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Effect of plant growth regulators on flowering behavior of cashew cv. Vengurla-4 grown in the hilly tracts of South Gujarat

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Abstract: A trial was conducted at Subhir and Chikhalda locations in Dang district of South Gujarat, India to assess the effect of Ethrel, NAA and GA_3 on the flowering behavior of cashew cultivar Vengurla-4 during 2013-14. Three concentrations each of GA_3 (50, 75, 100 ppm), Ethrel (10, 30, 50 ppm) and NAA (50, 75, 100ppm) were applied as foliar sprays 20 days before blossoming and 20 days after full bloom in twenty year old trees of cashew cultivar Vengurla-4. Trees sprayed with 50 ppm Ethrel had significantly the highest number of flowering panicles per square meter (13.09), number of perfect flowers per panicle (87.11) and sex ratio (0.24) across locations and in pooled data. However, this was at par with 10 ppm Ethrel which emerged as the second best treatment of the trial. This study demonstrated the potential of Ethrel in improving various flowering parameters of cashew which are important determinations in increasing nut production.

Keywords: *Anacardium occidentale,* Ethrel, GA_3, Perfect flowers, Sex ratio

INTRODUCTION

Cashew (*Anacardium occidentale* L.) belongs to the family Anacardiaceae and is native to Brazil. It was introduced into India by Portuguese travellers in the 16th century for afforestation and soil conservation. India was the first country in the world to exploit international trade in cashew kernels in the early part of 20th century (Chavan and Raut, 2013). It earns valuable foreign exchange for the country and is therefore regarded as a "gold mine". Tree nuts are globally consumed for their desirable sensory and nutritional attributes. Among dry fruits, cashew nuts are very popular due to their characteristic odour and taste. Cashew nuts are a good source of proteins (20%), carbohydrates (23%) and fats (45%) (Bhattacharjee *et al.,* 2003). The cashew seed is a good source of oil (45%) which is mainly used in brake linings as a friction particle and as a major constituent in phenalkamine (floor coating material). Cashew shells contain high quality oil known as cashew nut shell liquid (CNSL) which has several industrial applications. Value added products such as juice, *fenni*, wine, dried cashew apple, syrup and jam can be prepared from cashew apple (Suganya and Dharshini, 2011). The global production of cashew is around 43,10,027 MT from a total of 53,13,415 hectares (FAO, 2012). India is the second largest producer of raw cashew in the world, next only to Vietnam. India produces about 0.75 million MT of cashew from an area of 1.01 million hectares with a productivity of 0.7 MT/ha (NHB, 2014). Currently cashew occupies about 8.35 thousand hectare area in Gujarat with a production of 26.0 thousand MT. Dang and Valsad districts of Gujarat account for about 99% of the total cashew production in the state (GOG, 2014).

Cashew farmers in South Gujarat are now-a-days growing improved varieties like Vengurla-4, Vengurla-7 and Ullal. Amongst these, the maximum area is under cultivar Vengurla-4 due to its excellent kernel quality and high yield. Prolonged flowering, poor production of perfect flowers, narrow sex ratio and low fruit set are some major problems plaguing cashew cultivation across the country. Over the years, application of exogenous hormones has significantly improved flowering and fruiting in fruit crops like citrus (El-Otmani, 1992), grape (Dokoozlian, 2001) and mango (Davenport *et al*., 2001). It has been reported that foliar sprays of Gibberellic acid (GA_3), 1-Naphthaleneacetic acid (NAA) and Ethylene increased the production of perfect flowers and improved sex ratio in cashew (Puhual *et al.,* 1993; Kumar *et al*., 1995; Aliyu *et al.,* 2011). However, there is a dearth of information on the effect of plant growth regulators in cashew cultivar Vengurla-4 grown under South Gujarat conditions. Therefore, the present investigation was conducted to determine the effectiveness of plant growth regulators in improving flowering parameters of cashew nut cv. Vengurla-4.

