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Assessment and Correlation Studies on Influence of Foliar Nutrient Management on Yield Attributing Traits and Physico-chemical Parameters of Cashew (*Anacardium occidentale* L.) on Cv. Balabhadra

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ABSTRACT

Background: Cashew being a hardy crop is able to thrive and produce yield under low nutrient management practices yet suffers low productivity as the yield potential of plant is not expressed. Persistence of low productivity of cashew in Odisha is due to inconsequence of old senile plantation of seedling origin under unfertile, marginal lands as well as no proper adaptation of scientific nutrient management practices.

Methods: Present investigation was carried out at All India Coordinated Research Project on Cashew, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha during 2021-2022 and 2022-23 to evaluate the effect of nutrient management practices on yield attributing traits and physico-chemical properties of cashew cv. Balabhadra in randomized block design with six treatments and four replications.

Result: Treatment schedule *i.e.*, 100% RDF+10 kg FYM/plant/year+ Foliar spray of major nutrients (3% urea+0.5% MAP+1% K_2SO_4)+ Foliar spray of secondary and micro-nutrients (0.5% $ZnSO_4$ + 0.1% Solubor + 0.5% $MgSO_4$) witnessed better performance of cashew for most of the yield attributing traits and biochemical properties of cashew under study. Pearson correlation coefficient analysis revealed positive association of yield relevant traits ($P<0.001$) and negative correlation for apple length and TSS of cashew apple.

Key words: Apple characters, Correlation study, Fat, Kernel biochemical properties, Nut yield.

INTRODUCTION

The cashew (*Anacardium occidentale* L.), a highly profitable perennial crop native of Brazil is now grown throughout the globe. The Portuguese brought cashew to India as a crop for conserving soil during 16th century and it was subsequently used for commercial cultivation. Cashew is mostly grown in unfertile and barren lands in India by small and marginal farmers (Shankarppa *et al.*, 2017). Cashew being perennial large tree grown in poor soil leads to depletion of soil nutrient status resulting in poor productivity. Continuous growing of cashew in poor unfertile soil causes low productivity than potential yield of recommended cultivars and it can be attained by adopting proper nutrient management (FAO, 2017). According to Azam-Ali and Judge (2001), by undertaking proper management practices cashew nut at the rate of 10 to 15 kg can be harvested from a tree. India is a prominent global cashew grower, processor, exporter and consumer. Production of old and newly established cashew plantation can be improved by adopting proper nutrition and it was observed that cashew plants performs better under well managed fertilization and manures through its growth period. In young plants growth and flowering of cashew is enhanced by manures and fertilizers application (Adejuma, 2010). In India, cashew is grown in East and West coasts and parts of Madhya Pradesh and Karnataka (Kulkarni *et al.,* 2012). India grows 7.51 lakh metric tons of cashews annually over an area of 11.84 lakh

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hectares (Hubballi, 2023). According to Besavaraj *et al.* (2018) the productivity of cashew was quite low compared to other significant cashew-growing nations like Mozambique and Vietnam. Commercially, cashew is grown in Maharashtra, Kerala, Tamil Nadu, Odisha, West Bengal, Andhra Pradesh, Goa and Karnataka. Odisha is account for 1.21 lakh metric tonnes of total cashew production from area of 2.23 lakh hectare with productivity as low as 672 kg/ha as compared to other cashew growing states during 2021-22 (Hubballi, 2023). The main ingredient of cashew kernels, that account for up 48.3% of their weight, is fat. Out of total fat, 79.7% is unsaturated fatty acid, 20.1% is saturated fatty acid and 0.2% is trans fatty acid. Other ingredients include proteins (21.3 g/100 g), carbohydrates (20.5 g/100 g), vitamins and minerals (Rico *et al*., 2017). Cashew Nut Shell Liquid (CNSL), a high-quality oil found in cashew shells, has a variety of industrial uses. Vitamin C is found in abundant quantity in cashew apples, which may also be used to make value-added products including wine, fenni, juice, dried cashew apples, syrup and jam (Suganya and Dharshini, 2011). The use of high yielding cultivars has led to a continuous rise in cashew productivity and production. But the productivity of both India and Odisha is quite low and decrease in cashew productivity is contributed by non-adoption of scientific cultivation practices, no or less adoption of proper nutrient management practices (Maruthi *et al*., 2015). Though cashew is grown and perform well under unfertile and waste land in rainfed condition, but it responses well to manures and fertilizers application. Hence, keeping this fact in mind, the trial was undertaken to determine influence of yield and yield attributing traits of cashew with cashew kernel and apple physico-chemical properties.

