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Studies on synchronization of flowering in parental lines of RCRMH-4 maize hybrid

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Abstract
A field experiment was carried out to study the effect of foliar application of growth regulators, nutrients and fertilizers on synchronization and seed yield of maize hybrid (RCRMH-4) at Agricultural Research Station, Bheemarayanagudi during *Rabi* 2022-23. The experiment was laid out in a Randomized block design with fifteen treatments including control which were replicated thrice. The results revealed that, among the various treatments applied in the study, the male line treated with foliar spray of amino acid @ 2 mL L^{-1} + GA_3 @ 250 ppm + potash @ 5 per cent + urea @ 2 per cent recorded higher plant height of male parent (180.22 cm) and the synchronization of 50 per cent flowering between two parents has been reduced by 4-5 days to 1.19 days. Also, significantly higher cob length (13.68 cm), cob diameter (3.42 cm), cob weight per plant (75.62 g), hundred seed weight (30.77 g) and Seed yield (31.55 q/ha) has been recorded. The sowing of male and female parent on the same day (Control) was registered lowest values for the entire seed yield and its components.

Keywords: Plant height, 50% tasseling, 50% silking, synchronization, seed yield

Introduction
Maize (*Zea mays* L.) is the most versatile crop among cereals with respect to its adaptability, types and uses. It is the second most widely grown crop in the world after wheat crop and cultivated in tropics, sub-tropics to temperate climate and has several types like field corn, sweet corn, popcorn, and baby corn. Globally maize occupies an area of 197 million ha, with the production of 1210.7 million tonnes and productivity of 5.75 t/ha. In India maize growing area accounts for 9.95 million ha, with the production of 33.72 million tonnes and productivity of 3.38 t/ha (Anon., 2022) [2]. For successful adaption of the single cross hybrid technology in maize, the seed production technology should be feasible and viable on commercial basis. For successful hybrid seed production, synchrony in flowering of pollen and seed parent is very important. Non synchrony in flowering between parental lines results in very poor hybrid seed yields. This may be due to inherent genetic factors or climatic variations during the crop growth period. This problem is generally tackled by adjusting the sowing dates of parental lines. However, under situations where staggered sowing of parental lines is not possible, application of fertilizers, hydration treatments to seeds of late flowering parents *etc*., are being practiced to bridge the gap in flowering between the parental lines. Incessant rise in ambient temperature is threatening the sustainability of maize productions, worldwide. Heat stress resilience has emerged as an important trait in maize hybrids. Hybrid maize RCRMH series were developed by University of Agricultural Sciences Raichur in collaboration with the CIMMYT-Asia, Hyderabad. Maize hybrid RCRMH-4 was found to have superior grain yield and were highly adaptive to a diverse range of environments. It has parentage of CAL-1426 being female and CML-451 being male parent. The seed and pollen parents of RCRMH-4 have a difference of 4-5 days in flowering. In which the male parent CML-451 is late maturing. Synchronisation of flowering between parental lines can be achieved through manipulation of nutrients and cultural practices. Keeping this in view, the present study was carried out on effect of synchronisation techniques on flowering of the parental lines of single cross maize hybrid RCRMH-4.

