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

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Abstract: The effect of plant growth regulators on flowering and yield of watermelon (*Citrullus lanatus* (Thunb.) Matsumara and Nakai) was carried out during 2006-2007 and 2007-2008 seasons at Herbal garden, Rajendranagar, Hyderabad, India. The study consists of brassinosteroid (0.1, 0.5, 1.0 ppm), Ethrel (100, 200, 300 ppm), Paclobutrazol (100, 200, 300 ppm) and untreated control. The results of the study showed that, spraying of brassinosteroid at 0.1 ppm during 2nd and 4th leaf stage significantly influenced the flowering and enhanced the yield. The study further confirmed the role of plant growth regulators in sex modification, increase in production of female flowers and yield in watermelon. Spraying of brassinosteroid at 0.1 ppm may be beneficial for earlier production of female flowers, lowering the sex ratio by suppressing the production of male flowers and increase in yield.

Key words: Watermelon · *Citrullus lanatus* · Brassinosteroid · Ethrel · Paclobutrazol

INTRODUCTION

Watermelon belongs to the family Cucurbitaceae. It is known to have originated in tropical Africa and is now cultivated throughout the warmer parts of the world for its fruits which are used as dessert. It is an excellent summer dessert fruit and a natural source of lycopene, a carotenoid known for its antioxidant properties [1].

Watermelon is monoecious in nature, therefore has a highly variable range in the ratio of male to female flowers. Flower development is a critical factor influencing plant reproduction and crop yield. Sex determination of individual flower bud is regulated by a combination of genetic, environmental and hormonal factors. Several plant hormones including ethylene, auxins and gibberellins have been shown to influence flower sex expression in cucurbits [2]. The residual effects of the chemicals applied in the earlier stages of plant life have shown beneficial effects not only in increasing the number of female flowers but also vegetative growth and the ultimate yield. Earlier reports have conclusively demonstrated such effects on watermelon [3], cucumber [4], bitter gourd [5], pumpkin [6] and ridge gourd [7]. These reports however indicated that different chemicals seem to have dissimilar effects on different genera of cucurbitaceae.

There are few reports on new growth regulating chemicals like Paclobutrazol, Brassinosteroid and their influence on sex expression and yield. The present study was under taken to evaluate the influence of brassinosteroid, paclobutrazol and ethrel on flowering and yield.

MATERIALS AND METHODS

The present investigation was carried out during 2006-2008 at Herbal Garden, Rajendranagar, Hyderabad, India on watermelon cv. Sugar Baby. The seeds were sown at a spacing of 3.0 m x 0.9 m during both the years. Well decomposed farm yard manure @ 20 t ha^{-1} was applied for all the experimental plots uniformly as basal application. Nitrogen @ 80 kg ha^{-1} in the form of urea was applied in three equal split doses, one as basal application and other two split doses at 30 and 45 days after sowing. Phosphorous @ 50 kg ha^{-1} in the form of single super phosphate and potassium @ 50 kg ha^{-1} in the form of muriate of potash were applied as basal dose. Standard cultural practices were followed during the entire crop period for all the experimental plots. The experiment was laid out in randomized block design and replicated thrice.

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The treatments consists of Brassinosteroid 0.1, 0.5 and 1.0 ppm, Ethrel 100, 200 and 300 ppm, Paclobutrazol 100, 200 and 300 ppm and distilled water spray as control. The chemical solutions were prepared from their respective stock solutions using distilled water. The spray solution of each chemical was freshly prepared during each round of spray dissolving required quantity in required volume of water. Teapol (0.2 ml/L) was used as surfactant. The brassinosteroid and ethrel were imposed as foliar sprays and paclobutrazol was applied as soil application around the root zone by making small ring. The above treatments were imposed twice at 2^{nd} and 4^{th} leaf stage. The data were recorded on node at which first male and female flower appeared, number of days to first male and female flower appearance, number of fruits per plant, average fruit weight and yield per vine. All the recorded data were analyzed statistically [8].