MATERIALS AND METHODS

The field trial was carried out at Cashew Research Station, All India Coordinated Research Project on Cashew (AICRP on Cashew), Ranasinghpur, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha during 2021-22 to 2022-23 to identify the effects of foliar nutrient application on yield and yield attributing traits and apple physico-chemical properties. The experiment was designed in randomized block design (RBD) with 6 treatments *viz*., T_1- 100% RDF (500: 250: 250 g NPK/ plant/ year), T_2- 100% RDF+10 kg FYM/plant/ year, T_3- 100% RDF+10 kg FYM/plant/year +Foliar spray of major nutrients (3% Urea+0.5% MAP+1% K_2SO_4), T_4- 100% RDF+10 kg FYM/plant/ year+ foliar spray of secondary and micro-nutrients (0.5 % $ZnSO_4$ + 0.1 % Solubor + 0.5 % $MgSO_4$), T_5- 100% RDF+10 kg FYM/plant/year+ Foliar spray of major nutrients (3% urea +0.5% MAP+1% K_2SO_4) + Foliar spray of secondary and micro-nutrients (0.5 % $ZnSO_4$ + 0.1% Solubor + 0.5% $MgSO_4$) and T_6- Control *i.e*. without any application of manures and fertilizers and replicated four times. Each treatment consisted of six plants and bold nut early bearing cashew cultivar BPP- 8 was taken for study.

Data collection

For nut characters, 50 nuts for each treatment were sampled at early, mid and late harvesting period and pooled. Data on nut length (cm), nut breadth (cm) and nut weight (g) were recorded. For kernel weight sun dried raw nuts were shelled using foot operated shelling machine and weight of 50 whole kernel were taken and expressed in gram. Kernel weight and shell weights were noted and shelling percentage was calculated. Total raw nuts collected during harvesting period were taken and expressed as kilogram of raw nuts per plant as well as nut yield per hectare. Physical parameters like apple length (cm), breadth (cm) and weight (g) were recorded by measuring 10 ripened cashew apples for each treatment at different stages *viz*., initial, mid and final of apple production season and pooled to record the final data. Biochemical parameters like carbohydrate, starch, fat and protein content of cashew kernel and TSS, total sugar, titarble acidity and ascorbic acid content were analysed in laboratory and data recorded.

Statistical analysis

Data on growth and flowering characters were recorded at different growth stages and analysed following standard methodology for analysis of variance is appropriate for randomized block design (RBD) as stated by Panse and Sukhatme (1967). Pearson correlation coefficients for phsyico-chemical traits of cashew nut and apple under different nutrient treatments was studied using KAUGRAPES software.

