STUDY ON THE SYNERGISTIC EFFECTS OF PLANT GROWTH REGULATORS AND BIOSTIMULANTS ON FLOWERING AND YIELD OF RIDGE GOURD (*Luffa acutangula* L.)

ABSTRACT

The study explored the effects of plant growth regulators and bio stimulants on ridge gourd (*Luffa acutangula* L.) flowering and yield. Experiment was conducted at the Herbal Garden, College of Agriculture, Raichur, during the late *kharif* season (2023-24). The experiment was designed using a Randomized Complete Block Design with thirteen treatments and two replications. Among the treatments, a foliar spray of ethrel at 200 ppm combined with humic acid at 20 ml l^{-1} significantly enhanced various flowering parameters. This treatment resulted in a decrease in the number of male flowers per vine (107.36), while the number of female flowers per vine (27.53) increased. The sex ratio reduced to 3.90 and the fruit set percentage improved to 75.97%. Also, it led to increases in fruit length (35.57 cm), fruit diameter (3.73 cm), fruit weight (0.143 kg), fruit yield per vine (2.78 kg) and fruit yield per hectare (26.77 t). These findings suggest that using ethrel and humic acid together can be a practical strategy for boosting ridge gourd production, which can be beneficial for both sustainable farming practices.

KEYWORDS: Luffa acutangula L., bio stimulants, flowering parameters, treatment

Introduction

Ridge gourd (*Luffa acutangula* Roxb. L.), belongs to Cucurbitaceae family with 2n=26 chromosomes, is native to tropical Africa and Asia, including India. Its immature green fruits are commercially important as vegetables, used in curries and chutneys, while the fiber from mature fruits serves as bath sponges.

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, synthesized in young shoots, roots, and seeds, promote cell enlargement, break seed dormancy, stimulate alpha-amylase in germinating grains, encourage bolting and flowering in long days, induce maleness in dioecious flowers, and aid in seedless fruit development (Prajapati *et al*., 2015). Ethrel regulates plant height by slowing cell division in shoots without altering morphology (Hilli *et al*., 2010). It releases ethylene, enhancing female flowering and fruit yield in cucurbits (Patel *et al*., 2017). Ethrel also promotes gynoecium development, fruit ripening and early flowering, increasing femaleness at lower concentrations (Farhana, 2015).

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).

Material and Methods

The experiment was conducted during late *Kharif* season of 2023-24 in the fields of Herbal Garden, College of Agriculture, Raichur, University of Agricultural Sciences (UAS), 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). An average rainfall of 621 mm distributed throughout the season. The soil of the experimental site was red loam to clay loam.

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 flowering and yield parameters.

Results and Discussion

Flowering parameters

It is evident from Table 1 that the least number of male flowers per vine (107.36) and sex ratio (3.90), highest number of female flowers per vine (27.53) and fruit set percentage (75.97 %) were revealed in ethrel @ 200 ppm coupled with humic acid @ 20 ml l^{-1} (T_7). Whereas, highest number of male flowers per vine (220.34) and sex ratio (9.89), were resulted in GA_3 @ 100 ppm coupled with waste decomposer solution @ 10 ml l^{-1}. The lowest number of female flowers per vine (20.91) observed in control (T_{13}) and minimum fruit set percentage (66.47 %) was revealed with the application of vermiwash @ 40 ml l^{-1} (T_2).

The maximum number of female flowers per vine was noticed due to the application of ethrel may be attributed to its effect on endogenous auxin levels, which promote flowering primordia and act as an anti-gibberellin during flowering. This anti-gibberellin effect reduces the number of staminate flowers and increases the number of pistillate flowers (Pandey *et al*., 2019). A lower number of male flowers and a higher number of female flowers significantly enhance the yield of ridge gourd. Female flowers are directly responsible for fruit production, so an increased number of female flowers enhances potential fruit set. This optimal ratio ensures efficient pollination, as fewer male flowers are needed for sufficient pollen supply, and more resources are directed towards fruit development.