Materials and Methods

A field experiment was conducted during *Rabi* 2022 at Agricultural Research Station, Bheemarayanagudi, UAS, Raichur, Karnataka (16º 73´N, 76º 78´ E, altitude 428 m). The soil of the experimental site belongs to *Vertisols* (medium black soil). The experimental material comprises seeds of male (CML 451) and female (CAL 1426) parental lines. The experiment was laid out in Randomized Complete Block Design (RCBD) with fifteen treatments *viz.* T_1: Sowing male and female parent on the same day (Control), T_2: Sowing of female parent after 5 days sowing of male parent. (Recommended practice), T_3: T_1+ Foliar spray of nano urea @ 4 ml L^{-1} to male parent, T_4: T_1+ Foliar spray of seaweed extract @ 4 ml L^{-1} to male parent, T_5: T_1+ Foliar spray of urea 2 per cent to male parent, T_6: T_1 + Foliar spray of tryptophan 150 ppm to male parent, T_7: T_1 + Foliar spray of lysine 150 ppm to male parent, T_8: T_1+ Foliar spray of nano DAP @ 2 ml L^{-1} to male parent, T_9: T_1 + Foliar spray of lithovit @ 0.5 g L^{-1} to male parent, T_{10}: T_1 + Foliar spray of lysine 150 ppm and tryptophan 150 ppm to male parent, T_{11}: T_1 + Foliar spray of lithovit @ 0.5 g L^{-1} and seaweed extract @ 4 ml L^{-1} to male parent, T_{12}: T_1 + Foliar spray of lysine and tryptophan 150 ppm + seaweed extract @ 4 ml L^{-1} to male parent, T_{13}: T_1 + Foliar spray of lithovit @ 0.5 g L^{-1} + tryptophan 150 ppm and lysine 150 ppm + nano DAP @ 2 ml L^{-1} to male parent, T_{14}: T_1 + Foliar spray of zinc 0.5 per cent and boron 0.5 per cent to male parent and T_{15}: T_1+ Foliar spray of amino acid @ 2 mL L^{-1} + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent. The observations were recorded on plant height of male parent (CML 451) at different growth stages, days to 50% tasseling of male parent and days to 50% silking of female parent (CAL 1426) and yield parameters cob length, cob diameter, cob weight, 100 seed weight and seed yield. The data collected from experiment was analyzed statistically by the procedure prescribed by Sundararajan *et al.* (1972) [17].

Results and Discussion

The plant height of male parent (CML 451) at 60 DAS and at harvest was recorded highest (145.43 cm and 180.22 cm respectively) due to foliar spray of amino acid @ 2 mL L^{-1} + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent (T_{15}) (Table.1). Whereas, the lowest plant height was observed in absolute control (136.42 cm and 165.46 cm respectively).

The higher plant height may be due to foliar spray of amino acids provide organic materials like L-amino acids. These L-amino acids contain organic nitrogen, once amino acid enters inside the plant system; the organic nitrogen is released and used by the plant. Also, stomata openings are controlled by external and internal factors like amino acids, available potassium etc. The application of GA_3 might have increased translocation of assimilates to the vegetative organ which resulted in the increased of plant height (Khadija *et al*., 2013, Pepi *et al*., 2014) [8, 13]. The results of the present study were similar to the findings of El-Zohiri and Asfour (2009) [7] in potato, Wang *et al.* (2019) [21] in cowpea. Ramesh *et al*. (2019) [15] in rice.

The significant difference was observed for the days to 50 per cent tasseling in male parent (CML 451) due to different foliar sprays (Table.1). Whereas, days 50 per cent silking in female parent (CAL 1426) has observed no significant differences due to no foliar spray. Number of days to 50% tassel emergence vary significantly due to treatments imposed on male parent (CML 451). However, the treatment T_{15} (T_1+ Foliar spray of amino acid @ 2 mL L^{-1} + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent) has taken lesser number of days for 50% tassel emergence (61.71 days) when compared to sowing male and female parent on the same day (Control) *i.e.*, T_1 (66.44 days) (Figure 1). The difference of tassel emergence in pollen parent and silk emergence in female parent was maximum in T_1(Sowing male and female parent on the same day) (5.22 days) and minimum (1.19 days) in T_{15} (T_1+ Foliar spray of amino acid @ 2 ml L^{-1} + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent). T_{15} helps in bridging the gap when compared to other treatments.

