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ENHANCEMENT OF FLOWERING, FRUIT SET AND NUT YIELD OF CASHEW (*ANACARDIUM OCCIDENTALE* L.) BY FOLIAR APPLICATION OF NUTRIENTS AT COASTAL ZONE OF KARNATAKA INDIA

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ABSTRACT

A field experiment was carried out during 2023-24 at Krishi Vigyan Kendra, Brahmavara, Udupi. The experiment was laid out in Randomized Complete Block Design comprising of nine treatments, each replicated thrice. Results revealed that trees treated with RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 % (T_9) recorded maximum number of new shoot/m^2 (21.22), new shoot length (33.68 cm), number of lateral shoots (3.67), number of new leaves/shoot (14.78), leaf length (14.82 cm), leaf width (8.34 cm), leaf area/leaf (95.54 cm^2), chlorophyll-a (1.74 mg/g), chlorophyll-b (0.97 mg/g), total chlorophyll (2.46 mg/g), number of flowering panicles/m^2 (23.67), total number of staminate flowers/panicle (237.44), total number of perfect flowers/panicle (86.78), sex ratio (0.37), panicle length (27.94 cm), panicle width (28.50 cm), fruit set (9.64 %), number of nuts per panicle (8.33), length of apple (48.79 mm), girth of apple (43.96 mm), apple weight (82.00 g), nut length (32.93 mm), nut width (23.99 mm), nut weight (8.83 g), nut yield per tree (3.90 kg), nut yield per ha (682.69 kg) and minimum flowering duration (109.22) and number of nuts per kg (125.56).Whereas, minimum was observed in control (T_1).

Keywords **:** Cashew, forceps, nano urea, perfect flowers, panicle, raw nut yield.

Introduction

Cashew (*Anacardium occidentale* L.) belongs to the family Anacardiaceae. Cashew is a native to Eastern Brazil and introduced into India by the Portuguese during the 16th Century. In the beginning, cashew was mainly considered as a crop for afforestation and soil binding to check erosions and has now become one of the significant dollar-earning crops of India. Initially, cashew plants were seen in and around the region of Kerala and Goa in West Coast and later the cashew spread to remaining areas of East Coast. It was first grown in the gardens of Cochin and the Malabar Coast and Cochin served as a dispersal point for the cashew in India and perhaps South-East Asia as well (Johnson, 1973). It was an important export earning plantation crop of India, which has earned a foreign exchange of 3096.811 crores through export of cashew kernel and 6.921 crores by export of the cashew nut shell liquid during 2021-2022 (DCCD). During 2022-23 the total cashew nut production in the country is 7.81 lakh tonnes from an area of 11.92 lakh hectares with a productivity of 766 kg ha^{-1} (DCCD). While in Karnataka, cashew was grown in an area of 1.38 lakh hectares, producing 74,860 MT nuts with a productivity of 653 kg ha^{-1}. Low productivity of cashew in India is mainly due to the poor yielding

seedling originated cashew plantations and very low adoption of high yielding grafts.

Cashew being a regular bearer which puts forth flowering and sets fruit on the current season flush, the plant needs sufficient and continuous supply of nutrients for the growth production of new flowers, fruit set and development of nuts. Nutrients have the positive influence on floral biology, fruit set and nut yield. Young cashew plants respond well to nitrogen and phosphate application up to the pre-bearing stage, but at the bearing stage, potash in combination with nitrogen is most important. Nitrogen is an essential component of many plant tissues and occurs in chlorophyll, amino acids, proteins, enzymes and growth hormones and is a significant driver of plant growth, having a direct effect on tree vigour (Marschner, 1995).

Materials and Methods

Study site: The experiment was conducted at Krishi Vigyan Kendra, Brahmavara, Udupi. The experimental site situated in a cashew growing belt, which lies in the coastal region (Zone-10) in Karnataka State at $13^{0}42^{'}$ N latitude and $74^{0}76^{'}$ E longitude at an altitude. The climate is hot and humid throughout the year with an average annual rainfall of 3,760.30 mm, distributed mainly from June to September. The mean maximum and minimum temperature were 32.52 ºC and 22.03 ºC, respectively.

