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Original Research Paper

Effect of growth regulators and micronutrients on quality parameters in cashew (*Anacardium occidentale* L.)

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ABSTRACT

Cashew (*Anacardium occidentale* L.) is an important tropical nut crop of social and economic importance worldwide. However, the crop is threatened with the low yield. In the present study, an attempt was made to test the effects of plant growth hormones as well as micronutrients on nut and apple quality of cashew var. Bhaskara. Significant differences in kernel weight, shelling percentage, carbohydrates and starch content of cashew kernel and juice content of cashew apple were observed with the foliar application of growth hormones and micronutrients. The foliar application of ethrel @ 50 ppm increased shelling percentage (35.8%), carbohydrate content (21.63%), sugar content (6.26%), protein content (32.4%), starch content (31.42%), juice content (78.3%) and total soluble solids (12^0 Brix). Further, the foliar spray of zinc sulphate (0.5%) + borax (0.1%) increased shelling (36.13%), protein content (32.15%), starch content (32.03%) among all the treatments tested. Furthermore, higher cashew apple juice content (78%) and total soluble solids (12^0Brix) was also recorded with the foliar spray of zinc sulphate (0.5%) + borax (0.1%).

Keywords : Cashew, micronutrients, nut and apple quality, plant growth hormones

INTRODUCTION

Cashew (*Anacardium occidentale* L) is an important commercial plantation crop of the country, grown in an area of 10.27 lakh ha with a production of 7.25 lakh metric tonnes of raw cashew nuts (Anon. 2019). World's total area under the cultivation of cashew is around 35100 km^2 with India sharing 20 per cent and 16 per cent of cashew area and production globally, respectively. However, productivity of Indian cashew is very low (772 kg/ha). The present low productivity is attributed to several factors such as establishment of plantation with seedling of nondescript origin, due to poor and irregular flowering because of adverse environmental conditions (Parameswaran *et al.,* 1984), poor fruit set and excessive premature fruit drop (Patnaik *et al.,* 1985), low hermaphrodite flowers (Parameswaran *et al.,* 1984), nutritional deficiency (Subbaiah 1983), inefficient pollination (Heard *et al.,* 1990) and irregular and prolonged flowering (Aliyu, 2005).

Cashew is an evergreen dicotyledonous woody tropical tree with medium canopy size. On an average the plant attains 5-8 m height. The leaves are alternate, simple, globous, oblong, leathery, often notched at the apex. The size of leaf varies from 6-24 cm in length and 4-15 cm in width based on species and variety. The root system of complete grown cashew tree consists of a taproot surrounded by a well-developed and extensive network of lateral roots, 90% which lie on the 15-32 cm soil depth. The pattern of growth of cashew tree alternates with vegetative and reproductive phases. There are two types of branching in cashew intensive and extensive type (Damodaran, 1965). Intensive type of growth pattern tends to give bushy appearance to tree whereas extensive type results in spreading tree habit. Annually, two or three peak periods of growth are observed in bearing cashew tree with development of stray shoot growth. In bearing trees, from flower flush many shoots develop that give rise to terminal inflorescence/ panicle. The other vegetative flush gives rise to lateral shoots that develop soon after main crop has matured.

The cashew flowers are pentamerous, white or light green at the time of opening, later turn to pink. Two kinds of flowers *viz*. hermaphrodite (bisexual/perfect) and male (staminate) are present in the panicle. The perfect flowers are larger than staminate flowers (Damodaran *et al.,* 1965). Cashew is considered as andromonoecious species due to presence of both male (staminate) and hermaphrodite (perfect) flowers in the same terminal panicle usually called as inflorescence of cashew. Number of panicles per plant, flowers per panicle and distribution of male and hermaphrodite flowers (sex ratio) in each panicle vary among varieties. In flowering panicle, abundance of male flowers is reported higher than perfect flowers (Rao and Hassan, 1957; Bigger, 1990 and Damodaran *et al.,* 1965). The yield of cashew is very low owing to the production of low percentage of hermaphrodite flowers, poor fruit set, immature fruit drop and low fruit retention (Haribabu, 1982).

