

Effect of Micronutrients and Plant Growth Regulators on Growth, Yield and Quality of Watermelon (*Citrullus lanatus* (Thunb.) Matsum.) cv ‘Arka Shyama’

K. Sha^{1*} and R. Sanjai²

¹Department of Horticulture, Regional Research Station, TNAU, Virudhachalam, India

²Department of Horticulture, Faculty of Agriculture, Annamalai University, Tamil Nadu, India

*Corresponding author

ABSTRACT

A field experiment was conducted during 2023–2024 at the Orchard, Department of Horticulture, Annamalai University, Tamil Nadu, India, to evaluate the influence of micronutrients and plant growth regulators on the growth, yield and fruit quality of watermelon (*Citrullus lanatus* (Thunb.) Matsum.) cv ‘Arka Shyama’. The experiment was laid out in a randomized block design with three replications comprising fourteen treatments involving farmyard manure (FYM), recommended dose of fertilizers (RDF: 125:100:75 kg N:P: K ha⁻¹), Ethrel (100, 250 and 300 ppm) and brassinosteroid (1, 2 and 3 ppm), both alone and in combination with micronutrient mixture and micronutrient mixture (2%). The findings revealed that the integration of micronutrients and plant growth regulators significantly enhanced vegetative growth, flowering behaviour and yield performance. Among the treatments, FYM @ 20 t ha⁻¹ + RDF + brassinosteroid @ 2 ppm + micronutrient mixture @ 2% (T₁₃) exhibited superior performance with maximum vine length (317.14 cm), number of branches (6.08), leaves (372.39) and nodes (61.96). The same treatment improved flowering by increasing the number of female flowers (15.37) and optimizing the sex ratio. Yield attributes such as number of fruits per plant (3.12), yield per plant (11.48 kg) and yield per hectare (57.40 t ha⁻¹) were significantly higher in T₁₃. The study demonstrates that the combined application of micronutrients and brassinosteroids along with RDF is an effective strategy to improve productivity of watermelon under Tamil Nadu conditions.

Keywords

Watermelon,
Brassinosteroid,
Micro nutrients,
Yield and
Quality

Article Info

Received:

xx March 2026

Accepted:

xx April 2026

Available Online:

xx May 2026

Introduction

Watermelon (*Citrullus lanatus* (Thunb.) Matsum.) is one of the most widely cultivated cucurbitaceous crops in tropical and subtropical regions, valued for its high-water content, refreshing taste and nutritional composition. The

crop is rich in vitamins A and C, antioxidants such as lycopene and essential minerals, making it an important component of human diet and nutritional security (Perkins-Veazie *et al.*, 2012). It is believed to have originated in southern Africa and later spread across different continents, adapting to diverse agro-climatic

conditions (Esteras *et al.*, 2011). In India, watermelon occupies a prominent place among summer crops due to its high market demand and economic returns. However, its productivity is often limited by factors such as imbalanced nutrient management, poor flowering behaviour and low fruit set.

In cucurbits, sex expression plays a crucial role in determining yield, as fruit development depends on the production of female flowers. Typically, watermelon plants produce a higher proportion of male flowers compared to female flowers, which restricts fruit set and yield potential. Manipulation of sex expression through exogenous application of plant growth regulators has been widely explored as a strategy to enhance femaleness and improve productivity. Ethrel (ethephon), an ethylene-releasing compound, has been reported to increase the proportion of female flowers, while brassinosteroids are known to regulate plant growth by influencing cell division, elongation and reproductive development (Sathya, *et al.*, 2010 and Hayat and Ahmad, 2011). These growth regulators act by modifying endogenous hormonal balance and improving physiological efficiency.

Micronutrients are essential for plant growth and development, although required in small quantities. Elements such as zinc, boron, magnesium, iron and manganese are involved in various biochemical and physiological processes including enzyme activation, chlorophyll synthesis, carbohydrate metabolism and reproductive development (Marschner, 2012). Boron plays a key role in pollen germination and fertilization, whereas zinc is involved in auxin synthesis and protein metabolism. Deficiency of these nutrients can adversely affect plant growth and yield. Foliar application of micronutrients is considered an effective method for supplying nutrients directly to plant tissues, especially during critical growth stages, thereby improving nutrient use efficiency (Fageria *et al.*, 2009 and Ullah *et al.*, 2017).

The combined application of micronutrients and plant growth regulators is expected to produce synergistic effects by enhancing both physiological and biochemical processes. Such integrated approaches have been shown to improve vegetative growth, flowering behaviour, fruit set and yield in several horticultural crops. However, limited information is available regarding their combined effect on watermelon under Tamil Nadu conditions. Therefore, the present study was undertaken to evaluate

the influence of micronutrients and plant growth regulators on growth, flowering, yield and fruit quality of watermelon.