The foliar application of ethrel from an external source changed the sex ratio and flowering sequence in cucurbits by enhancing female flower production and suppressing male flower production consequently lowering the overall sex ratio. This phenomenon might be linked to the slowdown of starch digestion, transpiration and respiration in plant tissues after spray of ethrel. These findings are consistent with those reported by Thakar *et al*. (2021) in watermelon and Impana *et al.* (2024) in bitter gourd. The fruit set percentage in ridge gourd by encouraging the production of female flowers, improving ethylene regulation, increasing pollination efficiency and synchronizing the flowering period, all of which result in a higher ratio of successful pollinations and fruit development (Jyoti *et al*., 2016).

Humic acid improves nutrient availability and hormonal balance, accelerating male and female flower development. It enhances nutrient solubility, optimizes hormone levels, and promotes earlier, synchronized flowering, leading to higher fruit set and a better sex ratio. These results confirm with findings reported by Hamail *et al.* (2014) in cucumber and El-Gazzar *et al*. (2020) in watermelon.

Table 1. Impact of foliar sprays of plant growth regulators and bio stimulants on number of male and female flowers per vine, sex ratio and fruit set percentage of ridge gourd.

Treatments	Number of male flowers per vine	Number of female flowers per vine	Sex ratio (male: female)	Fruit set percentage (%)
T_1	191.35	21.96	8.71	67.66
T_2	186.66	21.54	8.67	66.47
T_3	182.76	21.12	8.65	67.11
T_4	148.46	25.48	5.83	68.08
T_5	160.73	25.03	6.42	67.07
T_6	176.05	24.55	7.17	67.51
T_7	107.36	27.53	3.90	75.97
T_8	120.71	26.97	4.48	70.71
T_9	124.76	25.14	4.96	70.16
T_{10}	199.85	24.01	8.32	67.30
T_{11}	203.98	23.28	8.76	67.53
T_{12}	220.34	22.28	9.89	67.17
T_{13}	182.02	20.91	8.70	66.88
Mean	**169.61**	**23.82**	**7.26**	**68.42**
S.Em. ±	**6.38**	**0.93**	**0.41**	**2.19**
C.D. @ 5%	**3.25**	**3.57**	**4.36**	**0.91**

