Environment and Ecology 41 (1) : 58—62, January—March 2023
ISSN 0970-0420

"Effect of Plant Growth Regulators on Flowering and Yield Attributes of Watermelon (*Citrullus lanatus* Thunb.)"

P. Santosh Kumar, M. Chandra Surya Rao, Anant Tamang, U. Shiva Kumar

Received 1 September 2022, Accepted 30 November 2022, Published on 27 January 2023

ABSTRACT

Sex manipulation is attributed to alter the ratio of male to female flowers within the individuals. In cucurbitaceous crops, a wide range of variation in sex forms were observed ranging from primitive hermaphrodite to gynoecious advanced sex form is observed. Sex expression in Cucurbitaceae family is regulated by hormonal factors. In general, female sex expression is promoted by exogeneous application of plant growth regulators which are called as the magic chemicals which in turn influence the sex expression upon application in small quantities. Therefore, a field experiment entitled as "Effect of plant growth regulators on flowering and yield attributing characters of watermelon (*Citrullus lanatus* Thunb)" was conducted at Horticultural research farm, MS Swaminathan School of Agriculture, Centurion University of technology and management, Ranadevi, Odisha during *rabi* season 2021 to 2022. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and replicated thrice. The experimental material consisted of one variety of watermelon and two concentrations each of four plant growth regulators that is T_1 - 2, 4-D @ 25 ppm, T_2 - 2, 4-D @ 50 ppm, T_3 - NAA @ 100 ppm, T_4 - NAA @ 150 ppm, T_5 - GA_3 @ 30 ppm, T_6 - GA_3 @ 40 ppm, T_7 - TIBA @ 20 ppm, T_8 - TIBA @ 25 ppm and T_9 control (Distilled water). The application of PGRs was carried at two stages (2- leaf stage and 4th leaf stage) in evening hours. The results revealed that, yield and yield attributing characteristics such as node number at which first male appeared (5.10), node number at which first female appeared (5.47), days taken to appear first male flower (35.33), days taken to appear first female flower (35.60), days taken from flower to fruit formation (41.13), fruit weight (3.50 kg) and fruit diameter (21.97 cm) was recorded upon the application of GA_3 @ 40 ppm. Whereas, the maximum number of fruits per plant (3.80), fruit length (21.42 cm) and rind thickness (15.96 mm) were obtained with application of TIBA @ 20 ppm, TIBA @ 25 ppm and 2, 4-D @ 50 ppm respectively.

Keywords Watermelon, Plant growth regulators,

P. Santosh Kumar[1], Dr M. Chandra Surya Rao[2]*, Dr Anant Tamang[3]
[2,3] Assistant Professor (Horticulture)
MS Swaminathan School of Agriculture,
Centurion University of Technology and Management, Parlakhemundi, Gajapathi, Odisha 761211, India

Dr Shiva Kumar Udayana[4]
[4] Assistant Professor (SSAC)
College of Horticulture,
Dr. YSR Horticultural University, Venkataramannagudem, Tadepalligudem, West Godavari, Andhra Pradesh 534101, India

Email: s_polaki@yahoo.com
*Corresponding author

GA_3, TIBA.

INTRODUCTION

Watermelon (*Citrullus lanatus* Thunb.) is a diploid (2n = 22) belongs to Cucurbitaceae family, originated in South Africa and edible part is endocarp (placenta). Watermelon is a warm-season crop which requires a long growing season. Watermelon is a major cucurbit in India covering an area of 1.10 million hectares, with an annual production of 2.78 million metric tons (NHB 2018).

Watermelon fruit contains 93% water, with small amounts of the nutrients. Hundred grams of watermelon flesh contains energy (127 kJ/30 kcal), carbohydrates (7.55 g), sugars (6.2 g), fiber (0.4 g), fat (0.2 g), protein (0.6 g), vitamin A (569 IU), vitamin C (8.1 mg), calcium (7 mg), iron (0.24 mg), lycopene (4532 µg). Lycopene is an anti carcinogenic compound found in red fleshed watermelon (Choo and Sin 2012). The lycopene content of the dark red watermelon cultivars is higher than that found in tomato, grapefruit and guava according to the USDA nutrient database (Cooperstone 2019).

