasing 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 with 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 3. 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 °brix) with the spray of GA_3 @50ppm, and the least fruit TSS was found in control (water spray) with (9.56 °brix (Table 1)). In reference to the fruit TSS, in variety TMWH-704, The highest fruit TSS was found (10.5 °brix) was found with the spray of GA_3 @50ppm, and the least fruit TSS was found in control (water spray) with (9.56 °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:

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Comment [TCH18]: I can not find Table 3 in the manuscript. Please provide the table.

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 and with highest ~~benefit —~~benefit-cost ratio.

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