The cashew produces abundant flowers but only less than 10 per cent of which are hermaphrodite, about 85 per cent of the hermaphrodite flowers are fertilized and only 4-6 per cent of them reach maturity to give fruits, the remaining shed away at different stages of development. The fruit drop in cashew during the early stages of development is attributed to physiological reasons (Nothwood, 1966). Immature fruit drop is one of the major reasons for reducing yield potential of cashew. The formative effects of growth hormones are gaining its importance for managing canopy, ensuring uniform flowering and enhancing fruit retention and yield under commercial cultivation for perennial fruit trees including cashew (Olivier *et al.,* 1990).

The application of exogenous plant growth hormones has been reported to induce better root and shoot development, to break seed and bud dormancy and improve flowering and fruiting in many crop plants. Foliar spray of gibberellic acid and auxin increased shoot and root growth and total shoot and root biomass in treated cashew seedlings (Shanmugavelu, 1985). The better seed germination induced by GA in cashew has also been reported by Khan *et al.,* (1957). Shanmugavelu *et al.* (1985) suggested that the natural auxin contained in seeds of tree species might probably regulate the seed germination. The use of cytokinin and auxin improved flowering and fruit set in mango (Chen, 1983) and cashew (Kumar, 1994). Therefore, growth hormones are gaining importance in cashew cultivation for overcoming problems associated with rooting, flowering, fruit set, fruit retention and poor yield. Hence, it is evident from studies that the economic importance of hormones is due to their ability to increase nut yield. There have been numerous reports considering increased yield due to the use of hormones especially in the horticultural sector but the use of plant growth regulators on cashew in particular is in its infancy. Hence, it is of utmost importance to address this research gap and it is also essential to understand how the endogenous hormones affect or regulate the stages of plant growth in order to make exogenously applied plant growth hormones to play an important role in maximizing cashew nut yield. The productivity of cashew can also be enhanced by adopting proper nutrient managementin addition to application of plant growth hormones. Numerous nutritional trials on the crop especially on the major nutrients have been attempted in India as well as in other tropical countries. And, response to applied nutrients has been very favorable. However, the information on role of micronutrients on cashew is limited. Further, no attempt has been made so far to study the influence of foliar spray of growth regulators and micronutrient in enhancing the quality parameters of raw cashew nut. In the light of aforementioned, the present study was undertaken to evaluate the effect of growth hormones and micronutrients on quality parameters of raw cashew nut.

MATERIALS AND METHODS

Site of experiment and plant material

The experiment was conducted at experimental farms of ICAR- Directorate of Cashew Research, Puttur, Dakshina Kannada district, Karnataka during 2009-10 to 2011-12 (latitude: 12.250 North, Longitude: 75.40 East), which is situated at 90 meter above mean sea level). The study was carried out on 10 years old plantation (var. Bhaskara) by adopting randomized block design (RBD) with 9 treatments and 3 replications for plant growth hormones and for micronutrient spray with 6 treatment and 4 replication. The plant growth regulators were sprayed during flushing, flowering and fruiting stages using foot pump paddle sprayer covering the entire canopy (Table 1). The growth regulator treatments consits of control (T_1), ethrel 50 ppm (T_2), 2,4-D 10 ppm (T_3), NAA 25 ppm (T_4), IAA 10 ppm (T_5), BA 1000 ppm (T_6), GA_3 50 ppm (T_7), NAA 25ppm + GA_3 50 ppm (T_8) and IAA 100 ppm + GA_3 50 ppm (T_9). However, micronutrient treatment constitute T_1 (Control), T_2 (borax 0.1%), T_3 (borax 0.2%), T_4 (Zinc sulphate 0.5%), T_5 (Zinc sulphate 0.5% + Borax 0.1%) and T_6 (Zinc sulphate

0.5% + Borax 0.2%). Observations on kernel weight (g), shelling (%), CHO (%), Sugar (%), Protein (%), Starch (%), Juice (%), TSS (^{0} Brix) were recorded. The micronutrients were sprayed during flushing, flowering and fruiting stages using a foot pump paddle sprayer covering the entire canopy (Table 2). Observations on kernel weight (g), shelling (%), CHO (%), Sugar (%), Protein (%), Starch (%), Juice (%), TSS (^{0} Brix) were recorded in all the treatments.

