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INTEGRATED EFFECT OF FOLIAR SPRAY OF PLANT GROWTH REGULATORS AND BIO STIMULATORS ON GROWTH AND FLOWERING OF RIDGE GOURD (*LUFFA ACUTANGULA* L.)

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ABSTRACT

The research entitled "Integrated effect of foliar spray of plant growth regulators and bio stimulants on growth and flowering of ridge gourd (*Luffa acutangula* L.)" was conducted at the Herbal Garden, AC, UAS, Raichur, during the late *kharif* season of 2023-24. Randomized Complete Block Design with thirteen treatments and two replications was employed for the layout of the experiment. The Foliar application of GA_3 @ 100 ppm and humic acid @ 20 ml l^{-1} (T_{10}) significantly increased vine length (562.30 cm), internodal length (13.50 cm), leaf length (15.88 cm), leaf width (23.78 cm), leaf area per vine (38808.77 cm^2), chlorophyll a (3.73 mg g^{-1}), chlorophyll b (1.68 mg g^{-1}) and total chlorophyll (5.41 mg g^{-1}). The foliar application of ethrel @ 200 ppm coupled with humic acid @ 20 ml l^{-1} (T_7) significantly increased the number of branches (17.18), nodes (39.84) and leaves (122.61) per vine, respectively. It also reduced the days to the appearance of the first female flower (31.00 days) and the nodal position (8.41). Therefore, it can be concluded that foliar sprays of plant growth regulators and bio stimulants significantly influence the growth and flowering characteristics of ridge gourd.

Key words : *Kharif* season, Foliar spray, GA_3, Humic Acid, Ethrel.

Introduction

Ridge gourd (*Luffa acutangula* Roxb. L.), belongs to Cucurbitaceae family with 2n=26 chromosomes, is native to tropical Africa and Asia, including India. In India, it is known as turiya, turai, eerakai and dodka in various regional languages.

Among cucurbitaceous, ridge gourd is one of the major vegetables. It is quite rich in vitamins and minerals The edible portion of every 100 g of ridge gourd fruit contains, 0.5 g of protein, 0.5 g of fiber, 0.35 g of carbohydrate, 37 mg of carotene, 5.0 mg of vitamin C, 18 mg of calcium and 0.5 mg of Iron. Seeds of ridge gourd contain 18 to 25% protein and 18.3 to 24.3% oil (Krishnamoorthy and Ananthan, 2017). It contains a gummy compound called "luffein", which has medicinal importance. Fruit is diuretic and nutritious. Its fruits are beneficial for the people, suffering from malaria and other seasonal fever due to its easy digestibility and very appetizing quality.

The use of plant growth regulators and micronutrients at the right stage is crucial for influencing sex expression and yield in ridge gourd (Sircar, 1971). Since yield depends on the number of female flowers and ridge gourd typically produces more staminate than pistillate flowers, regulators like NAA, ethrel and GA_3 are used to improve sex expression and sex ratio (Bose *et al.*, 1999).

Naphthalene acetic acid (NAA) promotes fruit set, prevents drop, induces flowering and boosts yield by synthesizing enzymes for cell and cytoplasmic components (Das and Rabha, 1999). Gibberellins, promotes cell enlargement, encourage bolting and flowering in long days (Prajapati *et al.*, 2015). Ethrel regulates plant height by slowing cell division in shoots without altering morphology (Hilli *et al.*, 2010).

Bio stimulants are natural or synthetic substances applied to soil, plants or seeds that enhance growth by improving resistance to abiotic stress, boosting yield and improving quality. Organic options like humic acid, vermiwash and waste decomposer solution are beneficial in organic farming, being cost-effective, easy to prepare, eco-friendly and reliable for supplementing crop nutrients (Hudda *et al*., 2020).

Humic acid, a key organic bio-stimulant in soil and compost, is used in organic-mineral fertilizers to boost crop production. It can be applied directly to soil or as a foliar treatment. Humic acid enhances plant growth through direct and indirect effects, including improved nutrient transport, protein synthesis, photosynthesis, micronutrient solubilization, reduction of toxic elements, increased microbial activity and better soil structure, cation exchange capacity and water retention (Chen and Aviad, 1990).

Vermiwash, a coelomic fluid from vermicomposting, contains vitamins, nutrients, enzymes and plant growth hormones like cytokinins and gibberellins. It is derived from agricultural residues mixed with cow dung and can enhance crop disease resistance. Its origin, cost-effectiveness, availability and biopesticide properties make vermiwash a promising, eco-friendly soil conditioner for sustainable agricultural biotechnology (Verma *et al*., 2018).