Planting material and treatments: The study was carried out on 10 years old plantation (variety Ullal-1) by adopting Randomized Complete Block Design (RCBD) with Nine treatments and three replications. The details of the treatments were RDF (Control) (T_1), RDF + Urea @ 2 % (T_2), RDF + Nano urea @ 4ml/L (T_3), RDF + Urea @ 2 % + Borax @ 0.1 % (T_4), RDF + Nano urea @ 4ml/L + Borax @ 0.1 % (T_5), RDF + Urea @ 2 % + $ZnSO_4$ @ 0.2 % (T_6), RDF + Nano urea @ 4ml/L + $ZnSO_4$ @ 0.2 % (T_7), RDF + Urea @ 2 % + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 % (T_8), RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 % (T_9). The nutrients were sprayed during flushing and 50% flowering stage using two stroke petrol power sprayer covering the entire canopy.

Growth parameters: One square meter wooden frame was hand held on the tree canopy and number of lateral shoots, number of new shoots per m^2, length of new shoot (cm), number of new leaves per shoot, leaf length and width in cm were recorded. Such observations were taken in all the four directions and the mean of them was calculated. The leaf area was also calculated by using leaf area meter.

Chlorophyll content (mg/g): The chlorophyll content in leaves was measured at fruiting stage by following Dimethyl sulfoxide (DMSO) method given by Shoaf and Lium (1976).

Flowering attributes: The four panicles were selected randomly from four directions in each tree and recorded different flowering parameters on alternate days and at each counting the newly opened flowers were removed from each selected panicle by forceps.

Fruiting behavior: Selected four panicles from four directions were used for taking fruiting observations and were tagged.

Yield parameters: The ten number of apples and nuts were selected for taking the length, girth and weight of apple and nut length width and weight.

Number of nuts per kg: Nuts were collected and mixed from each treatment separately. Sample of 1.0 kg is drawn from each pool. Nuts were counted and recorded as number of nuts per kg.

Nut yield (kg / tree): Yield per tree was recorded by collecting mature fallen nut and apple of each tree at 2-3 days interval, nut and apple of individual fruit were separated and weighed the total weight of nuts per tree in grams on weighing balance. This procedure was continued till the end of harvesting season and mean yield per tree was worked out.

Nut yield (kg / ha): Yield per hectare was worked out by multiplying the yield per tree with the number of plants per hectare (175) and the mean yield per hectare was worked out.

Results and Discussion

Influence of foliar application of nutrients on growth parameters: Foliar application of nutrients significantly affected the growth parameters of cashew cultivar Ullal-1 (Table 1). Trees sprayed with Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 % along with RDF (T_9) revealed maximum increase in number of new shoots per m^2 (21.22), length of new shoot (33.68 cm), number of lateral shoots (3.67), number of new leaves per shoot (14.78), leaf length (14.82 cm), leaf width (8.34 cm), leaf area per leaf (95.54 cm^2) and highest chlorophyll a (1.74 mg/g), chlorophyll b (0.97 mg/g) and total chlorophyll (2.46 mg/g) at fruiting stage as compared to minimum in control (T_1). This might be due to foliar application of nano-urea which play an important function in encouraging plant growth as nitrogen is a constituent of chlorophyll, the substance that allows plants to use sunlight energy to convert CO_2 to carbohydrates through the process of photosynthesis. The favourable influence of applied micronutrients (zinc and boron) on

vegetative characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic process of plants. They are essential component of enzymes responsible for nitrogen and carbohydrates metabolism respectively, thereby resulting in increased uptake of nitrogen by the plants. Further, zinc and boron increase the phenolic compounds which regulate polar auxin transport. The increased auxin activity results in increased vegetative growth characters. Similar results were obtained by Eiada *et al.* (2013) in pomegranate, Baiea *et al.* (2015) in mango, Narahari *et al.* (2018) in cape gooseberry, Sharma *et al.* (2024) in cape gooseberry.

Influence of foliar application of nutrients on flowering parameters: The values recorded on flowering parameters as influenced by different treatments were presented in Table 2. Significantly, higher number of flowering panicles (23.67 per m^2), total number of staminate flowers per panicle (237.44), total number of hermaphrodite flowers per panicle (86.78), sex ratio (0.37), panicle length (27.94 cm), panicle width (28.50 cm) and shortest flowering duration of 109.22 days was recorded in T_9 (RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + ZnSO4 @ 0.2 %) as compared with control (T_1). The increase in number of flowers and hermaphrodite flowers may be due to the nitrogen which is major component of protoplasm which increase photosynthesis as a result of which there is more accumulation of carbohydrates leading to flower initiation and profuse flowering (Ahuja 2022). Zinc sulphate and borax had stimulating effect and caused the physiological changes in the tissues influencing the flowering characters. Comparable results were obtained by Murali *et al.* (2015), Rao and Ramana (2017) and Yamakanamardi (2019) in cashew. Earliness in flowering might be because of better absorption of the nutrients which involved in the metabolic activity and also activated the hormone which influenced the earliness in these treatments. These findings are in accordance with the results obtained by Narahari *et al.* (2018). Bhalerao and Patel (2015) also revealed that the earliness (flowering) might be due to the boron, which regulates metabolism involved in translocation of carbohydrates, cell wall development and RNA synthesis and it also increased the phenolic compounds there by regulating polar auxin transport.