Fifty whole kernels were weighed and recorded in grams. Mean weight of one kernel was calculated by dividing the total weight of kernels by number of kernels. Fifty sun dried raw cashew nuts were weighed and weight was recorded in grams. These 50 nuts were shelled by using shelling machine. Weight of kernels with testa and shells obtained after shelling these nuts were recorded separately. The weight of kernel with testa and weight of shell of each sample was added up totally with the original weight of 50 nuts. Weight of kernel with testa was divided by the weight of nut (weight kernel with testa + weight of shell) and expressed as percentage, which gave the shelling percentage.

Nuts were shelled and kernels were extracted after removal of testa and the defatted cashew kernel flour was used for the estimation of carbohydrate, protein, starch, and sugar content by using the method suggested by Sadasivam and Balasubramanian (1987). Total soluble solids (TSS) of cashew apple were estimated using hand refractometer.

Statistical analysis

The data obtained from three successive seasons were pooled and analyzed using SAS 9.3 version. ANOVA was applied to evaluate the significant difference in the parameters studied in the different treatments. Least significant difference (Fisher's protected LSD) was calculated, following significant F-test (p=0.05).

RESULTS AND DISCUSSION

Effect of growth regulators

In the present study, significant increase in kernel weight, shelling percentage, carbohydrates and starch content of kernels and juice content of apple were recorded by the application of ethrel @ 50 ppm followed by NAA @ 25 ppm, NAA @ 25 ppm + GA_3 50 ppm, GA_3@ 50 ppm, IAA @100 ppm + GA_3 50 ppm, BA @ 1000 ppm, IAA @ 100 ppm and 2,4-D @ 10 ppm (Table 1). Spraying of ethrel @ 50 ppm also increased the protein percentage (32.20 %) followed by NAA @ 25 ppm (32.1 %), NAA @ 25 ppm + GA_3 50 ppm (32.00 %), GA_3 @ 50 ppm (31.4 %), IAA @ 100 ppm + GA3 50 ppm (31.5 %), BA @ 1000 ppm (31.20 %), IAA @ 100 ppm (30.50 %) and 2,4-D @ 10 ppm (30.30 %) compared to untreated trees (29.89 %). Kumar *et al.* (1996) reported that the combined application of ethrel @

Table 1 : Effect of growth regulators on quality parameters of cashew variety Bhaskara

Treatment	Kernel weight (g)	Shelling (%)	Carbohydrate (%)	Sugar (%)	Protein (%)	Starch (%)	Juice (%)	TSS (^{o} Brix)
Control	2.17^C	30.00^D	20.70^B	6.21	29.63^C	25.52^E	67.40^F	11.00
Ethrel@50 ppm	2.55^A	35.87^A	21.63^A	6.26	32.40^A	31.42^A	78.37^A	12.00
2,4-D@10 ppm	2.40^B	31.50^{BC}	21.47^A	6.21	30.43^{BC}	28.50^D	68.47^E	11.00
NAA@25ppm	2.55^A	35.58^A	21.60^A	6.25	32.37^A	31.40^A	76.40^B	11.00
IAA@100 ppm	2.40^B	31.17^{CD}	21.47^A	6.22	30.50^{BC}	29.00^{CD}	68.53^E	11.00
BA @1000 ppm	2.45^B	32.50^B	21.50^A	6.23	31.40^{AB}	29.37^{CD}	70.50^D	11.00
GA_3@50 ppm	2.54^A	35.50^A	21.53^A	6.24	31.47^{AB}	30.40^B	76.00^{BC}	12.00
NAA @25 ppm + GA_3 50 ppm	2.54^A	35.58^A	21.57^A	6.25	31.33^{AB}	31.00^{AB}	76.37^B	12.00
IAA @100 ppm + GA_3 50 ppm	2.54^A	35.50^A	21.53^A	6.24	31.50^{AB}	29.47^C	75.50^C	12.00
Mean	2.46	33.69	21.44	6.23	31.23	29.56	73.06	11.44
SE(d)	0.037	0.559	0.089	0.026	0.582	0.416	0.332	0.544
LSD at 5%	0.078	1.186	0.189	NS	1.235	0.882	0.704	NS

50 ppm and 500: 250: 250 g NPK/plant/year enhanced yield, nut and apple quality in cashew varieties. They also further opined that the increase in total soluble solids and apple yield might be attributed to the positive interaction between growth regulators and nutrients.