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MATERIALS AND METHODS

Study area: Dang is the smallest district of Gujarat state and was declared by the Planning Commission, Government of India as one of the three disadvantaged districts in Gujarat. It is located in the southern most part of Gujarat and comprises of two talukas and 311 villages. More than 98% of the population in Dang district is tribal. The entire district falls under South Gujarat heavy rainfall agro-climatic zone-I. The experiment was carried out in randomized block design with three replications in Dang district at two locations namely Subir and Chikhalda. Subir is located at latitude 20°-93° N and longitude 73°-77° E at an elevation of 437 m above mean sea level and Chikhalda at latitude 20°-69° N and longitude 73°-57° E at an elevation of 239 m above mean sea level, respectively. Each replication comprised of twenty trees, uniform in shape and size. In all, sixty trees were included in the study.

Three levels each of GA_3 (50, 75, 100 ppm), Ethrel (10, 30, 50 ppm) and NAA (50, 75, 100ppm) were applied as foliar sprays 20 days before blossoming and 20 days after full bloom in cashew cultivar Vengurla-4. Standard cultural practices and fertilizer recommendations as advocated by Bharat Agro Industries Foundation (BAIF) were implemented at both the locations. One square meter wooden frame was hand-held on tree canopy and all the shoots, flowering as well as non-flowering one's, falling within the wooden frame were counted. Such counts were taken from all four directions and the mean of them was expressed as the number of laterals per square meter canopy. The total numbers of panicles produced in one square meter area were counted in the same way as the total number of laterals per square canopy (mentioned above) and the mean data was worked out. Four flowering panicles per tree, one in each direction, were tagged at random before flowering. The panicles were tagged as and when emerged, depending on the time of flowering in each selected tree. The tagged panicles were used for recording the date of emergence of the first flowering panicle to the day of drying of the last flowering panicle. Staminate flowers were counted from four panicles, one in each direction, selected randomly. The mean number of staminate flowers produced per panicle was worked out for each selected tree. The mean number of perfect flowers produced per panicle was computed in the same way as the number of staminate flowers per panicle. The ratio of perfect flowers to staminate flowers was calculated for the tagged panicles and the mean values worked out.

Statistical analysis: The data, collected for all the characters involved in the study were subjected to statistical scrutiny for proper interpretation. The standard method of analysis of variance technique as described by Panse and Sukhatme (1967) was employed. The data was analyzed under the technical supervision of Department of Agricultural Statistics, Navinchandra Mafatlal College of Agriculture, Navsari Agricultural University, Navsari.

RESULTS AND DISCUSSION

Data pertaining to flowering parameter, sex ratio and related traits in cashew cultivar Vengurla 4 as influenced by plant regulators is presented in tables 1 and 2.

Mean number of laterals per square meter: Foliar application of plant growth regulators did not have a significant effect on mean number of laterals per square meter in cashew cv. Vengurla-4 (Table 1). However, the maximum numbers of laterals were observed in water sprayed trees at Subir location (18.05) and at Chikhalda (17.83). Even in pooled data, maximum laterals (17.94) were observed in water sprayed trees. This was in agreement with the results of Gawankar *et al.* (2010). They reported better vegetative growth in water sprayed trees of cashew cv. Vengurla-7.

Mean number of flowering panicles per square meter: Plant growth regulators exerted significant differences at 5% level on the number of flowering panicles per square meter at both locations and in pooled data (Table 1). Application of 50 ppm Ethrel resulted in the maximum number of flowering panicles (13.24) at Subir location. It also recorded the maximum number of flowering panicles (12.93) at Chikhalda location. The minimum number of flowering panicles [(Subhir-9.62) and (Chikhalda-8.75)] were observed in water sprayed trees. A similar trend was observed in pooled analysis, wherein Ethrel 50 ppm recorded the maximum flowering panicles (13.09). Ethrel 10 ppm was at par with Ethrel 50 ppm at both locations and in pooled analysis. Ethylene is believed to be the chemical which causes natural initiation of flowering. Plants can be artificially induced to flower by applying ethylene producing chemicals (Sinclair, 1993). In pineapple, it has been proposed that flowering is triggered by a small burst of ethylene production in the meristem in response to environmental cues (Trusov and Botella, 2006). It can also be attributed to an increase in the activity of peroxidase and α-amylase which ultimately released more sugar for induction of flowering (Yamdagni and Khangia, 1989). A significant increase in the number of flowering panicles per square meter with Ethrel 50 ppm in case of Bhaskara was reported by Lakshmipathi *et al.* (2014). Interaction between plant growth regulator treatments and locations was found non-significant for number of flowering panicles per square meter.