RESULTS AND DISCUSSION

Significant reduction in the number of node at which first male flower appeared was recorded with application of BR 0.1 ppm (3.44) and BR 0.5 ppm (3.67) (Table 1). Paclobutrazol at all the three concentrations lowered the node number. Ethrel treated plants produced first male flower at higher nodes, when compared to other treatments. Similar findings were also observed in ridge gourd [9] and in Gherkin [10]. Early appearance of first male flower was observed in plants sprayed with BR 0.1 ppm (42.44 days) followed by BR 0.5 ppm (44.20 days) and paclobutrazol 300 ppm (44.77 days).

Application of BR 0.1 ppm (7.28) followed by paclobutrazol 300 ppm (7.45) produced the first female flower at lowest node (Table 1). Similar phenomenon was observed in cucumber with the application of auxins [11,4]. Anatomical studies of the sex organs revealed that the application of certain growth substances induce the transformation of staminate flower buds into pistillate flower buds [12]. This may be the possible reason for the appearance of early female flowers on the lower nodes along the main axis of the treated plants. Exogenous application of epi-brassinolide also caused a significant decrease in node position of the first female flower on monoecious cucumber plants and significant increase in the number of female flowers [13]. Significantly early appearance of female flower on the nearest node in paclobutrazol treated plants, which was similar to the findings of Arora *et al.*[14]. Increase in the concentration of paclobutrazol also resulted in significant reduction in shoot length and caused early appearance of pistillate flowers on the nearest node in bottle gourd [15]. Spraying of Ethrel 200 ppm produced the first female flower at highest node (19.22).

Days to appearance of first female flower was minimum in plants sprayed with BR 0.1 ppm (45.73 days) followed by Paclobutrazol 300 ppm (46.94 days). Spraying of Ethrel 300 ppm resulted with maximum number of days (68.28 days) for appearance of first female flower (Table 2).

Endogenous levels of hormones are responsible for modification of sex ratio in cucurbits. Node at which first female flower appeared is an indication of sex modification. Plants treated with BR 0.1 ppm (8.96)

Table 1: Effect of plant growth regulators on node at which first male and female flowers appeared in watermelon

	Node at which first male flower appeared			Node at which first female flower appeared		
Treatment	2006-07	2007-08	Mean	2006-07	2007-08	Mean
BR 0.1 ppm	3.55	3.33	3.44	7.44	7.11	7.28
BR 0.5 ppm	3.89	3.44	3.67	8.11	8.89	8.50
BR 1.0 ppm	5.00	4.56	4.78	8.00	8.45	8.22
Ethrel 100 ppm	8.11	9.33	8.72	16.45	16.00	16.22
Ethrel 200 ppm	9.78	8.44	9.11	19.56	18.89	19.22
Ethrel 300 ppm	12.33	11.78	12.06	15.44	14.11	14.78
Paclobutrazol 100 ppm	3.44	3.78	3.61	9.44	10.44	9.94
Paclobutrazol 200 ppm	4.11	3.99	4.05	8.22	7.56	7.89
Paclobutrazol 300 ppm	4.56	4.22	4.39	7.56	7.33	7.45
Control	8.22	7.89	8.06	11.11	10.45	10.78
SEm ±	0.584	0.767	0.455	0.501	0.541	0.368
CD (0.05)	1.748	2.297	1.301	1.499	1.621	1.052

Table 2: Effect of plant growth regulators on days to flowering and sex ratio in water melon

	No. of days to first male flower appearance			No. of days to first female flower appearance			Sex ratio		
Treatment	2006-07	2007-08	Mean	2006-07	2007-08	Mean	2006-07	2007-08	Mean
BR 0.1 ppm	43.33	41.55	42.44	46.46	45.00	45.73	8.78	9.14	8.96
BR 0.5 ppm	45.09	43.30	44.20	48.22	47.33	47.78	9.03	9.80	9.42
BR 1.0 ppm	48.55	47.33	47.94	51.22	49.88	50.55	11.03	10.27	10.65
Ethrel 100 ppm	51.89	53.44	52.67	61.44	65.11	63.28	14.03	13.37	13.70
Ethrel 200 ppm	53.33	52.55	52.94	65.00	63.00	64.00	14.77	15.10	14.93
Ethrel 300 ppm	57.22	53.66	55.44	68.66	67.89	68.28	19.43	18.90	19.17
Paclobutrazol 100 ppm	46.11	47.11	46.61	54.66	52.77	53.72	10.40	10.74	10.57
Paclobutrazol 200 ppm	45.02	45.71	45.61	48.55	46.55	47.55	10.32	10.65	10.49
Paclobutrazol 300 ppm	45.22	44.33	44.77	47.11	46.78	46.94	11.09	10.75	10.92
Control	51.73	49.22	50.48	54.66	52.33	53.49	15.65	15.71	15.68
SEm ±	1.038	1.396	0.905	1.018	1.276	1.154	0.390	0.301	0.307
CD (0.05)	3.109	4.180	2.587	3.048	3.820	3.406	1.166	0.900	0.878