Spraying of growth regulators in all the treatments have given higher nut yield compared to control. It may be because of ethrel and auxin could induce better flowering in cashew (Aliyu *et al.,* 2011). Auxin is known to induce flowering via ethylene production and also independently (Li and Xu, 2014). Other reasons for more nut yield compared to control are growth regulators/hormone sprayed leaf area mobilizes all the photosynthates and nutrients which will be utilized for flower production and fruit growth (Li and Xu, 2014). And other reasons might be increased stomatal number increases inflow of carbon dioxide into the mesophyll tissue resulting more photosynthates, latter partitioned towards nut resulted in more nut yield (Aliyu *et al.,* 2011).

In the present study, gibberellic acid, GA_3 @ 50 ppm resulted in better nut and kernel quality in cashew variety Bhaskara. Application of GA_3 @ 50 ppm increased protein content (31.4%), carbohydrate content (21.5%), sugar content (6.4%) and starch content (30.4%) in cashew kernel (Table 1). Similar results were also reported by Murthy *et al.,* (1975) where they studied the free amino acid and total protein content in three developmental stages of kernel in cashew after foliar treatment with 40 ppm and 50 ppm gibberellic acid. Treatment with GA_3 resulted in a marked increase in protein content of kernel at all stages of development. In GA_3 treated cashew kernels, the amino acid contents showed progressive decrease with the growth and maturation of the nut and greater accumulation of protein.Similar results were also reported in mango where GA_3 treatment enhanced fruit quality of mango trees (Muarya and Singh, 1981; Saski and Utsunomiya, 2002 and Anila and Radha 2003.

Effect of micronutrients

Micronutrients perform an essential role in the production of fruit crops, and their deficiencies largely affect the quality of fruits. In the present study, the influence of micronutrient application on nut and apple quality was studied and presented in Table 2. Kernel weight was not significantly influenced by foliar application of micronutrients. This indicates that kernel weight is more of a genetical factor and least influenced by external factors. Higher shelling (36.13%) was found with the spray of zinc sulphate (0.5%) + borax (0.1%) compared to untreated trees (30.13%). Micronutrient spray did not significantly influence the carbohydrate and sugar content in kernel. Protein content was higher (32.15%) with the spray of zinc sulphate (0.5%) + borax (0.1%) followed by zinc sulphate (0.5%) (31.5%) and borax (0.1%) (31.3%), while it was lower in unsprayed trees (29.92%). Starch content was highest (32.03%) with the spray of zinc sulphate (0.5%) + borax (0.1%) followed by borax (0.1%) (31.38%), while unsprayed trees recorded lower starch content (25.26%).

Table 2 : Effect of foliar spray of micronutrients on quality parameters of cashew variety Bhaskara

Treatment	Kernel weight (g)	Shelling (%)	Carbohydrate (%)	Sugar (%)	Protein (%)	Starch (%)	Juice (%)	TSS (° Brix)
Control	2.43	30.13^{D}	20.85	6.20	30.10^{C}	25.26^{D}	67.38^{E}	11.00
Borax (0.1%)	2.47	34.13^{B}	21.58	6.24	31.33^{AB}	31.38^{AB}	74.00^{B}	12.00
Borax (0.2%)	2.35	31.58^{C}	21.53	6.22	30.15^{C}	28.38^{C}	69.00^{D}	11.00
$ZnSO_4$ (0.5%)	2.40	33.70^{B}	21.28	6.23	31.50^{AB}	30.35^{B}	70.75^{C}	11.00
$ZnSO_4$ (0.5%) + borax (0.1%)	2.45	36.13^{A}	22.10	6.25	32.15^{A}	32.03^{A}	78.00^{A}	12.00
$ZnSO_4$ (0.5%) + borax (0.2%)	2.41	33.38^{B}	21.48	6.22	30.60^{BC}	28.90^{C}	68.00^{DE}	11.00
Mean	2.42	33.17	21.47	6.22	30.97	29.38	71.19	11.33
SE(d)	0.25	0.52	0.49	0.02	0.48	0.49	0.59	0.60
LSD at 5%	NS	1.11	NS	NS	1.025	1.06	1.26	NS