Flowering duration: Regardless of locations, treatments applied, did not have a significant influence on flowering duration in cashew cv. Vengurla-4 (Table 1). The shortest flowering duration (75.05 days) was observed at Subhir location with the application of Ethrel 50 ppm. At the same location, water sprayed trees had the longest flowering duration (89.71 days). The flowering duration varied from 75.05 to 89.71

Table 1. Effect of Ethrel, GA_3 and NAA on flowering parameters of cashew cv. Vengurla-4 at Subhir and Chikhalda locations of South Gujarat.

Treatments	Mean no. of laterals per square meter			Mean no. of panicles per square meter			Flowering duration (days)		
	Locations		Pooled	Locations		Pooled	Locations		Pooled
	Subhir	Chikhalda		Subhir	Chikhalda		Subhir	Chikhalda	
T_1 - Ethrel 10 ppm	15.78	15.47	15.62	13.03	12.68	12.86	78.24	80.54	79.39
T_2 - Ethrel 30 ppm	14.89	15.56	15.23	11.66	11.20	11.43	77.39	81.06	79.22
T_3 - Ethrel 50 ppm	15.43	15.13	15.28	13.24	12.93	13.09	75.05	77.91	76.48
T_4 - GA_3 50ppm	17.11	17.06	17.09	11.97	11.82	11.89	77.63	79.52	78.58
T_5 - GA_3 75 ppm	14.71	14.73	14.72	11.84	11.36	11.60	86.54	79.68	83.11
T_6 - GA_3 100 ppm	14.41	16.08	15.25	11.08	11.10	11.09	81.21	82.84	82.02
T_7 - NAA 50 ppm	15.12	15.62	15.37	10.19	10.14	10.17	84.53	86.53	85.53
T_8 - NAA 75 ppm	17.03	14.54	15.79	10.49	10.21	10.35	83.02	82.97	82.99
T_9 - NAA 100 ppm	16.21	16.88	16.55	12.23	11.97	12.10	78.51	78.81	78.66
T_{10} - Control	18.05	17.83	17.94	9.62	8.75	9.19	89.71	87.21	88.46
S. Em. ± (T)	1.07	0.87	0.685	0.51	0.50	0.35	4.14	2.51	2.514
C.D. (T) at 5%	NS	NS	NS	1.52	1.48	0.99	NS	NS	NS
S. Em ± (L × T)	----	----	0.969	----	----	0.50	----	----	3.55
C.D. (L × T) at 5%	----	----	NS	----	----	NS	----	----	NS
CV%	11.66	9.45	10.56	7.69	7.68	7.51	8.84	5.32	7.56

Table 2. Effect of Ethrel, GA_3 and NAA on sex ratio and related traits of cashew cv. Vengurla-4 at Subhir and Chikhalda locations of South Gujarat.

Treatments	No. of staminate flowers per panicle			No. of perfect flowers per panicle			Sex ratio		
	Locations		Pooled	Locations		Pooled	Locations		Pooled
	Subhir	Chikhalda		Subhir	Chikhalda		Subhir	Chikhalda	
T_1 - Ethrel 10 ppm	379.40	393.49	386.45	85.60	82.97	84.28	0.23	0.21	0.22
T_2 - Ethrel 30 ppm	402.67	386.82	394.74	83.09	80.34	81.72	0.21	0.21	0.21
T_3 - Ethrel 50 ppm	364.67	358.53	361.60	89.27	84.94	87.11	0.25	0.24	0.24
T_4 - GA_3 50ppm	386.81	400.12	393.46	82.87	81.63	82.25	0.21	0.20	0.21
T_5 - GA_3 75 ppm	401.77	390.21	395.99	72.97	80.11	76.54	0.19	0.21	0.20
T_6 - G A_3 100 ppm	418.93	403.53	411.23	79.02	75.30	77.16	0.19	0.19	0.19
T_7 - NAA 50 ppm	403.33	383.41	393.37	79.53	77.71	78.62	0.20	0.21	0.21
T_8 - NAA 75 ppm	440.90	445.19	443.05	78.64	77.71	78.18	0.18	0.18	0.18
T_9 - NAA 100 ppm	412.00	387.08	399.54	81.74	80.34	81.04	0.20	0.21	0.20
T_{10} - Control	490.77	500.22	495.50	74.02	72.68	73.35	0.15	0.15	0.15
S.Em.± (T)	23.00	31.72	19.07	2.83	1.35	1.580	0.01	0.01	0.009
C.D. (T) at 5%	NS	NS	54.60	8.42	4.00	4.525	0.03	0.04	0.025
S. Em ± (L × T)	----	----	26.97	----	----	2.235	----	----	0.012
C.D. (L × T) at 5%	----	----	NS	----	----	NS	----	----	NS
CV%	9.71	13.57	11.46	6.09	2.94	4.84	8.99	12.06	10.52

days at Subhir, 77.91 to 87.21 days at Chikhalda and 76.48 to 88.46 days in pooled analysis.