In the present investigation, even though complete synchronization of flowering was not achieved by foliar spray of amino acid @ 2 ml/l + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent, but gap has been reduced to (1.19 days) for 50 per cent flowering between two parents in T_{15} by reduction of 3.81 days which is on par with T_{13} (Foliar spray of lithovit @ 0.5 g L^{-1} + tryptophan 150 ppm and lysine 150 ppm + nano DAP @ 2 ml L^{-1} to male parent). The early flowering in treatment T_{15} (amino acid @ 2 ml/l + GA_3 250 ppm + potash 5 per cent + urea 2 per cent + T_1) might be due to gibberllic acids, which regulates nutrient transport, induces stem elongation and increases dry matter production leaf area expansion and flowering (Khan and Samiullah, 2003, Shah *et al*., 2006) [9, 16], gibberllic acid also activates amylase enzyme that degrades starch into sugars and promotes flowering early (Kucera *et al.*, 2005) [11]. Adequate supply of potassium can enhance all the growth attributes of crop plant by increasing the rate of photosynthesis and accumulating sugars (Tawfik, 2008) [19]. Foliar application of mixture of amino acids in radish plants increases the N content of shoots (Liu *et al*., 2008) [12]. Amino acids may directly or indirectly influence the physiological activities in plant growth and development in tomato (Boras *et al*., 2011) [5].

Among the different treatments, foliar application of amino acid @ 2 ml/l + GA_3 250 ppm + potash 5 per cent + urea 2 per cent + T_1 (T_{15}) significantly registered higher cob length (13.68 cm), cob diameter (3.42 cm), cob weight per plant (75.62 g), hundred seed weight (30.77 g) and seed yield (31.55 q/ha) (Table 2) which is on par with T_{13} (T_1 + Foliar spray of lithovit @ 0.5 g L^{-1} + tryptophan 150 ppm and lysine 150 ppm + nano DAP @ 2 ml L^{-1} to male parent). Whereas, lowest seed yield and its components were lowest recorded in T_1 (Sowing male and female parent on the same day). The highest values of yield and yield parameters, which may be related to potassium and nitrogen's tendency to speed up development, photosynthetic activity and effective translocation of photosynthates. The availability and uptake of other nutrients are frequently influenced by potassium, which also has an impact on the overall yield. GA_3 promotes cell division and elongation, stimulates plant growth, and improves the quality of seeds. By influencing the production of gibberellins, amino acids that comprise phenylalanine can have an impact on plant growth and development (Waller and Nawacke, 1978) [20]. A higher seed yield may result from amino acids ability to be metabolized, transport, and promote photosynthesis. The promotion of root growth in plants receiving treatment due to the amino acid impact may also increase their capacity to absorb water and nutrients, increasing yield output. Amino acid (L-methionine) plays an important role in maintaining the structure of proteins required for cell division, cell differentiation and growth. L-methionine helps in increasing initiation of roots, which helps in absorption of more nutrients by the plant. Amino acid has positive effect on plant growth, yield and significantly mitigates the injuries caused by a biotic stress (Azimi *et al.* 2013) [3]. The amino acids activate plant synthesis efficiency and internal

immunity in addition to improve the qualities of growth and yield. Nitrogen plays an important role in increasing the cell division and thus increasing the expansion of the cells. The similar results are reported by Dhedhi *et al*. (2006) [6] and Tanwir Alam *et al*. (2007) [18] in maize, Bhanuje *et al*. (2014) [4] in bajra and Abido *et al*. (2017) [1] in maize. Rahim *et al*. (2018) [14] in maize and Khan *et al*. (2019) [10] in Lettuce.

Table 1: Effect of foliar spray on plant height at different growing stages, days to 50% tasseling of male parent and days to 50% silking of female parent of maize hybrid RCRMH-4.