The effect of micronutrient spray on apple quality was also studied (Table 2). Higher juice content in cashew apple (78%) was found with the spray of zinc sulphate (0.5%) + borax (0.1%) compared to unsprayed trees (67.38%). The role of micronutrients in improving the vegetative growth, fruit quality and yield has been reported in several fruit crops (Abdollahi *et al.* 2012; Farid *et al.,* 2020, Sanjeela *et al.,* 2021). The present study is in consistent with findings of Shafeek *et al.* (2014), Singh *et al.* (2015) and Mishra *et al.* (2006) where application of micronutrients mainly zinc, boron and iron improved reproductive traits mainly fruiting parameters and quality traits. Significant increase in TSS was also observed with the foliar spray of zinc sulphate (0.5%) + borax (0.1%) and Borax (0.1%). Similar results were also reported by Sanjeela *et al.* (2021) where application of boron @ 0.2% increased the TSS (8.3^{0}Brix) in strawberry. The role of boron in sugar translocation helps to improve fruit quality parameters (Gauch and Dugger, 1953; Sathya *et al.,* 2010). Moreover, the deficiency of boron aggravatesthe quality of fruit by increasing titrable acidity and its application improves the quality of fruit (Haider *et al.,* 2019).

CONCLUSION

Significant differences in nut and apple quality were observed with the foliar application of plant growth hormones and micronutrients. The foliar application of Ethrel @ 50 ppm and NAA @ 25 ppm + GA_3 50 ppm as well as zinc sulphate (0.5%) + borax (0.1%) improved the kernel as well as apple quality traits.The present study represents the first preliminary study on the influence of growth hormones and micronutrients on the nutritional qualities of cashew nuts and apples in the variety Bhaskara. This study can be extended to screen other cashew varieties in terms of the nutritional quality of cashew nuts and apples.

REFERENCES

Abdollahi, M., S. Eshghi, E. Tafazol and N. Moosavi. 2012. Effect of paclobutrazol, boric acid and zinc sulfate on vegetative and reproductive growth of strawberry (*Fragaria x ananassa Duch.*) cv. Selva. *J. Agric. Sci. Technol.,* **14**: 357-363

Aliyu, O. M and Awopetu, J.A. 2005. *In vitro* regeneration of hybrid plantlets of cashew (*Anacardium occidentale* L.) through embryo culture. *Af. J. Biotech.,* **6**: 548-553.

Anila, R. and Radha, T., 2003. Studies on fruit drop in mango varieties. *J. Trop. Agric.,* **41**: 30-32.

Anonymous. 2019. Production scenario of Cashew. Directorate of Cashewnut and Cocoa Development (DCCD).

Bigger, M. 1990. *Selenothripsrubrocinctus* (Grand) and the floral biology of cashew in Tanganyika, *East African Agri. J.,* **25**: 229-234

Chen, W.S. 1983. Cytokinins of the developing mango fruit, *Plant* Physiol. **71**: 356-362.

Damodaran, V.K., Abraham, J., Alexander, K.M. 1965. The morphology and biology of the cashew flower I-Flowering habit, flowering season, morphology of the flower and sex ratio. Agric. Res. J. Kerala. **3**(1&2): 23-28.

Farid, M.Z., Qureshi, K.M., Shah, S.H., Qureshi, A.A., Umair, M. and Shafiq, H. 2020. Foliar application of micronutrients improves growth, productivity and fruit quality of strawberry (*Fragaria ananassa* duch). *J. Anim. Plant Sci.,* **30**(4): 905-912.

Gauch, H.G. and Dugger, W.M. 1953. The role of boron in the translocation of sucrose. *Am. Soc. Plant Biol*., **28**: 457-467.