Watermelon is a trailing vine with thin, hairy and angular stem having branched tendrils at each node. The flowers of watermelon are small, yellow, five-petalled with one cm diameter and less showy than other cucurbits (Paris *et al*. 2013). Flowers are usually monoecious (distinct male and female flowers grow on the same plant) and solitary. The flowers are produced in a ratio of 5 to 7 male flowers for every one female flower. The pistillate flowers have an inferior ovary. The pistillate or perfect flowers are borne at every seventh node and the staminate flowers at the intervening nodes in many varieties (Zaitoun and Al-Ghzawi 2016).

Sex manipulation is the process of altering male and female flower ratio within the individuals of a species, the sex modification leads to alteration in the sequence of flowering phenology by modifying beneficial sex ratio in order to enhance the economic yield (Manjunathagowda and Bommesh 2017). The monoecious plants are characterized by three phases of flowering, i.e. an initial period where only male flowers are produced, secondly equal proportionate of male and female flowers are produced for maximum period and finally predominate in female flowers production. Growth regulators have tremendous effects on sex expression and flowering in various cucurbits lead to suppression of male flowers or an increased number of female flowers (Thappa *et al*. 2011), without imposing any deleterious effect on environment and human health. Growth regulators can alter the sex ratio and sequence if applied at the two- or four-leaf stage, which is the critical stage at which the suppression or promotion of either sex is possible (Garg *et al*. 2020). Hence, the yield of cucurbits can be increased.

Therefore there is a need to investigate the potentiality of 2, 4-D [2, 4 dichlorophenoxy acetic acid], NAA [Napthalene acetic acid], GA_3 [Gibberellic acid] and TIBA [2, 3, 5- tri-iodobenzoic acid] on the growth and flowering of watermelon.

MATERIALS AND METHODS

The present investigation entitled "Effect of plant growth regulators on flowering and yield attributing characters of watermelon (*Citrullus lanatus* Thunb)" was undertaken to study the influence of different plant growth regulators at different concentrations on the performance of watermelon for reproductive and yield characters at Horticulture Research Farm, MS Swaminathan School of Agriculture, Centurion University of Technology and Management, Parlakhemundi, Odisha during *rabi*, 2021. The location falls under North Eastern Ghat Agro Climatic Zone with an average annual rainfall of 1423.6 mm at an altitude of 1035 m MSL. The experimental site was geo-graphically situated at 18° 46' 41.8584'' N latitude and 84° 5' 37.1436'' E longitude. The site experiences hot moist and sub-humid climate. The experiment was laid out in Randomized Block Design with nine treatments namely application of 2, 4-D (25 and 50 ppm), NAA (100 and 150 ppm), GA_3 (30 and 40 ppm) TIBA (20 and 25 ppm) and Control with three replications. The plants of individual treatments were sprayed with respective plant growth regulator solutions applied carefully with the help of hand sprayer at two and four leaf stages in the evening hours, whereas the control plots were sprayed with

distilled water as per the schedule.

The seeds of watermelon were sown in fourth week of December, 2021 and the last harvesting was carried out in the second week of April, 2022. The data was recorded from five randomly selected and tagged plants in the from the individual experimental plot excluding the border plants. The data were analyzed using the procedure outlined by Panse and Sukhatme (1967). Statistical significance was tested by 'F' value at 5% level of significance.

The position of first male and female flower were noted in terms of number of node on the main axis and mean values were computed. The position of first male flower were noted in terms of number of node on the main axis and mean values were computed. The days required for appearance first male and female flower from sowing were recorded and mean values were calculated. Days taken from flower to fruit formation are recorded from pollination to edible maturity and the days were recorded. Number of fruits per plant was counted at each picking of the five observation plants and mean were calculated. The Five fruit from each treatment were selected randomly and weight was measured and average fruit weight was worked out per plant in terms of kilogram. Randomly selected five matured fruit from each experimental plot were selected and the equatorial diameter was measured from the middle portion of fruit using scale at edible maturity. Randomly selected five matured fruit from each experimental plot were selected and the polar length was measured of fruit using scale at edible maturity. Rind thickness is measured by using digital vernier calliper, after removing the pink flesh of watermelon.