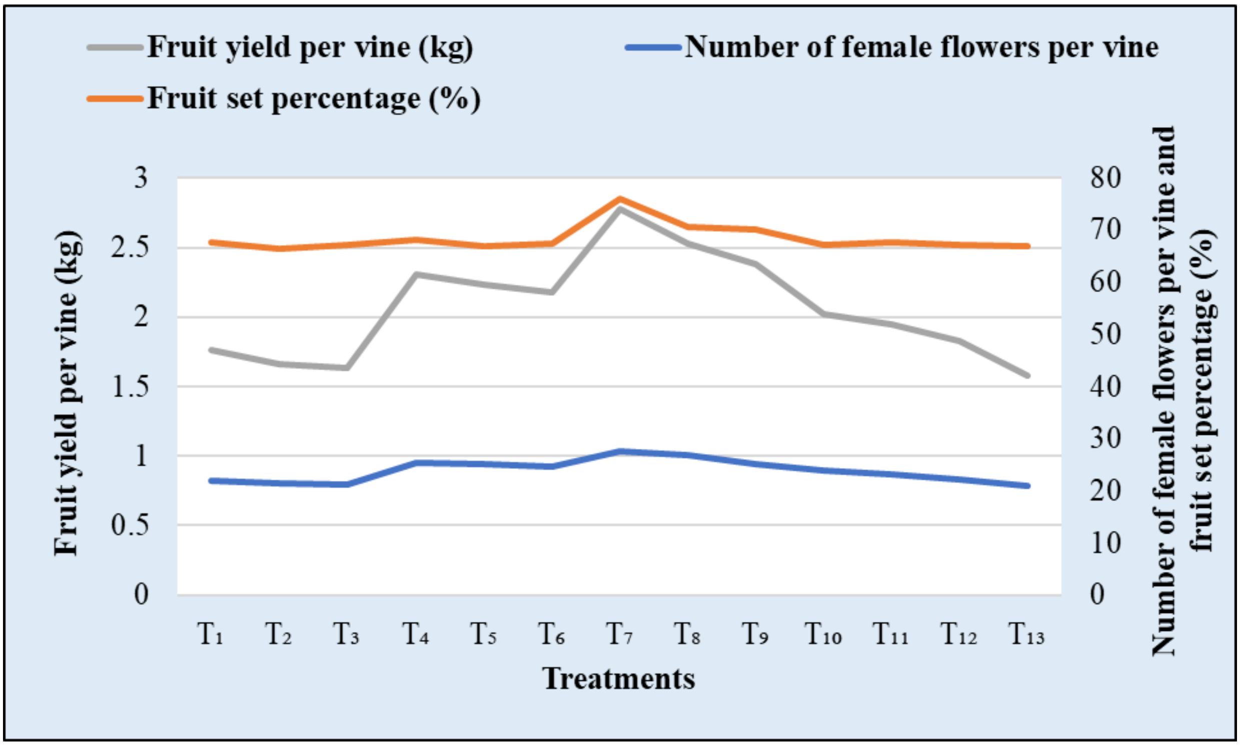

Fig. 1. Synergistic effects of plant growth regulators and bio stimulants on number of female flowers per vine, fruit set percentage and fruit yield per vine of ridge gourd

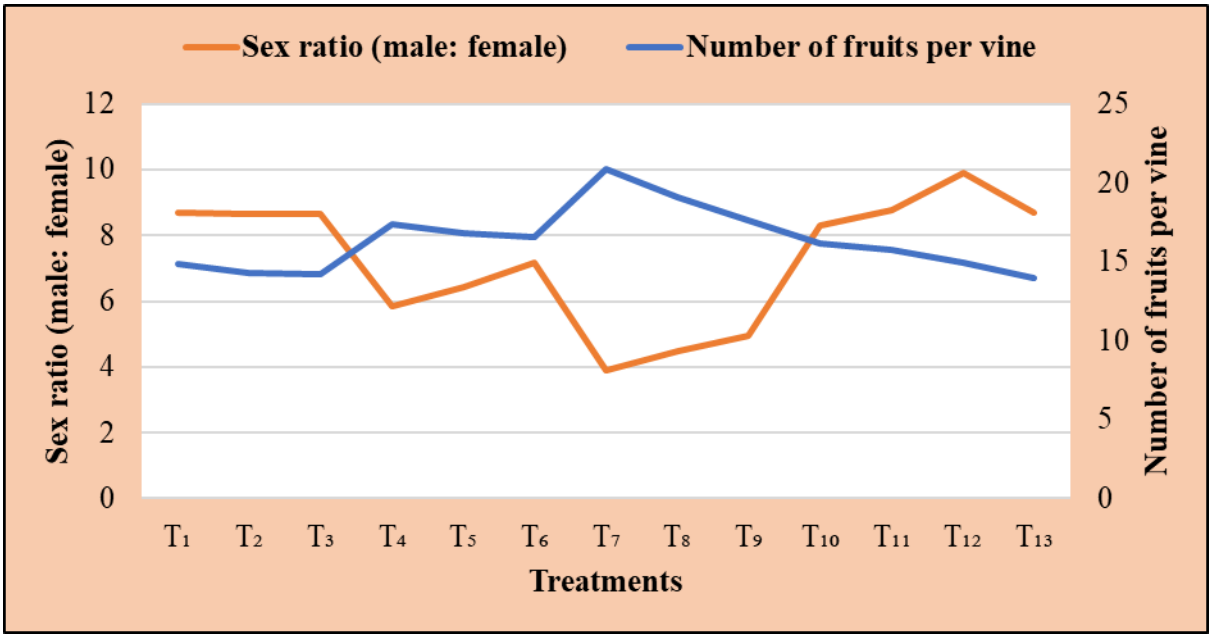

Fig. 2. Synergistic effects of plant growth regulators and bio stimulants on sex ratio and number of fruits per vine of ridge gourd