Haider, Z., Ahmad, N., Danish, S., Iqbal, J., Ali, M.A. and Chaudhry, U.K. 2019. Effect of foliar application of boric acid on fruit quality and yield traits of mango. *Adv. Hortic. Sci*., **33**(4): 457-465.

Haribabu Sri, R. 1982. Increasing fruit set in cashew by growth substances. Cashew causerie, **4** (4): 14-15.

Heard, T. A., Vithanage, V. and Chacko, E. K. 1990. Pollination biology of cashew in the Northern Territory of Australia. *Aust. J. Agric. Res.,* **41**: 1101-1114.

Khan, A., Gross, J.A., Smith, D.E. 1957. Effect of gibberellins on germination of lettuce seed, *Science,* **125**: 645-646.

Kumar, D. P., Khan, M. M. and Melanta, K. R. 1994. Effect of growth regulators on sex expression, fruit set, fruit retention and yield of cashew. In: Proceedings of the PLACROSYM XI held during 30 November to 3 December 1994 at Calicut, Kerala, India. pp. 610-627.

Kumar, D. P., Khan, M. M., Melanta, K. R., 1996. Effect of nutrition and growth regulators on apple characters and yield in cashew (Anacardium occidentale L.). *The Cashew,* **10**(2): 17-24.

Muarya, A. N. and Singh, J. N., 1981. Effect of three growth regulators on fruit retention and quality of mango (*Mangifera indica* L.) cv. Langra. *J. Agric. India,* **16**: 53-56.

Murthy, K.N., Kumaran. P.M. and Nayar, N.M. 1975. Increasing fruit set in cashew by hormone spraying, *J. Plantation Crops,* **3**: 81-82.

Nothwood, P.J. 1966. Some observations on the flowering and fruit-setting in the cashew (*Anacardium occidentale* L.). *Tropical Agric.* (Trin.) **43**: 35-42.

Oliveira, E.T. 1989. Propagacao vegetative de Pinus sp. Via cultura de tecido, Sao Paulo Univ. / ESALQ, Diss., Piracicaba, Sao Paulo, Brazil.

Parameswaran, N.K., Damodaran, V.K. and Prabhakaran, P.V. 1984. Relationship between yield and duration of different phases in flower opening in cashew (*Anacardium oecidentale* L.). *Indian Cashew J.,* **16**(4): 15-19.

Patnaik, H. P., Das, M.S. and Panda, J. M. 1985. Studies on the fruit set and fruit drop in cashew (*Anacardium occidentale* L.) under Odisha Conditions. *Indian Cashew Causerie J.*, **7**(4): 7-8.

Rao, V.N.M., Rao, I.K.S. and Hassan, M. 1957. Studies on seed viability in cashew, *Ind. J. Agric. Sci.,* **27**: 289-294.

Sadasivam.S. and Balasubramanian, T.1987. Determination of ascorbic acid. Practical manual in Biochemistry, Tamil Nadu Agricultural University, Coimbatore, p. 14.

SanjeelaSabahat, Juliya Abbasi, Mushtaq Ahmad, Saima Mumtaz, Taj Naseeb Khan, Sudheer Tariq and Muhammad Imran. 2021. Role of Micronutrients in improving fruit quality and yield of strawberry cv. chandler under microclimatic conditions. *Pakistan J. Agric. Res.,* **34**(4): 897.

Sasaki, K. and Utsunomiya, N. 2002. Effect of combined application of CPPU and GA_3 on the growth of "Irwin" mango fruits. *Japanese J. Trop. Agric.* **46** (4): 224-228.

Sathya, S., Mani, S., Mahedran, P.P. and Arulmozhiselvan, K. 2010. Effect of application of boron on growth, quality and fruit yield of PKM 1 tomato. *Indian J. Agric. Res.,* **44**: 274- 280.

Shanmugavelu, K.G. 1985. Studies on the effect of plant growth regulators in cashew, *Acta Hortic.,* **108**: 35-43.

Subbaiah, C.C. 1983. Fruiting and abscission patterns in cashew. *J. Agric. Sci.* (Cambridge) **100**: 423-427.

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