Materials and Methods

The field experiment was conducted during the year 2023–2024 at the Orchard, Department of Horticulture, Annamalai University, Tamil Nadu, India. The experimental site is characterized by a tropical climate with moderate temperature and well-distributed rainfall. The soil of the experimental field was sandy loam in texture with good drainage capacity. Prior to sowing, the land was prepared thoroughly by deep ploughing followed by harrowing and levelling to achieve a fine tilth. Farmyard manure (FYM) was applied at the rate of 20 t ha⁻¹ and incorporated into the soil to improve fertility and soil structure.

The experiment was laid out in a randomized block design (RBD) with three replications, comprising fourteen treatments involving combinations of FYM, recommended dose of fertilizers (RDF: 125:100:75 kg N: P: K ha⁻¹), plant growth regulators (Ethrel and brassinosteroid) and micronutrient mixture (2%). The watermelon variety 'Arka Shyama' was selected for the study due to its adaptability and yield potential. Seeds were sown during the first week of January at a spacing of 2 m × 1 m by dibbling method. Standard agronomic practices such as irrigation, weeding and plant protection measures were followed uniformly for all treatments to ensure optimal crop growth.

Plant growth regulators were applied as foliar spray at 15 days after sowing (2–4 leaf stage), followed by three subsequent sprays at weekly intervals. The micronutrient mixture, containing zinc (Zn), boron (B), magnesium (Mg), manganese (Mn), copper (Cu), molybdenum (Mo) and iron (Fe), was applied at 2% concentration one day after the application of plant growth regulators. The treatments included different concentrations of Ethrel (100, 250 and 300 ppm) and brassinosteroid (1, 2 and 3 ppm), both alone and in combination with micronutrient mixture.

Observations were recorded from five randomly selected plants in each treatment for various growth parameters such as vine length, number of branches, number of leaves and number of nodes per vine. Flowering parameters including number of male flowers, number of female flowers and sex ratio were recorded during the

flowering period. Yield parameters such as number of fruits per plant, average fruit weight, yield per plant and yield per hectare were recorded at harvest. Quality parameters including total soluble solids (TSS), total sugars, reducing sugars, non-reducing sugars and ascorbic acid content were estimated using standard laboratory procedures. The collected data were statistically analyzed using analysis of variance (ANOVA) appropriate for randomized block design, and treatment means were compared at 5% level of significance.

Results and Discussion

The results of the present investigation revealed that the application of micronutrients and plant growth regulators had a significant influence on growth, flowering, yield and quality parameters of watermelon. The combined application of FYM, RDF, brassinosteroid and micronutrient mixture (T₁₃) consistently recorded superior performance compared to other treatments, indicating a strong synergistic effect.

Vegetative growth parameters such as vine length, number of branches, leaves and nodes were significantly enhanced under T₁₃. The maximum vine length (317.14 cm) observed in this treatment may be attributed to the role of brassinosteroids in promoting cell elongation and division, along with improved nutrient uptake facilitated by micronutrients.

Similar findings have been reported by [Hayat and Ahmad \(2011\)](#), who emphasized the role of brassinosteroids in enhancing plant growth and development.

The increased number of branches (6.28) and leaves (372) under this treatment indicates improved vegetative vigor, which can be linked to enhanced photosynthetic activity and metabolic efficiency. Micronutrients such as magnesium and iron play a crucial role in chlorophyll synthesis, thereby improving photosynthetic efficiency and overall plant growth ([Marschner, 2012](#)).

Flowering behaviour was significantly influenced by the treatments, particularly with respect to female flower production and sex ratio. The highest number of female flowers (15.37) was recorded in T₁₃, indicating enhanced femaleness. This may be attributed to the combined effect of brassinosteroids and micronutrients in regulating hormonal balance and promoting reproductive development. Boron, an essential micronutrient, plays a

vital role in pollen viability and fertilization, thereby improving fruit set. The improved sex ratio (1: 9.92) observed in this treatment suggests a shift towards higher female flower production, which is desirable for increased yield in cucurbits. Similar results have been reported in previous studies where plant growth regulators influenced sex expression and flowering behaviour ([Taiz et al., 2015](#)).

Yield parameters were significantly improved under the combined application of micronutrients and plant growth regulators. The highest number of fruits per plant (3.12), yield per plant (11.48 kg) and yield per hectare (57.40 t ha⁻¹) were recorded in T₁₃. The increased yield may be attributed to improved source-sink relationship, enhanced carbohydrate accumulation and efficient translocation of assimilates to developing fruits. Brassinosteroids are known to enhance sink strength and reduce flower drop, thereby improving fruit set and yield.