Table 3: Effect of plant growth regulators on Average fruit weight (kg), No. of fruits per vine and yield per vine (kg) in watermelon

	Average fruit weight			No. of fruits per vine			Yield per vine		
Treatment	2006-07	2007-08	Mean	2006-07	2007-08	Mean	2006-07	2007-08	Mean
BR 0.1 ppm	3.55	3.33	3.44	4.33	4.00	4.17	13.07	12.37	12.72
BR 0.5 ppm	3.25	3.11	3.18	3.33	3.00	3.17	11.13	10.36	10.75
BR 1.0 ppm	3.16	3.14	3.15	2.33	2.00	2.17	8.40	7.73	8.06
Ethrel 100 ppm	3.33	3.21	3.27	2.67	2.33	2.50	7.45	7.12	7.29
Ethrel 200 ppm	3.29	3.15	3.22	1.67	1.33	1.50	6.60	5.90	6.25
Ethrel 300 ppm	3.12	3.04	3.08	1.33	1.00	1.17	5.10	4.43	4.76
Paclobutrazol 100 ppm	3.17	3.06	3.12	2.33	2.00	2.17	7.87	7.23	7.55
Paclobutrazol 200 ppm	3.17	3.04	3.10	2.67	2.33	2.50	8.88	8.34	8.61
Paclobutrazol 300 ppm	3.30	3.17	3.24	1.67	1.33	1.50	6.62	6.08	6.35
Control	3.28	3.17	3.22	2.67	2.33	2.50	8.57	7.90	8.23
SEm ±	0.091	0.136	0.074	0.330	0.288	0.196	0.505	0.245	0.238
CD (0.05)	NS	N.S.	NS	0.987	0.861	0.559	1.511	0.735	0.679

followed by BR 0.5 ppm (9.42) had lower sex ratio (Table 2). This may be due to marked suppression of male flowers and increase in female flower production. Earlier and increased flower production might be due to increase in ethylene production. Brassinosteroids have been reported to cause increased ethylene biosynthesis in excised mungbean hypocotyls [16], Arabidopsis seedlings [17] and tomato pericarp discs [18]. Mc Ardle [19] and Pak [20] reported the role of exogenous application of plant growth regulators in altering the sex ratio. The highest sex ratio was recorded in plants sprayed with ethrel 300 ppm (19.17) indicating suppressed female flower production. Similar results were reported by Rudich [21], David and Loy [22] speculated that application of ethephon results in high internal levels of ethylene in watermelon bud tissues which promotes maleness and also promotes anther development in flower buds normally predestined to be a pistillate flower.

Significantly maximum number of fruits per plant (4.17) was produced in plants treated with BR 0.1 ppm (Table 3). The increased number of fruits per plant in plants sprayed with BR 0.1 ppm may be attributed to the production of more branches which are responsible for production of large number of pistillate flowers and ultimately the fruit set. However, significant differences were not observed among the treatments with respect to average fruit weight in both the years. It ranges from 3.44 kg in plants sprayed with BR 0.1 ppm to 3.08 kg in plants sprayed with ethrel 300 ppm (Table 3).