Treatments	Plant height (cm) at different growing stages			Days to 50% tasselling in male parent	Days to 50% silking in female parent
	30 DAS	60 DAS	At harvest		
T_1: Sowing male and female parent on the same day. (Control)	30.11	136.42	165.46	66.44	61.22
T_2: Sowing of female parent after 5 days sowing of male parent. (Recommended practice)	29.27	136.09	162.23	66.41	61.15
T_3: T_1+ Foliar spray of nano urea @ 4 ml L^{-1} to male parent.	30.07	139.36	174.46	64.13	60.64
T_4: T_1+ Foliar spray of seaweed extract @ 4 ml L^{-1} to male parent.	31.22	136.64	168.26	66.13	60.8
T_5: T_1+ Foliar spray of urea 2 per cent to male parent.	29.42	139.01	172.29	64.55	60.78
T_6: T_1 + Foliar spray of Tryptophan 150 ppm to male parent.	30.16	137.68	167.33	65.42	61.03
T_7: T_1 + Foliar spray of Lysine 150 ppm to male parent.	29.43	137.79	165.46	65.11	60.68
T_8: T_1+ Foliar spray of nano DAP @ 2 ml L^{-1} to male parent.	28.05	139.82	173.49	62.82	60.52
T_9: T_1 + Foliar spray of Lithovit @ 0.5 g L^{-1} to male parent.	30.98	140.71	176.13	62.39	60.51
T_{10}: T_1 + Foliar spray of Lysine 150 ppm and Tryptophan 150 ppm to male parent.	31.32	138.06	176.79	64.88	61.04
T_{11}: T_1 + Foliar spray of Lithovit @ 0.5 g L^{-1} and seaweed extract @ 4 ml L^{-1} to male parent.	30.05	139.39	176.73	62.29	60.55
T_{12}: T_1 + Foliar spray of Lysine and Tryptophan 150 ppm + seaweed extract @ 4 ml L^{-1} to male parent.	31.13	138.39	178.33	64.78	60.74
T_{13}: T_1 + Foliar spray of Lithovit @ 0.5 g L^{-1} + Tryptophan 150 ppm and Lysine 150 ppm + nano DAP @ 2 ml L^{-1} to male parent.	29.64	142.60	179.54	61.94	60.54
T_{14}: T_1 + Foliar spray of zinc 0.5 per cent and boron 0.5 per cent to male parent.	29.46	136.99	175.56	65.83	60.57
T_{15}: T_1+ Foliar spray of amino acid @ 2 ml L^{-1} + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent.	30.74	145.43	180.22	61.71	60.52
Mean	30.07	138.96	172.82	64.32	60.75
S.Em. ±	0.87	1.60	3.49	0.17	0.18
CD @ 5%	NS	4.65	10.12	0.54	NS

Table 2: Effect of foliar spray on hybrid seed yield parameters of maize hybrid RCRMH-4