The waste decomposer solution works as a biofertilizer, biocontrol agent and soil health reviver. It enhances the composting of bio-wastes and can be used as a biopesticide in drip irrigation or as a foliar spray to control most plant diseases. It readily makes the nutrients, present in applied organic sources and soil available (Ganvir and Deshmukh, 2022).

Materials and Methods

The experiment was conducted at the Herbal Garden, College of Agriculture, Raichur during late *Kharif* season of 2023-24. Raichur is situated in the North Eastern Dry Zone (Zone-II) of Karnataka at 16°20' North latitude and 77°37' East longitude, at an average altitude of 407 meters above mean sea level (MSL).

The experiment was laid out in Randomized Complete Block Design and comprising of 13 treatment combinations replicated twice. Treatment details were, T_1: Humic acid @ 20 ml l^{-1}, T_2: Vermiwash @ 40 ml l^{-1}, T_3: Waste decomposer solution @ 10 ml l^{-1}, T_4: NAA @ 100 ppm + Humic acid @ 20 ml l^{-1}, T_5: NAA @ 100 ppm + Vermiwash @ 40 ml l^{-1}, T_6: NAA @ 100 ppm + Waste decomposer solution @ 10 ml l^{-1}, T_7: Ethrel @ 200 ppm + Humic acid @ 20 ml l^{-1}, T_8: Ethrel @ 200 ppm + Vermiwash @ 40 ml l^{-1}, T_9: Ethrel @ 200 ppm + Waste decomposer solution @ 10 ml l^{-1}, T_{10}: GA_3 @ 100 ppm + Humic acid @ 20 ml l^{-1}, T_{11}: GA_3 @ 100 ppm + Vermiwash @ 40 ml l^{-1}, T_{12}: GA_3 @ 100 ppm + Waste decomposer solution @ 10 ml l^{-1}, T_{13}: Control.

Observations were recorded on five randomly selected and tagged plants for growth and flowering parameters.

Results and Discussion

Growth parameters

Tables 1 and 2 depicts foliar sprays of plant growth regulators and bio stimulants revealed significant variation in growth parameters. The imposition of treatment T_{10} (GA_3 @ 100 ppm + Humic acid @ 20 ml l^{-1}) resulted in significantly higher vine length (562.30 cm), internodal length (13.50 cm), higher leaf length (15.88 cm), higher leaf width (23.78 cm), higher leaf area per vine (38808.77 cm^2), higher leaf chlorophyll *a* (3.73 mg g^{-1}), leaf chlorophyll *b* (1.68 mg g^{-1}) and total leaf chlorophyll content (5.41 mg g^{-1}). However, T_{13} (Control) was found to be less vigorous, exhibiting vine length (434.60 cm), shortest leaf length (12.54 cm), shortest leaf width (16.61 cm), lower leaf area per vine (17173.70 cm^2), lowest leaf chlorophyll *a* (1.96 mg g^{-1}), leaf chlorophyll *b* (0.69 mg g^{-1}) and total leaf chlorophyll content (2.65 mg g^{-1}). The treatment T_3 (Waste decomposer solution @ 10 ml l^{-1}) exhibited shorter internodal length (11.03 cm).

Gibberellins enhance vine length and internodal length by increasing cell wall plasticity and converting starch to sugars, reducing cell water potential and allowing water uptake for cell enlargement in bottle gourd (Kumari *et al*., 2019). It promotes leaf growth by stimulating cell elongation and division, leading to increased leaf length and width. Which results in larger leaves with improved photosynthesis and nutrient transport, supporting overall plant growth in watermelon (Thakar *et al*., 2021). Nitrogen leads to greater assimilation of food material by plants, resulting in increased meristematic activities of cells and consequently results in maximum leaf area per vine (Shafeek *et al*., 2016 in summer squash). The differences in chlorophyll content due to growth regulators can be ascribed to reduced chlorophyll degradation and enhanced chlorophyll biosynthesis in bitter gourd (Mangal *et al*., 2002).

Foliar spraying of humic acid increases mRNA synthesis linked to hydrolytic enzymes, which may enhance cell division and extend vine and internodal length (Dell' Agnola *et al*., 1981). It boosts leaf length

Table 1 : Integrated effect of foliar spray of plant growth promoters and bio stimulants on growth parameters of ridge gourd.