RESULTS AND DISCUSSION

All the yield attributing characters such as (node number at which first male and female flower appeared, days taken to appear first male and female flower and days taken from flower to fruit formation) and yield characters (number of fruits per plant, fruit weight, fruit diameter, fruit length and rind thickness) were effected by the application of different plant growth regulators at different concentrations presented in the Tables 1- 2.

Yield attributing characteristics: The results revealed that, application of GA_3 @ 40 ppm (T_6) recorded the highest (5.10) node number at which first male flower appeared, lowest (5.67) node number at which first female flower appeared, minimum (35.33) days taken to appear first male flower, minimum (35.60) days taken to appear first female flower and minimum (41.13) days taken from flower to fruit formation.

Yield attributes: The results state that, application of TIBA @ 20 ppm (T_7) recorded the maximum (3.80) number of fruits per plant. Whereas, the maximum (3.50 kg) fruit weight and fruit diameter (21.97 cm)

Table 1. Effect of different plant growth regulators on yield attributing characters of watermelon.

Treatments	Node no at which 1st male appear	Node no at which 1st female appear	Days taken to appear 1st male flower	Days taken to appear 1st female flower	Days taken to flower to fruit formation
T_1	3.70 cd	7.13 a	42.40 c	42.93 b	48.53 c
T_2	4.00 bcd	6.93 ab	40.47 b	42.53 b	45.53 bc
T_3	4.13 bc	6.20 cd	36.00 a	37.07 a	42.73 ab
T_4	4.20 bc	6.47 bc	36.40 a	37.40 a	43.07 ab
T_5	4.60 ab	5.67 de	35.53 a	36.33 a	41.60 ab
T_6	5.10 a	5.47 f	35.33 a	35.60 a	41.13 a
T_7	4.13 bc	5.60 def	35.53 a	35.90 a	42.20 ab
T_8	3.40 d	5.53 ef	36.33 a	36.53 a	42.60 ab
T_9	3.93 cd	6.47 bc	36.60 a	38.13 a	43.13 ab
SE (m) ±	0.23	0.22	0.55	1.16	1.39
CD @ 5%	0.68	0.65	1.66	3.48	4.16

T_1 - 2, 4-D @ 25 ppm
T_2 - 2, 4-D @ 50 ppm
T_3 - NAA @ 100 ppm
T_4 - NAA @ 150 ppm
T_5 - GA_3 @ 30 ppm
T_6 - GA_3 @ 40 ppm
T_7 - TIBA @ 20 ppm
T_8 - TIBA @ 25 ppm
T_9- Control (Distilled water)

Table 2. Effect of different PGRs on yield characteristics of watermelon.

Treatments	Number of fruits per plant	Average fruit weight (kg)	Average fruit diameter (cm)	Fruit length (cm)	Rind thickness (mm)
T_1	2.40 f	1.97 e	18.59 d	15.88 e	13.40 c
T_2	2.67 ef	2.20 e	19.45 cd	20.75 ab	15.96 a
T_3	3.27 bc	3.20 ab	21.61 ab	18.46 cd	13.88 bc
T_4	3.13 cd	3.25 ab	21.74 a	18.47 cd	13.75 b
T_5	3.53 ab	3.37 ab	21.88 a	19.42 bcd	13.99 bc
T_6	3.40 bc	3.50 a	21.97 a	19.61 abc	14.29 bc
T_7	3.80 a	3.11 bc	20.64 abc	20.74 ab	14.15 bc
T_8	3.73 a	2.87 cd	20.77 abc	21.42 a	13.83 bc
T_9	2.93 de	2.72 d	19.74 bcd	17.65 de	14.80 ab
SE (m)±	0.10	0.10	0.66	0.62	0.44
CD @ 5%	0.30	0.30	1.98	1.87	1.33

