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Impact of GA_3, NAA and Ethrel on growth, flowering and sex expression of ridge gourd (*Luffa acutangula* L.) cv. GRG-2

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Abstract
The experiment entitled "Impact of GA_3, NAA and Ethrel on growth, flowering and sex expression of ridge gourd (*Luffa acutangula* L.) cv. GRG-2" was conducted at Instructional farm Jambuvadi, JAU., Junagadh. during summer, 2024. The study was conducted in Randomized Block Design with three replications. There was total ten treatments, i.e., NAA 70 ppm (T_1), NAA 85 ppm (T_2), NAA 100 ppm (T_3), GA_3 30 ppm (T_4), GA_3 45 ppm (T_5), GA_3 60 ppm (T_6), Ethrel 100 ppm (T_7), Ethrel 150 ppm (T_8), Ethrel 200 ppm (T_9) and control (T_{10}). The experimental result revealed that the GA_3 60 ppm (T_6) gave maximum main vine length at final harvest (4.25 m), leaf area index (2.19), minimum days taken to first male flower (34.27). Whereas, Ethrel 200 ppm (T_9) gave maximum number of primary branches at harvest (6.78), minimum days taken to first female flower (39.27), minimum number of male flowers per plant (124.87), maximum number of female flowers per plant (26.78), lowest sex ratio (4.68) and minimum number of days taken from fruit set to edible maturity (6.12).

Keywords: Ridge gourd, GA_3, NAA, Ethrel, ppm, Growth, Flowering, Sex expression

Introduction
Luffa acutangula L., commonly known as ridge gourd, is a cross-pollinated diploid crop (2n=26) native to India. It is classified under the Cucurbitaceae family, which encompasses 118 genera and approximately 825 species, representing about 5.6% of India's total vegetable production. Ridge gourd exhibits a climbing or trailing growth habit and shows extensive morphological variation in fruit shape and size. Although primarily cultivated as a summer vegetable, it is grown year-round in the northeastern regions of India. The genus name is derived from the fibrous "loofah" product obtained from mature fruits, widely used in personal care and household cleaning applications such as sponges, scrubbers, mats, and pillows. Ridge gourd is known to have originated in India and is cultivated in the tropics and sub-tropics for its tender edible fruits both on commercial scale and in kitchen gardens throughout the country and in some parts of Indonesia, Myanmar, Malaysia, Philippines, Sri Lanka and Taiwan (Karthick *et al.*, 2017) [9].

The external application of plant growth regulators (PGRs) such as GA3, NAA, and Ethrel at the two to four-leaf stage a critical period for influencing the promotion or suppression of floral sex can alter the sex ratio and flowering sequence in ridge gourd. In cucurbits, PGRs affect a diverse range of floral morphologies, including staminate (male), pistillate (female), and hermaphrodite flowers, which occur in various arrangements and result in different sexual expressions. Among these regulators, Ethrel has proven particularly effective in inducing early female flower formation at the lower nodes. Additionally, GA3, NAA, and Ethrel are used to regulate vegetative growth in cucurbit plants, allowing for increased plant density per unit area and thus potentially boosting yield (Latimer, 1991) [13]. Applying these growth regulators at the appropriate developmental stage plays a significant role in modifying sex expression and enhancing yield in ridge gourd. Sex expression and the ratio of male to female flowers are crucial factors that influence yield in cucurbits. Ridge gourd is a monoecious plant with a highly variable male-to-female flower ratio. Generally, male flowers outnumber female flowers, with early nodes bearing predominantly male flowers while pistillate and hermaphrodite flowers are found at later nodes. This uneven distribution often results in delayed harvesting and lower yields.

However, this issue can be mitigated by the exogenous application of PGRs, which shifts the balance in favor of pistillate flowers. Since female flowers continue to appear until the final harvest, increasing their numbers directly improves fruit set and productivity. Therefore, the use of GA3, NAA, and Ethrel is important for manipulating sex expression and sex ratio in ridge gourd, ultimately leading to higher yields. To investigate these effects, the present experiment was conducted with the following objective:

1. To study the effect of GA_3, NAA and Ethrel on growth, flowering and sex expression in ridge gourd

2. Materials and Methods

The present investigation was conducted to know impact of GA_3, NAA and Ethrel on growth, flowering and sex expression of ridge gourd (*Luffa acutangula* L.) cv. GRG-2. The experiment was conducted at Instructional farm Jambuvadi, Dept. of Vegetable Science, COH, JAU., Junagadh. during summer, 2024. Seeds of ridge gourd variety (Gujarat Ridge Gourd-2) was collected from vegetable research station, JAU, Junagadh. The study was conducted in Randomized Block Design with three replications. There was total ten treatments, i.e., NAA 70 ppm (T_1), NAA 85 ppm (T_2), NAA 100 ppm (T_3), GA_3 30 ppm (T_4), GA_3 45 ppm (T_5), GA_3 60 ppm (T_6), Ethrel 100 ppm (T_7), Ethrel 150 ppm (T_8), Ethrel 200 ppm (T_9) and control (T_{10}). Foliar application of plant growth regulators given during evening. Spraying of plant growth regulators were done as per the treatments at 2-4 leaf stage of plant. Both the surface of leaves and whole plant fully moistened. Spraying was done with the plastic hand sprayer.