Additionally, micronutrients improve nutrient use efficiency and support various physiological processes, leading to better crop performance ([Vardhini and Rao 2002](#); [Fageria et al., 2009](#)).

Fruit quality parameters such as total soluble solids, sugars and ascorbic acid content were also significantly enhanced under T₁₃. FYM @ 20 t ha⁻¹ + RDF + brassinosteroid @ 2 ppm + micronutrient mixture @ 2% total soluble solids 12.36 (°Brix) sugars 8.37 (%) and 4.26 (mg 100g⁻¹) ascorbic acid content. The improvement in quality may be due to increased metabolic activity and efficient synthesis of carbohydrates and organic acids. Enhanced photosynthetic efficiency and better nutrient status of plants contribute to improved fruit quality.

These findings are in agreement with previous studies, which reported that balanced nutrient management and growth regulator application improve both yield and quality attributes in horticultural crops.

Overall, the results of this study clearly indicate that the integration of micronutrients and plant growth regulators, particularly brassinosteroid at 2 ppm combined with micronutrient mixture at 2%, plays a significant role in enhancing growth, flowering, yield and fruit quality of watermelon. The synergistic interaction between nutrients and hormones improves physiological efficiency, leading to higher productivity. This approach can be effectively utilized in watermelon cultivation to achieve better yield and quality under field conditions.

Table.1 Effect of micronutrients and PGR on Growth and Flower of watermelon (*Citrullus lanatus* (Thunb.) Matsum.) cv‘Arka Shyama’

Treatments		Vine length at harvest (cm)	No of branches	Number of leaves per plant at Harvest	Number of nodes per vine	First female flower appearance (Days)	No. of Male flowers	No. of female flowers	Sex ratio (F:M)
T ₁	FYM 20 t ha ⁻¹ + RDF + Water spray (Control),	274.79	5.16	329.74	54.87	36.34	128.27	6.18	1:20.76
T ₂	FYM + RDF + Ethrel @ 100 ppm	289.16	5.44	336.08	57.43	35.63	139.78	10.38	1:13.47
T ₃	FYM + RDF + Ethrel @ 250 ppm	300.05	5.89	353.35	59.20	34.88	145.53	12.62	1:11.53
T ₄	FYM + RDF + Ethrel @ 300 ppm	296.97	5.75	349.31	59.34	35.09	143.92	12.01	1:11.98
T ₅	FYM + RDF + Ethrel @ 300 ppm	299.48	5.84	352.87	59.97	34.92	145.24	12.56	1:11.56
T ₆	FYM + RDF + Brassinosteroid @ 1 ppm	294.69	5.66	345.45	58.71	35.25	142.58	11.47	1:12.43
T ₇	FYM + RDF + Brassinosteroid @ 2 ppm	293.73	5.62	344.13	58.55	35.28	142.35	11.43	1:12.46
T ₈	FYM + RDF + Brassinosteroid @ 3 ppm	291.45	5.53	339.54	58.04	35.44	141.08	10.89	1:12.95
T ₉	FYM + RDF + Micronutrient mixture @ 2%,	303.12	5.97	357.03	59.72	34.72	146.82	13.17	1:11.14
T ₁₀	FYM + RDF + Ethrel @ 100 ppm + Micronutrient mixture @ 2%	310.82	6.20	365.16	60.98	34.35	149.85	14.29	1:10.48
T ₁₁	FYM + RDF + Ethrel @ 250 ppm + Micronutrient mixture @ 2%,	306.76	6.11	361.74	60.42	34.51	148.56	13.76	1:10.79
T ₁₂	FYM + RDF + Ethrel @ 300 ppm + Micronutrient mixture @ 2%,	314.03	6.29	368.83	61.43	34.18	151.20	14.82	1:10.20
T ₁₃	FYM + RDF + Brassinosteroid @ 1 ppm + Micronutrient mixture @ 2%,	317.14	6.38	372.39	61.96	34.02	152.48	15.37	1:9.92
T ₁₄	FYM + RDF + Brassinosteroid @ 2 ppm + Micronutrient mixture @ 2%	305.59	6.08	360.52	60.25	34.56	148.12	13.71	1:10.80
	S.Ed	1.02	0.03	1.22	0.20	0.06	0.61	0.24	0.30
	C.D=0.05	2.07	0.07	2.46	0.41	0.13	1.23	0.49	0.62

Table.2 Effect of micronutrients and PGR on yield and Quality of watermelon (*Citrullus lanatus* (Thunb.) Matsum.) cv‘ Arka Shyama’