T_1 - 2, 4-D @ 25 ppm; T_2 - 2, 4-D @ 50 ppm; T_3 - NAA @ 100 ppm
T_4 - NAA @ 150 ppm; T_5 - GA_3 @ 30 ppm; T_6 - GA_3 @ 40 ppm
T_7 -TIBA @ 20 ppm; T_8 - TIBA @ 25 ppm; T_9 -Control (Distilled water)

were recorded with the application of GA_3 @ 40 ppm (T_6). The highest (21.42 cm) fruit length was recorded upon the application of TIBA @ 25 ppm (T_8). The maximum (15.96 mm) rind thickness was recorded upon the application of 2, 4-D @ 50 ppm (T_2).

However, application of 2, 4-D @ 25 ppm (T_1) recorded the minimum number of fruits per plant (2.40), fruit weight (1.97 kg), fruit diameter (18.59 cm), rind thickness (15.96 mm) and lowest fruit length (15.88 cm).

Flowering is an important phenomenon that expresses the differentiation process, which initiates the transition phase from vegetative to reproductive phase in plants. The studies indicated that nodes to first female flower appearance were significantly lowered by application of GA_3 at 40 ppm. Chovatia *et al*. (2010) reported that, at the primordial stage, all the flowers carry both sets of sex organ and the application of plant growth regulators induce the transformation of male flower buds into female flowers. This seems to be a reasonable explanation for the early appearance of pistillate flower at lower node with GA_3 application (Sinojiya *et al*. 2015).

Among all the treatments, TIBA @ 20 ppm recorded the maximum number of fruits per plant. It might be due to high positive correlation which was established between the production of female flowers and fruit set. Application of TIBA might have shown the effectiveness in increasing number of fruits per plant by reducing the flower and fruit drop which resulted in retention of more number of fruits per plant. These results were in conformity with the findings of Susila *et al*. (2013) in watermelon. In the present study it was observed that, application of GA_3 at 40 ppm was found most effective in increasing the fruit weight. This might be due to the respiration and photosynthesis of treated plants with GA_3 (Ouzounidou *et al*. 2010). This indicates that, there may be greater accumulation of carbohydrate owing to the process of photosynthesis which resulted into increased in fruit weight (Flore 2011). Similar findings were also reported by Kumar and Rao (1988) in ridge gourd and Kabir *et al*. (1989) in bitter gourd.

The probable reason for increase in fruit diameter was due to respiration and photosynthesis of treated plants with plant growth regulators. Upon the application of GA_3 favored the cell division and greater accumulation of carbohydrates owing to photosynthesis, which result in increased in diameter of the fruits (Hazarika *et al*. 2015). These results are in close accordance with finding of Chaudhary *et al*. (2016) in watermelon. It was observed that among all the treatment, the maximum length of fruits was observed with the application of TIBA @ 25 ppm. This effect may be explained in light of the report of Crane and Overbeek (1965) who suggested that the sole function

of fertilized ovules or seeds in relation to growth of fruits depend upon foods can be translocated from parts of plants towards the fruits and studies state that increased fruit length could be related to increased cell elongation and rapid cell division of individual cells. This result is in conformation with bottle gourd (Saimbhi and Thakur 1974).

CONCLUSION

Based on the findings of the present study, it can be concluded that, GA_3 treated plants performed better in yield attributing characters of watermelon compared to other plant growth regulators. Application of GA_3 @ 40 ppm proved better and produced lowest node at which first female flower appeared and minimum number of days taken for the appearance of first female flower and days taken from flower to fruit formation which are considered as earliness parameters for better yield in cucurbits such as fruit weight, average fruit diameter which were maximum upon the application of GA_3 @ 40 ppm. Therefore, it can be recommended for the farmers to spray GA_3 @ 40 ppm at 2 and 4 leaf stages for obtaining higher yield in watermelon which can bring the earliness to female flowers by altering the sex ratio from male to female.

REFERENCES

Chaudhary DC, Patel NM, Rathva VD, Nurbhanej MH (2016) Effect of growth substances on growth, flowering, yield and quality attributes of watermelon (*Citrullus lanatus* Thumb mansf.) cv Durgapura lal. *Int J Agric Sci* 8(40): 1825-1828.