Influence of foliar application of nutrients on fruit set attributes: The values recorded on fruit set attributes as influenced by different treatments were presented in Table 3. Significantly highest fruit set percentage (9.64) and number of nuts per panicle (8.33) was recorded in T_9 (RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %). Whereas, the lowest fruit set percentage (8.16) and number of nuts per panicle (5.78) was recorded in T_1 (Control). Increase in fruit set percent with the application of zinc might be due to fact that benzyl adenine causes the production of large number of fruits with rapid elongation of peduncle, leading to full development of flower buds having all reproductive parts functional which increases the fruit set and number of berries per plant. Similar results were obtained by Nilesh and Banik (2011) in mango, Jat and Kacha (2014) in guava, Lakshmipathi *et al.* (2015) in cashew, Murali *et al.* (2015) in cashew, Kumar *et al.* (2017) in guava, Mahida *et al.* (2018) in mango and Yamakanamardi *et al.* (2020) in cashew.

The beneficial effect of zinc sulphate and boric acid on fruit set and reducing fruit drop might be due to the higher availability of photosynthates. These chemicals are also associated with hormone metabolism which promotes synthesis of auxin, necessary for fruit set and fruit growth. These findings are in concordance with the results obtained by Rajkumar *et al.* (2014).

Nano-urea application has influenced fruit set and fruit drop due to its rapid absorption and translocation within the plants, resulting in increased photosynthesis and greater accumulation of dry matter. These findings are in conformity with the results obtained by Bhatti *et al*. (2023).

Influence of foliar application of nutrients on apple characteristics: The values recorded on apple characteristics as influenced by different treatments were presented in Table 3. Significantly maximum apple length (48.79 mm), girth (43.96 mm) and weight (82.00 g) were recorded in T_9 (RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %). Whereas, the minimum apple length (47.49 mm), girth (42.54 mm) and weight (78.19 g) were recorded in T_1 (Control). Zinc helps in regulating the cell wall permeability, thereby allowing more mobilization of water in fruits that attributes to the greater fruit length and breadth. These findings are in accordance with the results obtained by Saraswathy *et al.* (2004) in sapota, Meena *et al.* (2005) in guava, Bhowmick *et al.* (2012) in mango, Sandipkumar (2015) in mango, Kumar *et al.* (2017) in guava, Singh *et al.* (2017) in mango, Yamakanamardi (2019) in cashew, Beniwal *et al.* (2024) in strawberry and Kumar *et al.* (2024) in guava.

Maximum fruit weight might be due to the zinc which plays a vital role to promote starch formation, boron actively involved in transportation of carbohydrates in plants. Thus, the cumulative effect of

combined treatment of micronutrients (Zn + B) might have resulted higher fruit weight in mango. These findings are in accordance with the results obtained by Kacha *et al.* (2021).

Higher fruit set percentage, fruit weight and size might be due to the involvement of boron in cell division, cell expansion and increased volume of intercellular spaces in the mesocarpic cells. It could also be due to higher mobilization of photosynthates from other parts of the plant towards the developing fruits that are extremely active metabolic sink. The application of zinc and boron might have caused rapid synthesis of protein and translocation of carbohydrate which ultimately led to increase fruit weight. These findings are in accordance with the results obtained by Lakshmipathi *et al.* (2015). Similar findings were done by Saraswathy *et al.* (2004) in sapota, Gurjar *et al.* (2015) in mango, Sandipkumar (2015) in mango, Singh *et al.* (2017) in mango, Mahida *et al.* (2018) in mango, Narahari *et al.* (2018) in cape gooseberry, Yamakanamardi (2019) in cashew, Kumar *et al.* (2024) in guava, Beniwal *et al.* (2024) in strawberry, Sharma *et al.* (2024) in cape gooseberry.