3. Results and Discussions

3.1 Effect on growth parameters: Maximum length of main vine at final harvest (4.25 m) was observed under treatment T_6 (GA_3 60 ppm). Whereas, minimum length of main vine at final harvest (3.51 m) was recorded in T_{10} (Control). The application of GA_3 in ridge gourd appears to enhance vine length, likely due to accelerated internodal growth driven by increased cell division and elongation, as suggested by Krishnamoorthy and Sandooja (1981). Similar trends have been observed in other cucurbits, including bottle gourd (Ansari and Chaudhary, 2018; Kumari et al., 2019) [2, 12] and cucumber (Kadi *et al*., 2018) [8], supporting these findings.

Maximum no. of primary branches at harvest (6.78) was observed under treatment T_9 (Ethrel 200 ppm). Whereas, minimum no. of primary branches (3.71) was recorded in T_{10} (Control). The positive influence of Ethrel on the number of primary branches per vine in ridge gourd may be attributed to its inhibitory effect on auxin activity, which normally promotes apical dominance and suppresses the growth of lateral buds. These findings are in close agreement with those of Kumari *et al*. (2019) [12], who observed reduced vine length and increased branching in bottle gourd with the application of Ethrel at 200 ppm. Similar outcomes were reported by Chaurasiya et al. (2016) [4] in muskmelon, where Ethrel at 200 ppm decreased vine length but enhanced branching. Additionally, Hill *et al*. (2010) [6] recorded the highest number of branches per vine in ridge gourd with the application of Ethrel at 500 ppm.

Maximum leaf area index (2.19) was observed under treatment T_6 (GA_3 60 ppm). Whereas, lower leaf area index (1.40) was recorded in T_{10} (Control). The positive effect of GA_3 on leaf area index can primarily be attributed to enhanced cell division through mitosis and increased cell elongation. These physiological processes contribute to greater cell size and length, ultimately leading to increased vine length, a higher number of leaves per plant, and expanded leaf area. Similar results were reported by Shafeek *et al*. (2016) [15] in squash, Chaurasiya *et al*. (2016) [4] in muskmelon, Murthy *et al*. (2007) [14] in gherkins, and Ansari and Chowdhary (2018) [2] in bottle gourd.

3.2 Effect on flowering parameters: Minimum days taken to opening first male flower (34.27) was observed under treatment T_6 (GA_3 60 ppm). Whereas, maximum days taken to opening first male flower (42.07) was recorded in T_{10} (Control). The number of days for the initiation of first male flower were reduced because of GA_3. This might be due to the action of GA_3 which induces maleness in cucurbits. These findings are in accordance with the results of Hossain *et al.* (2006) in bitter gourd.

Minimum days taken to opening first female flower (39.27) was observed under treatment T_9 (Ethrel 200 ppm). Whereas, maximum days taken to opening first female flower (47.13) was recorded in T_{10} (Control). The application of ethrel significantly reduced the number of days to appearance of first female flower. The early emergence of female flowers following Ethrel application may be attributed to its role in enhancing starch and carbohydrate accumulation, which supports floral development (Singh, 1982). These findings are consistent with those reported by Chaurasiya *et al*. (2016) [4] in muskmelon, as well as Ansari and Chowdhary (2018) [2] and Kumari *et al*. (2019) [12] in bottle gourd.

Minimum number of male flowers per plant (124.87) was observed under treatment T_9 (Ethrel 200 ppm). Whereas, maximum number of male flowers per plant (150.35) was recorded in T_6 (GA_3 60 ppm). The suppression of male flower formation by Ethrel is likely due to its role in reducing the endogenous production of gibberellins during floral differentiation, as well as its influence on altering the gibberellin-to-auxin ratio. This hormonal imbalance tends to inhibit male flower development while promoting the emergence of female flowers, particularly when Ethrel is applied at the 2-4 leaf stage, which is considered critical for modifying sex expression. These findings align with those of Hilli *et al*. (2010) [6] in ridge gourd and Ansari and Chowdhary (2018) [2] in bottle gourd.

Maximum number of female flowers per plant (26.78) was observed under treatment T_9 (Ethrel 200 ppm). Whereas, minimum number of female flowers per plant (14.55) was recorded in T_{10} (Control). The early flowering and increased production of female flowers and fruit set in plants treated with Ethrel may be attributed to the accumulation of high carbohydrate reserves following foliar application (Sulochanamma, 2001) [16]. These observations agree with the findings of Ghani *et al.* (2013). Additionally, the exogenous application of plant growth regulators has the potential to modify the sex ratio and flowering pattern, especially when applied during the 2-4 leaf stage recognized as a critical period for the hormonal regulation of floral sex expression.