Treatments	Vine length (cm)	Internodal length (cm)	Stem diameter (cm)	Number of branches per vine	Number of nodes per vine	Number of leaves per vine
T_1	451.05	11.24	1.28	13.21	32.68	96.16
T_2	441.21	11.12	1.23	13.00	31.74	92.00
T_3	437.88	11.03	1.19	12.71	30.26	89.26
T_4	514.85	12.74	2.03	15.12	37.07	102.68
T_5	476.95	12.36	1.89	14.89	36.61	99.40
T_6	459.57	12.15	1.78	14.47	36.14	98.53
T_7	457.90	10.93	1.63	17.18	39.84	122.61
T_8	454.74	11.55	1.52	16.73	38.96	118.17
T_9	446.91	11.78	1.49	16.26	37.64	114.96
T_{10}	562.30	13.50	1.43	16.06	35.87	111.32
T_{11}	524.27	13.21	1.38	15.85	34.75	107.11
T_{12}	490.36	13.04	1.33	15.54	33.87	105.87
T_{13}	434.60	11.96	1.13	12.33	29.63	94.54
Mean	**473.27**	**12.04**	**1.48**	**14.87**	**35.00**	**104.04**
S.Em. ±	**23.70**	**0.52**	**0.09**	**0.95**	**2.13**	**6.26**
C.D. @ 5%	**73.03**	**1.60**	**0.28**	**2.93**	**6.57**	**19.29**

Table 2 : Integrated effect of foliar spray of plant growth promoters and bio stimulants on growth parameters of ridge gourd.

Treatments	Leaf length (cm)	Leaf width (cm)	Leaf area per vine (cm^2)	Chlorophyll a ($mg\ g^{-1}$)	Chlorophyll b ($mg\ g^{-1}$)	Total chlorophyll ($mg\ g^{-1}$)
T_1	13.27	19.03	20601.49	2.43	0.80	3.23
T_2	12.96	18.69	20095.26	2.32	0.76	3.08
T_3	12.71	17.85	17580.73	2.21	0.72	2.93
T_4	14.11	20.37	26436.44	2.84	0.99	3.83
T_5	13.89	20.02	24727.18	2.67	0.92	3.59
T_6	13.64	19.36	23109.24	2.54	0.86	3.40
T_7	15.02	22.21	34408.37	3.21	1.20	4.41
T_8	14.78	21.70	34136.14	3.15	1.12	4.27
T_9	14.52	20.89	31619.29	3.04	1.07	4.11
T_{10}	15.88	23.78	38808.77	3.73	1.68	5.41
T_{11}	15.61	23.37	37291.05	3.62	1.50	5.12
T_{12}	15.34	22.96	35886.31	3.54	1.25	4.79
T_{13}	12.54	16.61	17173.70	1.96	0.69	2.65
Mean	**14.17**	**20.52**	**27836.46**	**2.86**	**1.04**	**3.90**
S.Em. ±	**0.67**	**1.13**	**2779.98**	**0.20**	**0.10**	**0.24**
C.D. @ 5%	**2.07**	**3.50**	**8565.99**	**0.63**	**0.33**	**0.75**

and width by increasing chlorophyll content and promoting hormonal balance. Also, it aids in stress resistance, stimulates cell division and elongation and results in healthier plants with larger leaves (Bhuvaneshwari and Anburani, 2023, in bottle gourd). Humic acid enhances ion absorption, distributes heavy metals as chelates and influences plant metabolic reactions, leading to higher water and mineral consumption in cucumbers. It also impacts respiration and photosynthesis, increasing leaf area (Atiyeh *et al*., 2002) and has beneficial physiological effects, such as enhancing photosynthesis and increasing leaf chlorophyll concentration in cucumbers (Sure *et al*., 2012).

The application of treatment T_7 (Ethrel at 200 ppm + Humic acid at 20 ml l^{-1}) revealed highest number of branches (17.18), number of nodes per vine (39.84) and number of leaves per vine (122.61). However, treatment

Table 3 : Integrated effect of foliar spray of plant growth regulators and bio stimulants on flowering parameters of ridge gourd.

Treatments	Days to first male flower appearance	Days to first female flower appearance	Days to 50 per cent flowering	Node at which first male flower appeared	Node at which first female flower appeared
T_1	30.50	33.50	37.50	5.68	10.00
T_2	31.00	33.50	37.50	5.85	10.26
T_3	31.50	34.00	38.00	5.90	10.51
T_4	28.00	32.00	36.50	4.64	9.35
T_5	28.50	32.00	36.50	4.80	9.45
T_6	28.50	32.50	37.00	5.00	9.45
T_7	29.00	31.00	35.50	5.14	8.41
T_8	29.50	31.50	35.50	5.27	8.73
T_9	30.00	31.50	36.00	5.41	8.94
T_{10}	27.00	32.50	34.50	4.00	9.52
T_{11}	27.50	33.00	35.00	4.29	9.78
T_{12}	27.50	33.00	35.50	4.35	9.85
T_{13}	32.00	34.50	38.50	5.97	10.71
Mean	**29.26**	**32.65**	**36.42**	**5.09**	**9.61**
S.Em. ±	**1.05**	**1.16**	**1.41**	**0.29**	**0.34**
C.D. @ 5%	**3.25**	**3.57**	**4.36**	**0.91**	**1.05**

T_{13} (Control) recorded a lower number of branches (12.33) and number of nodes per vine (29.63). While, the application of treatment T_3 (Waste decomposer solution @ 10 ml l^{-1}) resulted in significantly fewer leaves per vine (89.26).