The yield per vine was highest (12.72 kg) in plants sprayed with BR 0.1 ppm followed by BR 0.5 ppm (Table 3). Higher yield of BR treated plants could be attributed to the increased female flower production, higher fruit number per plant and diversion of photosynthates from vegetative growth to reproductive phase. Vidyavardhini and Rao [23] demonstrated that application of 28- homobrassinolide increased the yield of tomato. Similar improvement in yield of wheat [24] and grapes [25,26] were reported by application of brassinosteroids. Increase in concentration of paclobutrazol caused detrimental effect on yield and its contributing characters. Poor response of ethrel at higher concentration might be due to poor vegetative growth and higher sex ratio. Zhou-zhixiang *et al.*, [27] reported that optimum treatment for enhancing the number of female flowers and the fruit yield as well as for reducing the percentage of empty chestnuts is BR 0.01 mg l^{-1} + pp333 1000 ppm + KH_2PO_4 7500 ppm + H_3BO_3 5000 ppm. Kurapov *et al.* [28] concluded that epi-brassinolide treatment stimulated the transport of foliar applied 14C-glucose to tubers and increased the final yield by 22-25 per cent in potato cv. Nevskii. Torres and Nunez [29] showed that increase in yields of potato cv. Desiree with the application of synthetic brassinosteroid, Biobrass-6. Nunez *et al.* [30] reported increased bulb mass per plant in onion cv.Red creole with foliar application of synthetic brassinosteroid, Biobras-16 (0.1 mg l^{-1}) 50 days after planting. Hayat *et al.* [31] observed spraying of 28-homobrassinolide to mustard seedlings led to higher fresh and dry weights, enhanced carbonic enhydrase activity and net photosynthetic rate and enhanced pod number and seed yield per plant.

CONCLUSION

It can be concluded that application of brassinosteroid at 0.1 ppm significantly lowered the node at which first female flower appeared. Early female flower production coupled with significantly higher number of fruits per vine and yield per vine were obtained in plants treated with BR at 0.1 ppm. Thus the application of brassinosteroid at 0.1 ppm was most effective in improvement of yield in watermelon.

REFERENCES

1. Gerster, H., 1997. The potential role of lycopene for human health. J. American college of Nutrition, 16: 109-126.
2. Rudich, J., 1990. Biochemical aspects of hormonal regulation of sex expression in cucurbits. In: D.M. Bates, R.W. Robinson and C. Jeffrey, (eds.) Biology and Utilization of Cucurbitaceae Cornell University Press, Ithaca, New York..
3. Gopalakrishnan, P.K. and B. Choudhury, 1978. Effect of plant regulator sprays on modification of sex, fruit set and development in watermelon (*Citrullus lanatus* Thunb. Mansf.). Indian J. Horticulture, 35: 235-241.
4. Choudhury, B. and S.C. Pathak, 1959. Sex expression and fruit development in cucumber (*Cucumis sativus* L.) as affected by gibberellin. Indian J. Horticulture, 16: 233-235.
5. Gedam, V.M., R.B. Patil, Y.B. Suryawanshi and S.N. Mate, 1998. Effect of plant growth regulators and boron on flowering, fruiting and seed yield in bitter gourd. Seed Res., 26(1): 97-100.
6. Arora, S.K. and P.S. Partap, 1988. Effect of plant growth regulators on vegetative growth, flowering and fruit yield in Pumpkin (*Cucurbita moschata* Duch, Ex. Poir.). Haryana Agricultural University J. Res., 18(4): 284-290.
7. Mandal, D., N.C. Paria and T.C. Maity, 1990. Response of bottle gourd (*Lagenaria siceraria* Mol. Stand.) to some plant growth regulators. Crop Research Hissar., 3(2): 244-246.
8. Panse, V.G. and P.V. Sukhatme, 1985 Statistical Methods for Agricultural Workers. Indian Council for Agricultural Res. New Delhi.
9. Varalaxmi, B., 1992. Studies on genetic divergence, stability of populations and temporal dioecism in ridge gourd (*Luffa acutangla* Roxb.) PH. D Thesis ANGRAU, Hyderabad.
10. Devaraju., M.A.N., K.C. Reddy, M. Sivakumar, Deepu and D. Mathew, 2002. Effect of ethrel, cycocel and mepiquat chloride on flowering and sex expression in gherkin. Current Research University of Agricultural Sciences Bangalore, 31(2): 16-17.
11. Shifriss, O. and E. Galun, 1956. Sex expression in cucumber. Proceedings of American Society of Horticultural Sci., 67: 479-486.
12. Ito, H. and T. Kato, 1954. Factors responsible for the sex expression in Japanese cucumber (II) Anatomical studies on sex expression and transformation of cucumber flower induces by pinching. Ibid., 23: 65-70.
13. Papadopoulou, E. and R. Grumet, 2005. Brassinosteroid induced femaleness in cucumber and relationship to ethylene production. Horticultural Sci., 40(6): 1763-1767
14. Arora, S.K., M.L. Jitender kumar, Pandita and J. Kumar, 1989. Effect of cycocel on growth, flowering and yield of sponge gourd. Research and Development Reporter, 6(2): 71-75.