3.3 Effect on sex expression: Lowest sex ratio (4.68) was observed under treatment T_9 (Ethrel 200 ppm). Whereas, highest sex ratio (Male: Female) (9.88) was recorded in T_{10}

(Control). The exogenous application of Ethrel appears to influence the sex ratio and flowering sequence in cucurbits by enhancing female flower development while suppressing male flower formation. This effect may be linked to Ethrel's role in slowing down physiological processes such as starch breakdown, transpiration, and respiration in plant tissues. These results align with the findings of Shafeek *et al.* (2016) [15] in ridge gourd and Kadi *et al.* (2018) [8] in cucumber. Since sex differentiation in cucurbits occurs early in the plant's development specifically at the 2-4 leaf stage the application of plant growth regulators during this critical window can effectively influence floral development. At this stage, floral primordia (whether male or female) can be chemically suppressed or promoted through foliar application of hormones. This observation is consistent with the findings of Choudhary and Phaldak (2002).

Minimum number of days taken from fruit set to edible maturity (6.12) was observed under treatment T_9 (Ethrel 200 ppm). Whereas, maximum number of days taken from fruit set to edible maturity (9.28) was recorded in T_{10} (Control). The advancement of fruit maturity may be attributed to the role of ethylene in accelerating fruit ripening, likely due to its senescence-inducing effects on plant tissues (Sureshkumar *et al*., 2016) [17]. Comparable findings were reported by Gedam *et al*. (1998) [5] in bitter gourd.

Table 1: Impact of GA_3, NAA and Ethrel on growth of ridge gourd cv. GRG-2

Treatment no	Concentration	Main vine length (m)	Primary branches	Leaf area index
T_1	NAA 70 ppm	3.66	4.46	1.67
T_2	NAA 85 ppm	3.70	4.74	1.79
T_3	NAA 100 ppm	3.75	5.15	1.91
T_4	GA_3 30 ppm	3.99	4.94	1.86
T_5	GA_3 45 ppm	4.20	5.86	2.03
T_6	GA_3 60 ppm	4.25	6.02	2.19
T_7	Ethrel 100 ppm	3.61	5.87	1.71
T_8	Ethrel 150 ppm	3.63	6.29	1.70
T_9	Ethrel 200 ppm	3.65	6.78	1.68
T_{10}	Control	3.51	3.71	1.40
S.E.M.±		0.163	0.242	0.071
C.D. at 5%		0.48	0.72	0.21
C.V.%		7.42	7.79	6.81

Table 2: Impact of GA_3, NAA and Ethrel on flowering of ridge gourd cv. GRG-2

Treatment no	Concentration	Days to first male flower	Days to first female flower	No. of male flowers/plant	No of female flowers/plant
T_1	NAA 70 ppm	42.32	46.75	129.83	17.92
T_2	NAA 85 ppm	41.92	46.11	131.80	18.74
T_3	NAA 100 ppm	40.87	45.80	134.13	19.77
T_4	GA_3 30 ppm	38.76	44.91	141.55	18.29
T_5	GA_3 45 ppm	35.88	44.43	144.57	20.65
T_6	GA_3 60 ppm	34.27	43.54	150.35	16.66
T_7	Ethrel 100 ppm	39.88	42.59	129.62	21.71
T_8	Ethrel 150 ppm	37.95	40.75	127.48	24.97
T_9	Ethrel 200 ppm	36.81	39.27	124.87	26.78
T_{10}	Control	42.07	47.13	143.84	14.55
S.E.M.±		1.455	1.662	5.027	0.851
C.D. at 5%		4.32	4.94	14.94	2.53
C.V.%		6.45	6.52	6.41	7.36

Table 3: Impact of GA_3, NAA and Ethrel on sex expression of ridge gourd cv. GRG-2

Treatment no	Concentration	Sex ratio (Male: Female)	Days from fruit set to edible maturity
T_1	NAA 70 ppm	7.29	9.07
T_2	NAA 85 ppm	7.03	8.18
T_3	NAA 100 ppm	6.80	7.53
T_4	GA_3 30 ppm	7.72	7.85
T_5	GA_3 45 ppm	7.03	7.28
T_6	GA_3 60 ppm	9.03	7.27
T_7	Ethrel 100 ppm	5.98	7.03
T_8	Ethrel 150 ppm	5.15	6.71
T_9	Ethrel 200 ppm	4.68	6.12
T_{10}	Control	9.88	9.28
S.E.M.±		0.400	0.369
C.D. at 5%		1.19	1.10
C.V.%		9.8	8.37

4. Conclusion

Based on the experimental findings, it is evident that different treatments had significant effects on growth, flowering, and sex expression. The foliar application of GA_3 at 60 ppm during the 2-4 leaf stage proved to be the most effective for enhancing growth parameters. In contrast, applying Ethrel at 200 ppm during the same stage was most beneficial for promoting the development of female flowers and modifying the sex ratio in ridge gourd.

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