Yield parameters

Table 2 depicts foliar application of ethrel @ 200 ppm coupled with humic acid @ 20 ml l^{-1} (T_7) emerged with longest fruits (35.57 cm), thickest fruits diameter (3.73 cm), heaviest fruits (0.143 kg), higher number of fruits per vine (20.91 fruits), fruit yield per vine (2.78 kg) and fruit yield per hectare (26.77 t). The response of the treatment control was found to be the lowest among all the treatments with fruit length (28.40 cm), fruit diameter (2.92 cm), fruit weight (0.115 kg), number of fruits per vine (14.00 fruits), fruit yield per vine (1.58 kg) and fruit yield per hectare (15.75 t).

Ethrel enhances fruit length by supporting protein synthesis and gene expression (mRNA) during fruit development, accelerating fruit growth. Its beneficial effect on fruit diameter is due to increased endogenous auxin levels, which promote cell enlargement and metabolic activity, leading to greater fruit girth. The increase in fruit weight likely results from enhanced photosynthetic activity, which builds up sufficient food reserves, accelerates transport and efficiently utilizes photosynthetic products, promoting the development of more female flowers and fruits (Meena *et al*., 2017).

The increased number of fruits per vine with application of ethrel treatment may be attributed to the formation of more branches, which in turn produce a higher number of pistillate flowers and ultimately result in a greater fruit set in ridge gourd (Arora *et al*., 1987). The maximum number of fruits per vine, heavier fruit weight and maximum fruit yield per vine may have resulted from the crop being sprayed with ethrel at a concentration of 200 ppm. Ethrel have exhibited higher fruit yields per vine and per hectare due to enhanced physiological activation, which provides sufficient nutrients for flower and fruit development (Singh *et al*., 2023). Humic acid increases fruit length, diameter, weight and yield in cucumber by enhancing plant metabolism, photosynthesis and chlorophyll concentration. These findings are consistent with studies by Esho and Saeed (2017) in summer squash and Meena *et al*. (2017) in cucumber.

Table 2. Impact of foliar sprays of plant growth regulators and bio stimulants on fruit yield and its attributes.

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Number of fruits per vine	Fruit yield per vine (kg)	Fruit yield per hectare (t)
T_1	29.56	3.11	0.123	14.85	1.76	17.54
T_2	29.20	3.08	0.120	14.31	1.66	16.53
T_3	28.83	3.04	0.118	14.18	1.63	16.23
T_4	33.60	3.53	0.138	17.34	2.31	23.08
T_5	32.31	3.32	0.135	16.78	2.23	22.28
T_6	31.26	3.22	0.134	16.57	2.18	21.73
T_7	35.57	3.73	0.143	20.91	2.78	26.77
T_8	34.77	3.69	0.141	19.06	2.53	25.23
T_9	33.75	3.64	0.139	17.63	2.38	23.76
T_{10}	31.16	3.19	0.131	16.15	2.02	20.18
T_{11}	30.91	3.17	0.129	15.73	1.95	19.48
T_{12}	30.56	3.15	0.126	14.96	1.83	18.20
T_{13}	28.40	2.92	0.115	14.00	1.58	15.75
Mean	**31.52**	**3.29**	**0.129**	**16.34**	**2.06**	**20.51**
S.Em. ±	**1.41**	**0.16**	**0.005**	**0.61**	**0.10**	**1.36**

C.D. @ 5%	**4.35**	**0.50**	**0.017**	**1.88**	**0.32**	**4.21**

Conclusion

Foliar sprays of plant growth regulators and bio stimulants significantly influence flowering and yield of ridge gourd. Applying a combined foliar spray of ethrel at 200 ppm and humic acid at 20 ml l^{-1} can help achieve higher yields.

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Disclaimer (Artificial intelligence)

Author hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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