Influence of foliar application of nutrients on nut characteristics and raw nut yield: The values recorded on nut characteristics and raw nut yield as influenced by different treatments were presented in Table 3. Significantly maximum nut length (32.93 mm), width (23.99 mm) and weight (8.83 g) were recorded in T_9 (RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %). Whereas, the minimum nut length (30.71 mm), width (23.13 mm) and weight (6.69 g) were recorded in T_1 (Control). The lesser number of nuts per kg (125.56) was recorded in T_9 (RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %), indicating the best treatment. In contrast, the higher number of nuts per kg (139.11) was recorded in T_1 (Control). Significantly maximum nut yield (3.90 kg per tree and 682.69 kg per ha) was recorded in T_9 (RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %). Whereas, the lowest (2.34 kg per tree and 409.89 kg per ha) was recorded in T_1 (Control). This might be due to the cumulative effects of nitrogen on photosynthetic and metabolic activities which resulted in increased fruit size and weight therefore increased the yield. The nano fertilizers hold potential to fulfil plant nutrition requirements along with imparting sustainability to crop production systems. Nano fertilizers have higher transport and delivery of nutrients through plasmodesmata leading to higher nutrient use efficiency (NUE). The higher NUE and significantly lesser nutrient losses of nano fertilizers lead to higher productivity. These findings are in accordance with the results obtained by Ahuja (2022). Similar findings were done by Singh *et al.* (2017) in mango, Zagade *et al.* (2017) in guava, Guvvali *et al.* (2018) in sapota, Narahari *et al.* (2018) in cape gooseberry, Yamakanamardi (2019) in cashew, Beniwal *et al.* (2024) in strawberry, Sharma *et al.* (2024) in cape gooseberry.

The results of study inferred that, the foliar application of Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 % before flushing and 50 % flowering are favourable to influence the growth parameters and flowering attributes of cashew. Moreover, the application of Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 % showed earliness in flowering duration in cashew cv. Ullal-1.

Table 1 : Effect of foliar application of nutrients on growth parameters in cashew cv. Ullal-1

Tr. No	Treatment details	Number of new shoots per m^2	Length of new shoot (cm)	Number of lateral shoots	Number of new leaves per shoot	Leaf length (cm)	Leaf width (cm)	Leaf area per leaf (cm^2)	Chloro-phyll a (mg per g)	Chloro-phyll b (mg per g)	Total Chloro-phyll (mg per g)
T_1	RDF (Control)	11.67	24.41	0.78	11.78	11.44	6.86	59.12	0.42	0.19	0.68
T_2	RDF + Urea @ 2 % (Check)	14.56	29.54	1.67	12.56	12.57	7.25	72.72	1.13	0.54	1.73
T_3	RDF + Nano urea @ 4ml/L	14.33	28.22	2.22	12.89	12.85	7.05	73.48	1.21	0.58	1.78
T_4	RDF + Urea @ 2 % + Borax @ 0.1 %	15.22	29.96	1.78	12.78	13.39	7.39	78.34	1.56	0.86	2.23
T_5	RDF+Nano urea @ 4ml/L+Borax @ 0.1 %	16.56	27.99	2.11	12.78	13.30	7.48	78.94	1.62	0.81	2.28
T_6	RDF + Urea @ 2 % + $ZnSO_4$ @ 0.2 %	16.22	30.41	2.44	13.22	13.48	7.66	81.47	1.48	0.72	1.94
T_7	RDF+Nano urea @ 4ml/L+$ZnSO_4$ @0.2 %	16.33	28.53	2.00	13.22	13.80	7.59	84.14	1.51	0.74	1.98
T_8	RDF+Urea @ 2 %+Borax @ 0.1 %+$ZnSO_4$ @ 0.2 %	18.56	29.47	3.00	14.22	14.21	8.04	92.18	1.68	0.92	2.35
T_9	RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %	21.22	33.68	3.67	14.78	14.82	8.34	95.54	1.74	0.97	2.46
S. Em ±		0.52	0.48	0.17	0.19	0.12	0.07	0.83	0.02	0.01	0.01
C. D. @ 5 %		1.56	1.44	0.52	0.56	0.36	0.21	2.48	0.06	0.02	0.02

Note: RDF- 500:250:250 g NPK $plant^{-1}$ + FYM 50 kg $plant^{-1}$ per year

Table 2 : Effect of foliar application of nutrients on flowering attributes in cashew cv. Ullal-1