Increased number of branches may be attributed to ethylene's negative impact on endogenous auxins and gibberellins. Transient exposure to physiological concentrations of ethylene can alter cell fate and enhance cell division propensity thereby promoting more branches (Singh *et al.*, 2023 in ridge gourd). The increase in the number of nodes per vine due to use of ethrel might be attributed to the shortening of internodal distance by inhibiting cell division (Kumar *et al.*, 2020 in bottle gourd). Increase in the number of leaves is may be due to ethylene's negative effect on endogenous production of auxin and gibberellins. Higher ethylene levels reduced vine length but increased branching, leading to more leaves (Pratyksh *et al.*, 2021 in cucumber).

The increased in number of branches may probably due to the rise in chlorophyll, leaf N, P and K content which is caused by humic acid (Meena *et al.*, 2017 in cucumber). Maximum number of nodes per vine is likely a result of increased protoplasm assimilation, which leads to enhanced cell division, tissue development and overall plant vigor. (Ciba *et al.*, 2020 in snake gourd). The increased number of leaves per vine results from enhanced nutrient uptake, improved photosynthesis and stimulated root growth. It also boosts stress tolerance, influences plant hormones and improves water retention, all of which contribute to vigorous vegetative growth (Sayed *et al.*, 2023 in bottle gourd).

The impact of treatment T_4 (NAA @ 100 ppm + Humic acid @ 20 ml l^{-1}) resulted in significantly thicker stem diameter (2.03 cm). The treatment T_{13} (Control) exhibited thinner stem diameter (1.13 cm). NAA activates enzymes that loosen cell walls, promoting expansion and protein synthesis essential for growth. It also, stimulates secondary growth by activating the vascular cambium, directs carbohydrates to the stem and encourages uniform growth and thicker stems in cucumber (Thappa *et al.*, 2011). Humic acid increases stem diameter by enhancing nutrient uptake, stimulating root growth and activating growth hormones like auxins and cytokinins (Ghehsareh and Kalbasi 2012 in cucumber).

Flowering parameters

The application of treatment T_{10} (GA_3 @ 100 ppm + Humic acid @ 20 ml l^{-1}) took significantly lesser days to the first male flower appearance (27 days) and days to 50 per cent flowering (34.50 days) (Table-3). It also resulted effectively in the appearance of first male flower in the very proximal nodes of the vine at 4^{th} node. Whereas, maximum days for first male flower appearance (32.00 days), days to 50 per cent flowering (38.50 days) and first male flower at the higher nodes of the vine at 5.97^{th} node, were revealed in control (T_{13}).

This could be attributed to GA_3's role in inducing maleness in cucurbits and reducing sugars, thereby enhancing metabolic activity in cells, which promotes early flowering. It was effective in increasing the number of flowers produced and promoted the development of both staminate and pistillate flowers, indicating its dual action. Also, it can affect the node at which the first male flower appears, often inducing earlier male flowering at lower nodes (Sabu *et al*., 2022 in bottle gourd).

The application of ethrel @ 200 ppm coupled with humic acid @ 20 ml l^{-1} (T_7) significantly reduced the days to the appearance of the first female flower (31.00 days) and the nodal position (8.41). In contrast, the control treatment (T_{13}) resulted in the late female flower appearance (34.50 days) and the highest nodal position (10.71).

It is evident that foliar application of ethrel suppressed male flowers during the entire reproductive phase. The suppression of male flowers by ethrel is attributed to the reduction in endogenous production of gibberellins during differentiation and the alteration of the proportion of gibberellins to auxins. This gradually leads to the suppression of male flower production and the induction of more female flowers (Ansari and Chowdhary, 2018).

Conclusion

Foliar sprays of plant growth regulators and bio stimulants significantly influence the growth and flowering parameters of ridge gourd. Applying a combined foliar spray of ethrel at 200 ppm and humic acid at 20 ml l^{-1} on ridge gourd increased the number of branches, nodes per vine and leaves per vine. Ethrel, by enhancing ethylene production, promotes early flowering and induces the rapid development of female flowers, resulting in earlier days to first female flower appearance and the node at which the first female flower appeared.

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