15. Rai, N., D.S. Yadav and R.K. Yadav, 2002. Standardization of Paclobutrazol concentrations in vegetable crops. Vegetable Sci., 29(2): 149-153.
16. Arteca, R.N., J.M. Bachman and N.B. Mandava 1988. Effects of indole -3-acetic acid and brassinosteroid on ethylene biosynthesis in etiolated mungbean hypocotyls segments. J. Plant Physiol., 133: 430-435.
17. Vardhini, B.V. and S. Rao, 2002. Acceleration of ripening of tomato pericarp discs by brassinosteroids. Phytochemis., 16: 843-847.
18. Woeste, K.E., J.P. Vogel and J.J. Kieber, 1999. Factors regulating ethylene biosynthesis in etiolated *Arabidopsis thaliana* seedlings. Physiology Plantarum, 105: 478-484.
19. Mc Ardle, R.N., 1990. Effect of growth regulator regimes and cultivar on femaleness and compactness of watermelon plants in green house. Plant Growth Regulatory society of America, 18(4): 177-186.
20. Pak, H.Y., 1993. Effects of plant growth regulators on parthenocarpic fruit development in watermelon. J. the Korean Society for Horticultural Sci., 34(3): 167-172.
21. Rudich, J., 1980. Biochemical aspects of hormonal regulation of sex expression in cucurbits. Conference on the Biology and Chemistry of Cucurbitaceae Ithaca N.Y. (Abstract)
22. David, A. and J.B. Loy, 1982. Influence of foliar applied growth regulators on sex expression in watermelon. J. American Society of Horticultural Sci., 107(3): 401-404.
23. Vidyavardhini, B. and S.S.R. Rao, 2001. Effect of Brassinosteroids on growth and yield of tomato (*Lycopersicon esculantum* Mill.) under field conditions. Indian Journal of Plant Physiol., 6(3): 326-328.
24. Sairam, R.K., 1994. Effect of homobrassinolide application on plant metabolism and grain yield under irrigated and moisture stress conditions of two wheat varieties. Plant Growth Regulat., 14: 173-181.
25. Xu, R.J., X.D. Li, Y.J. He, Y.Q. Wang and Y.J. Zhao, 1994. Effects of treatment with epibrassinolide and cholic lactone on the fruit set and ripening in some grape cultivars. J. Shanghai Agricultural College. 12: 90-95.
26. Tambe, T.B., 2002. Effect of Gibberellic acid in combination with Brassinosteroid on berry size, yield and quality of Thompson seedless grapes. J. Maharastra Agricultural Universit., 27(2): 151-153.
27. Zhouzhixiang., Xu-Yong, Rong Wang Peng, X.R. Cheng Xu, P.C. Wang, X.Y. Xu and C. Wang, 2000. Effect of Chemical regulators and their combinations on female flower. Number and fruit bearing in Chinese Chestnut. Forest Res., 13(2): 153-159.
28. Kurapov, P.B., I.V. Skorobogaatora, A.G. Siusbera and T.A. Kozik, 1996. Hormonal balance and productivity of wheat, barley and potatoplants under the influence of epibrassinolide treatment. Sel'skokhozy aistrennaya- Biologiya, 5: 99-104.
29. Torres, W. and M. Nunez, 1997. The application of Biobrass-6 and its effects on Potato (*Solanum tuberosum* L.) yield. Cultivos Tropicales, 18(2): 8-10.
30. Nunez, M., J.L. Sosa, J.L. Alfanso and F. Coll, 1998. The influence of two new Cuban bioregulators on plant yield of Onion (*Allium cepa L.*) cv. Red creole. Cultivos Tropicales, 19(1): 21-24.27.
31. Hayat S., A. Ahme, A. Hussain and M. Mobain, 2001. Growth of wheat seedlings raised from the grains treated with 28-homobrassinolide. Acta Physiology Plantarum, 23: 27-30.