Number of staminate flowers per panicle: Application of plant growth regulars did not have a significant effect on the number of staminate flowers per panicle at Subhir and Chikhalda locations (Table 2). At both these locations, maximum numbers of staminate flowers were observed in water sprayed trees at Subir (490.77) and Chikhalda (500.22). In pooled analysis, significantly the highest number of staminate flowers was recorded in water sprayed trees (495.50). Gawankar *et al*. (2010) indicated that the number of staminate flowers was related to the number of lateral per square meter. Higher number of laterals in water sprayed trees could have resulted in higher number of staminate flowers.

Number of perfect flowers per panicle: Foliar sprays of plant growth regulators had a positive and significant effect on total number of perfect flowers at both the locations and in pooled analysis (Table 2). The highest values for number of perfect flowers were recorded under Ethrel 50 ppm at Subir (89.27), Chikhalda (84.94) and in pooled data (87.11). This was at par with application of Ethrel at 10 ppm across locations and in pooled analysis. In an earlier report, foliar application of Ethrel @100 ppm increased the number of perfect flowers in cashew (Singh *et al*., 1992).

Sex ratio: Sex ratio in cashew cv. Vengurla-4 at Subir and Chikhalda locations as well as in pooled analysis was significantly influenced by PGRs (Table 2). At Subir location, foliar application of Ethrel @ 50 resulted in the highest sex ratio (0.25) which was at par with 10 ppm Ethrel (0.23). The same treatment also registered the highest sex ratio at Chikhalda location i.e. 0.24. This was at par with Ethrel 10 ppm (0.21), Ethrel 30 ppm (0.21), GA_3 75 ppm (0.21), NAA 50 ppm (0.21) and NAA 100 ppm (0.21). At both locations, the lowest sex ratio was noticed in water sprayed trees. In pooled data, the maximum sex ratio (0.24) was observed in Ethrel 50 ppm which was at par with Ethrel 10 ppm , Ethrel 30 ppm, GA_3 50 ppm and NAA 50 ppm i.e. 0.22, 0.21, 0.21 and 0.21. Interaction effect between locations and treatments came out non significant. Improvement in the sex ratio with the application of Ethrel was mainly due to increased number of perfect flowers. Ethrel may also have exerted its effect on sex expression by manipulating endogenous auxin levels corresponding to a reduction in staminate flowers as reported by Mariappan *et al*. (1995). Gawankar *et al.* (2010) in cv. Vengurla-7 and Lakshmipathi *et al.* (2014) in cv. Bhaskara also recorded an improvement in sex ratio by foliar application of Ethrel at prebloom stage.

Kumar *et al.* (1996) reported that number of perfect flowers per panicle was positively correlated with yield in cashew. A similar correlation was observed by Lenka *et al*. (2001). Dorajeerao *et al.* (2001) reported that clones having broader sex ration were high yielder. Based on the current trial, it can safely assumed that yield would be higher in cashew trees sprayed with Ethrel 10 or 50 ppm as they had higher number of perfect flowers per panicle and a broader sex ratio.

Conclusion

In the present investigation, cashew trees sprayed with 50 ppm Ethrel recorded significantly the highest values for mean number of flowering panicles per square meter, number of perfect flowers per panicles and sex ratio across locations and in pooled data of Subhir and Chikhalda locations in Dang district of South Gujarat. However, foliar application of 50 ppm Ethrel was at statistically at par with 10 ppm Ethrel for all the above mentioned parameters at individual locations as well as in pooled analysis. Therefore, it would be advisable to recommend Ethrel at a lower concentration i.e. 10 ppm for improving the sex ratio in cashew cv. Vengurla 4 grown in hilly tracts of South Gujarat.

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