RESULTS AND DISCUSSION

Nut parameters

Yield attributing traits like nut length, nut breadth, nut weight, nut yield plant^{-1} and nut yield hectare^{-1} were found significantly influenced by foliar application of nutrients from flowering to fruit set as compared with control (Table 1). Maximum length (3.83 cm), breadth (92.65 cm) and weight (7.79 g) of nut were observed in T_5 whereas, minimum nut length (3.58 cm), nut breadth (2.51 cm) and nut weight (6.89 g) were reported in control. T_5 was found statistically parity with T_3 and T_4 for nut length and with T_4 for nut breadth and nut weight. T_5 was found superior among all the treatment and highest nut yield plant^{-1} (6.05 kg) and nut yield hectare^{-1} (1.24 tonnes) were found in T_5 and lowest nut yield plant^{-1} (4.00 kg) and nut yield hectare^{-1} (0.82 tonnes) in T_6. Foliar nutrient application significantly influenced kernel weight of cashew and T_5 observed maximum kernel weight of 2.35 g which is statistically at par with T_4 (2.27 g) whereas, lowest kernel weight (1.95 g) was recorded in T_6. Shelling percentage of cashew was found non-significant and it ranged between 28.36% - 29.75%. Foliar spraying of nutrients resulted in more vegetative growth and accumulation of more photosynthates as reserved food material and utilized by plants during nut developmental stages which significantly improves nut characters like nut

length, breadth and nut weight. Increase in nut set, nut retention and nut weight resulted in more nut yield plant^{-1} and per hectare. These results were well supported by Ramteke *et al.* (2022) in cashew, Boora (2016) in mango, Prabhu *et al.* (2018) in acid lime and Jat and Kacha (2014) in guava. According to Yamakanamardi *et al.* (2020), the storage tissues would have retained the leftover effects of nutrients like N, P and K that were adsorbed throughout the blooming and fruit set phase. These tissues then serve as a resource material for the growth and maturity of nuts. Sapkal *et al*. (2000) have also reported on the increased cashew nut production resulted by urea spray. Increased nutrient adsorption and improved nut retention would have improved the tree's ability to use its nutritional resources, producing a maximum production (Kumar and Reddy, 2008).

Apple characters

Nutrient management of cashew impacted apple characters and found significant among treatments (Table 2). Maximum apple length (6.40 cm) was found in T_4 and it was at par with T_2 and T_3 whereas, minimum apple length was reported in T_6 (5.73 cm). Maximum and minimum apple breadth were observed in T_5 (4.28 cm) and T_6 (3.89 cm) respectively. Highest apple weight was recorded in T_5 (56.03 g) which was at *par* with T_2, T_3 and T_4. Lowest apple weight found in T_6 (48.22 g). Spraying of macro, secondary and micronutrients resulted in protein and carbohydrate synthesis which helps in increasing size, shape and weight of cashew apple. In cashew, Lakshmipathi *et al*. (2015) also corroborated these findings. Similar findings were also reported by Gurjar *et al.* (2015) in mango. Biochemical parameters like apple TSS, total sugar, titratable acidity and ascorbic acid content also influenced by foliar nutrient application. Highest TSS content was found in T_4 (12.74°Brix) and lowest in T_6 (11.46°Brix). T_5 reported maximum total sugar (12.42 %) and ascorbic acid content (180.38 mg/100 g). Maximum and minimum titarble acidity were found in T_4 (0.48%) and T_6 (0.43%) respectively. Spraying of secondary and micronutrients along with major nutrients improving reproductive and quality traits and these results were accordance with Lakshmipathi *et al*. (2023) in cashew, Viswakarma *et al*. (2022) in mango and Sabahat *et al.* (2021) in strawberry.

Biochemical parameters of kernel

Biochemical parameters of cashew kernel was found significantly influenced by foliar nutrient management (Table 3). Fat content of cashew kernel was found maximum in T_5 (46.18%), it was statistically at par with T_4 (45.79%) and lowest in control (43.11%). T_5 (22.78%) recorded highest carbohydrate content of cashew kernel which was statistically at par with T_4 (22.68%) and T_3 (22.09%) and

Table 1: Effect of foliar nutrient application on physical properties of cashew nut cv. Balabhadra.