Treatments	Cob length (cm)	Cob diameter (cm)	Cob weight (g)	100 seed weight (g)	Seed yield/ hectare (q)
T_1: Sowing male and female parent on the same day. (Control)	11.42	3.01	32.43	21.35	9.30
T_2: Sowing of female parent after 5 days sowing of male parent (Recommended practice)	12.50	3.28	67.19	28.30	29.33
T_3: T_1+ Foliar spray of nano urea @ 4 ml L^{-1} to male parent.	12.12	3.10	52.48	28.20	27.14
T_4: T_1+ Foliar spray of seaweed extract @ 4 ml L^{-1} to male parent.	11.45	3.00	33.63	26.63	12.84
T_5: T_1+ Foliar spray of urea 2 per cent to male parent.	12.01	3.10	51.21	28.09	25.24
T_6: T_1 + Foliar spray of Tryptophan @ 150 ppm to male parent.	11.68	3.15	35.10	27.09	16.34
T_7: T_1 + Foliar spray of Lysine 150 ppm to male parent.	11.75	3.17	35.20	27.27	18.34
T_8: T_1+ Foliar spray of nano DAP @ 2 ml L^{-1} to male parent.	12.41	3.15	64.33	28.87	28.83
T_9: T_1 + Foliar spray of Lithovit @ 0.5 g L^{-1} to male parent.	12.56	3.20	65.96	28.27	29.02
T_{10}: T_1 + Foliar spray of Lysine 150 ppm and Tryptophan 150 ppm to male parent.	11.86	3.08	36.46	27.49	21.02
T_{11}: T_1 + Foliar spray of Lithovit @ 0.5 g L^{-1} and seaweed extract @ 4 ml L^{-1} to male parent.	12.60	3.22	66.10	28.38	29.34
T_{12}: T_1 + Foliar spray of Lysine and Tryptophan 150 ppm + seaweed extract @ 4 ml L^{-1} to male parent.	11.98	3.09	37.54	27.87	22.21
T_{13}: T_1 + Foliar spray of Lithovit @ 0.5 g L^{-1} + Tryptophan 150 ppm and Lysine 150 ppm + nano DAP @ 2 ml L^{-1} to male parent.	12.94	3.35	72.62	30.10	31.23
T_{14}: T_1 + Foliar spray of zinc 0.5 per cent and boron 0.5 per cent to male parent.	11.49	3.11	40.09	26.79	15.36
T_{15}: T_1+ Foliar spray of amino acid @ 2 ml L^{-1} + GA_3 250 ppm + potash 5 per cent + urea 2 per cent to male parent.	13.68	3.42	75.62	30.77	31.55
Mean	12.16	3.16	51.06	27.70	23.13
S.Em. ±	0.35	0.04	1.47	0.80	0.69
CD @ 5%	1.02	0.11	4.27	2.32	2.01

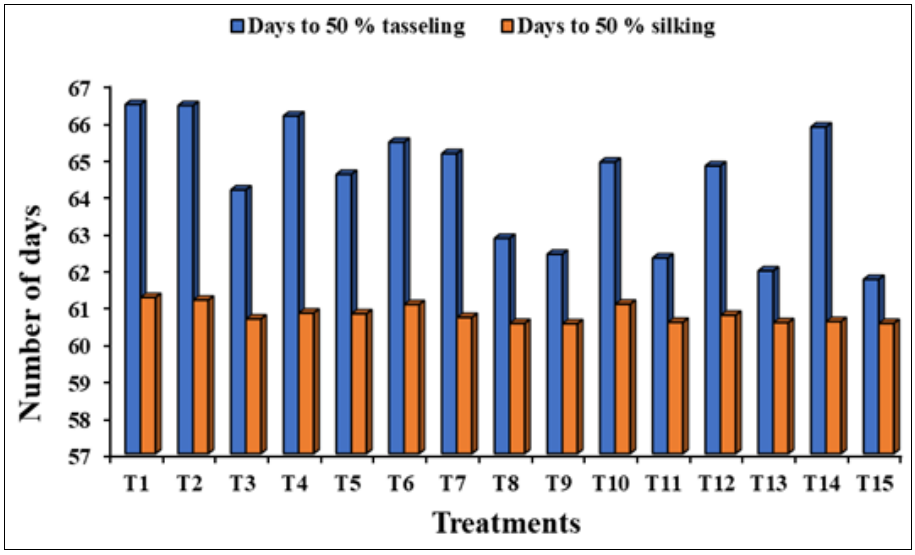


Fig 1: Effect of foliar spray on days to 50% tasseling in male parent and 50% silking in female parent of maize hybrid RCRMH-4

Conclusion

Based on the experimental results, it was concluded that even though complete synchronization of flowering was not achieved by foliar spray of amino acid @ 2 ml/l, GA_3 @ 250 ppm potash @ 5 per cent and urea @ 2 per cent to male parent, but gap has been reduced for 50 per cent flowering between two parents by 1.19 days and reduction of 4.03 days. Also, the yield parameter significantly registered higher cob length (13.68 cm), cob diameter (3.42 cm), cob weight per plant (75.62 g), hundred seed weight (30.77 g) and seed yield (31.55 q/ha).

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