Tr. No	Treatment details	Number of flowering panicles per m^2	Total number of staminate flowers per panicle	Total number of perfect flowers per panicle	Sex ratio	Panicle length (cm)	Panicle width (cm)	Flower duration in days
T_1	RDF (Control)	18.11	207.67	66.89	0.33	23.72	26.00	127.22
T_2	RDF + Urea @ 2 % (Check)	21.00	226.00	75.56	0.33	25.17	26.87	121.22
T_3	RDF + Nano urea @ 4ml/L	20.89	226.89	76.22	0.34	25.40	26.87	119.67
T_4	RDF + Urea @ 2 % + Borax @ 0.1 %	21.67	229.89	77.00	0.33	25.69	26.96	118.00
T_5	RDF + Nano urea @ 4ml/L + Borax @ 0.1 %	21.33	232.22	78.78	0.34	25.89	27.13	116.22
T_6	RDF + Urea @ 2 % + $ZnSO_4$ @ 0.2 %	21.67	230.11	77.78	0.34	26.04	27.17	115.89
T_7	RDF + Nano urea @ 4ml/L + $ZnSO_4$ @ 0.2 %	21.89	231.11	81.00	0.35	26.78	27.27	115.56
T_8	RDF + Urea @ 2 % + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %	21.22	236.00	83.11	0.35	27.22	27.99	111.78
T_9	RDF+Nano urea @ 4ml/L+Borax @ 0.1 %+$ZnSO_4$ @ 0.2 %	23.67	237.44	86.78	0.37	27.94	28.50	109.22
S. Em ±		0.31	0.45	0.70	0.0031	0.23	0.02	0.40
C. D. @ 5 %		0.92	1.35	2.11	0.0092	0.70	0.05	1.20

Note: RDF- 500:250:250 g NPK $plant^{-1}$ + FYM 50 kg $plant^{-1}$ per year

Table 3 : Effect of foliar application of nutrients on fruit set attributes, apple and nut characteristics and nut yield in cashew cv. Ullal-1

Tr. No	Treatment details	Fruit set (%)	Number of nuts per panicle	Length of apple (mm)	Girth of apple (mm)	Apple weight (g)	Nut length (mm)	Nut width (mm)	Nut weight (g)	Number of nuts per kg	Nut yield (kg per tree)	Nut yield (kg per ha)
T_1	RDF (Control)	8.16	5.78	47.49	42.54	78.19	30.71	23.13	6.69	139.11	2.34	409.89
T_2	RDF + Urea @ 2 % (Check)	8.40	6.44	47.77	42.72	81.24	31.15	23.46	7.10	135.56	2.60	455.00
T_3	RDF + Nano urea @ 4ml/L	8.70	6.78	47.78	42.91	81.47	31.01	23.25	7.08	135.22	2.81	491.56
T_4	RDF + Urea @ 2 % + Borax @ 0.1 %	8.51	6.22	47.85	42.65	81.54	31.28	23.43	7.48	134.00	2.76	482.81
T_5	RDF + Nano urea @ 4ml/L + Borax @ 0.1 %	8.48	6.11	47.85	43.02	81.62	31.24	23.51	7.69	133.00	2.94	514.31
T_6	RDF + Urea @ 2 % + $ZnSO_4$ @ 0.2 %	9.18	7.00	47.94	43.06	81.66	31.61	23.57	7.60	132.89	3.11	543.67
T_7	RDF + Nano urea @ 4ml/L + $ZnSO_4$ @ 0.2 %	8.93	6.67	48.06	42.88	81.76	31.65	23.63	7.94	131.00	3.29	575.36
T_8	RDF + Urea @ 2 % + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %	9.22	7.33	48.55	43.56	81.94	32.60	23.87	8.39	128.00	3.57	625.14
T_9	RDF + Nano urea @ 4ml/L + Borax @ 0.1 % + $ZnSO_4$ @ 0.2 %	9.64	8.33	48.79	43.96	82.00	32.93	23.99	8.83	125.56	3.90	682.69
S. Em ±		0.28	0.27	0.07	0.03	0.01	0.10	0.03	0.10	0.44	0.01	2.12
C. D. @ 5 %		0.85	0.82	0.22	0.10	0.03	0.29	0.10	0.29	1.33	0.04	6.36

Note: RDF- 500:250:250 g NPK $plant^{-1}$ + FYM 50 kg $plant^{-1}$ per year

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