Treatments		Number of fruits plant ⁻¹	Yield (kg plant ⁻¹)	Estimated yield (t ha ⁻¹)	TSS (°Brix)	Total sugar (%)	Ascorbic acid content (mg 100g ⁻¹)
T ₁	FYM 20 t ha ⁻¹ + RDF + Water spray (Control),	2.56	7.96	39.80	10.18	5.62	2.89
T ₂	FYM + RDF + Ethrel @ 100 ppm	2.69	8.76	43.80	10.87	6.49	2.98
T ₃	FYM + RDF + Ethrel @ 250 ppm	2.89	9.99	49.95	11.56	7.38	3.62
T ₄	FYM + RDF + Ethrel @ 300 ppm	2.83	9.62	48.10	11.37	7.14	3.41
T ₅	FYM + RDF + Ethrel @ 300 ppm	2.87	9.87	49.35	11.52	7.32	3.56
T ₆	FYM + RDF + Brassinosteroid @ 1 ppm	2.79	9.37	46.85	11.20	6.93	3.31
T ₇	FYM + RDF + Brassinosteroid @ 2 ppm	2.77	9.25	46.25	11.15	6.87	3.27
T ₈	FYM + RDF + Brassinosteroid @ 3 ppm	2.73	9.00	45.00	11.01	6.68	3.11
T ₉	FYM + RDF + Micronutrient mixture @ 2%,	2.93	10.25	51.25	11.71	7.57	3.73
T ₁₀	FYM + RDF + Ethrel @ 100 ppm + Micronutrient mixture @ 2%	3.04	10.94	54.70	12.07	7.98	4.04
T ₁₁	FYM + RDF + Ethrel @ 250 ppm + Micronutrient mixture @ 2%,	2.99	10.64	53.20	11.92	7.79	3.92
T ₁₂	FYM + RDF + Ethrel @ 300 ppm + Micronutrient mixture @ 2%,	3.08	11.21	56.05	12.21	8.18	4.15
T ₁₃	FYM + RDF + Brassinosteroid @ 1 ppm + Micronutrient mixture @ 2%,	3.12	11.48	57.40	12.36	8.37	4.26
T ₁₄	FYM + RDF + Brassinosteroid @ 2 ppm + Micronutrient mixture @ 2%	2.97	10.51	52.55	11.85	7.75	3.86
S.Ed		0.10	0.01	–	0.05	0.05	0.03
C.D=0.05		0.22	0.03	-	0.12	0.11	0.08

Author Contributions

K. Sha: Investigation, formal analysis, writing—original draft. R. Sanjai: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

References

Esteras, C., Picó, B., and Nuez, F. (2011). Genetic diversity studies in watermelon (*Citrullus lanatus* (Thunb.) Matsum.). *Plant Genetic Resources* 9(1): 1–8.

- Fageria, N.K., Baligar, V.C. and Clark, R.B. (2009). Micronutrients in crop production. *Adv. Agron.* 77: 185–268.
- Hayat, S. and Ahmad, A. (eds.) (2011). *Brassinosteroids: A class of plant hormone*. Springer, Dordrecht, The Netherlands.
- Marschner, P. (2012). *Marschner's mineral nutrition of higher plants*, 3rd edn. Academic Press, London, UK.
- Perkins-Veazie, P., Collins, J.K., and Pair, S.D. (2012). Watermelon fruit quality. *HortScience* 47(7), 1–5.
- Sathya, S., Pitchai, G. J., & Indirani, R. (2010). Influence of micronutrients on crop growth and yield: A review. *Agricultural Reviews*, 31(2), 159–164
- Taiz, L., Zeiger, E., Møller, I.M., Murphy, A. (2015). *Plant physiology and development*. Sinauer Associates.
- Ullah, A.; Muhammad, I.; Shabir, S.; Khan, A. Effect of brassinosteroids on Zn uptake and metabolism in plants. *Plant Biol.* 2017, 19, 1–7
- Vanlalruati, V., Sindhu, S. S., Anand, P., & Kumar, G. (2019). Effect of micronutrients (Fe and Zn) on flowering and yield attributes of chrysanthemum (*Chrysanthemum morifolium*) cv. *Mayur 5*. *Indian Journal of Agricultural Sciences*, 89(8), 1282–1286.
- Vardhini, B. V., & Rao, S. S. R. (2002). Acceleration of ripening of tomato pericarp discs by brassinosteroids. *Phytochemistry*, 61, 843–847.

How to cite this article:

Sha K. and Sanjai R. 2026. Effect of Micronutrients and Plant Growth Regulators on Growth, Yield and Quality of Watermelon (*Citrullus lanatus* (Thunb.) Matsum.) cv 'Arka Shyama'. *Int.J.Curr.Microbiol.App.Sci.* 15(5): 189-194.
doi: <https://doi.org/10.20546/ijcmas.2026.1505.024>