Choo WS, Sin WY (2012) Ascorbic acid, lycopene and antioxidant activities of red-fleshed and yellow-fleshed watermelons. *Adv Appl Sci Res* 3(5): 2779-2784.

Chovatia RS, Ahlawat TR, Kavathia YA, Jivani LL, Kaila DC (2010) Effect of plant growth regulators on vegetative growth, flowering and yield of bitter gourd cv Priya. *Ind J Horticult* 67(11): 254-258.

Cooperstone JL (2019) Lycopene: Food Sources, Properties and Effects on Human Health. In Handbook of nutraceuticals and functional foods, pp 37-53. CRC Press.

Crane JC, Van Overbeek J (1965) Kinin-induced parthenocarpy in the fig, *Ficus carica. Life Sci* 147(3664): 1468-1469.

Flore JA(2011) Environmental and Physiological Regulation of Photosynthesis in Fruit. *Horticul Reviews, Volume* 11, 11, 111.

Garg P, Dev R, Raj S, Patel VJK, Singh VK (2020) Influence of plant growth regulators (PGRs) on growth parameters and sex ratio in cucumber (*Cucumis sativus* L.). *J Pharmacog Phytochem* 9(3): 1658-1661.

Hazarika TK, Ralte Z, Nautiyal BP, Shukla AC (2015) Influence of bio-fertilizers and bio-regulators on growth, yield and quality of strawberry (Fragaria× ananassa). *Ind J Agric Sci* 85(9): 1201-1205.

Kabir J, Chatterjee R, Biswas B, Mitra SK (1989) Chemical alteration of sex-expression in *Momordica charantia*. *Prog Hortic* 21: 1-2.

Kumar BS, Rao MR (1988) Effect of certain plant growth regulators and nutrients on growth, sex expression and yield of ridge gourd. *South Ind Horticult* 36(6): 336-339.

Manjunathagowda DC, Bommesh JC (2017) Sex manipulation in cucurbitaceous vegetables. *Int J Curr Microbiol Appl Sci* 6(9): 1839-1851.

NHB D (2018) National horticulture board.

Ouzounidou G, Papadopoulou P, Giannakoula A, Ilias I (2010) Plant growth regulators treatments modulate growth, physiology and quality characteristics of *Cucumis melo* L. plants. *Pak J Bot* 40(3): 1185-1193.

Panse VG, Sukhatme PV (1967) Statistical methods of agricultural workers. 2nd Endorsement. ICAR Publication, New Delhi, India, pp 381.

Paris HS, Daunay MC, Janick J (2013) Medieval iconography of watermelons in Mediterranean Europe. *Annals of Bot* 112(5): 867-879.

Saimbhi MS, Thakur MR (1974) Growth sex expression and yield of bottle gourd (*Lagenaria siceraria* (Molina) Standl) as affected by CEPA, TIBA and CCC [India]. *Haryana J Horticult Sci*.

Sinojiya AG, Kacha HL, Jethaloja BP, Giriraj J (2015) Effect of plant growth regulators on growth, flowering, yield and quality of watermelon (*Citrullus lanatus* Thunb.) cv Shine Beauty. *Environ Ecol* 33(4A): 1774-1778.

Susila T, Reddy SA, Rajkumar M, Padmaja G, Rao PV (2013) Studies on exogenous application of CPPU and GA_3 on yield. *World J Agric Sci* 9(2): 132-136.

Thappa M, Kumar S, Rafiq R (2011) Influence of plant growth regulators on morphological, floral and yield traits of cucumber (*Cucumis sativus* L.). *Agric Natural Res* 45(2): 177-188.

Zaitoun S, Al-Majeed Al-Ghzawi Abd (2016) Influence of elevation on honeybees *Apis melliferasyriaca* (HYMENOPTERA: APIDAE) flight activities and its impact on fruit set and quality of watermelon (*Citrullus lanatus*, Cucurbitaceae). In Proceedings of the 3rd International Conference on Agriculture and Forestry (Vol. 2: 127-134).