Treatment	Nut length (cm)	Nut breadth (cm)	Nut weight (g)	Nut yield per plant (kg)	Nut yield per hectare (t)	Kernel weight (g)	Shelling (%)
T_1	3.63	2.55	7.11	4.43	0.90	2.04	28.81
T_2	3.67	2.56	7.19	4.60	0.94	2.08	28.95
T_3	3.79	2.59	7.43	4.98	1.02	2.16	29.12
T_4	3.78	2.64	7.60	5.15	1.05	2.27	29.54
T_5	3.83	2.65	7.79	6.05	1.24	2.35	29.75
T_6	3.58	2.51	6.89	4.00	0.82	1.95	28.36
Mean	3.71	2.58	7.33	4.87	0.99	2.14	29.09
SE(m) ±	0.02	0.02	0.12	0.17	0.04	0.03	0.49
CD @ 5%	0.07	0.04	0.34	0.50	0.10	0.10	NS
CV %	1.78	1.62	4.56	9.99	9.99	4.60	4.75

Table 2: Effect of nutrient management on physical and chemical properties of cashew apple cv. Balabhadra.

Treatment	Apple length (cm)	Apple breadth (cm)	Apple weight (g)	TSS (°Brix)	Total sugar (%)	Ascorbic acid (mg/100 g)	Titratable acidity (%)
T_1	6.18	3.94	49.79	11.64	11.51	167.63	0.44
T_2	6.33	3.99	51.93	11.75	11.78	171.00	0.45
T_3	6.31	4.07	52.57	11.94	11.83	173.13	0.46
T_4	6.40	4.18	55.03	12.74	11.98	178.88	0.48
T_5	6.09	4.28	56.13	12.21	12.42	180.38	0.46
T_6	5.73	3.89	48.22	11.46	10.51	155.63	0.43
Mean	6.18	4.06	52.28	11.95	11.67	171.10	0.45
SE(m) ±	0.05	0.05	1.88	0.18	0.25	4.95	0.01
CD @ 5%	0.15	0.13	5.42	0.52	0.73	NS	0.03
CV %	2.43	3.19	10.15	4.24	6.12	8.18	5.96

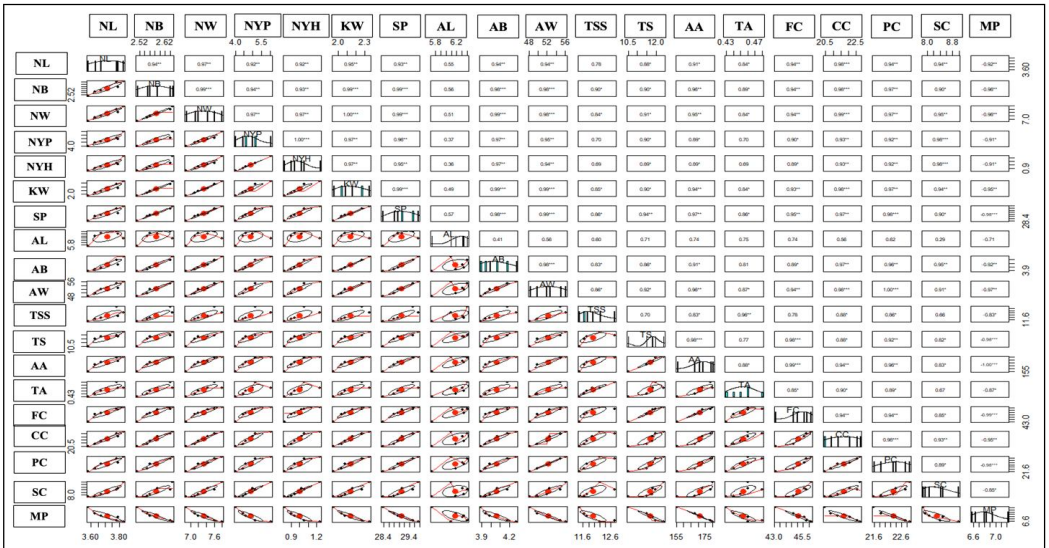
minimum carbohydrate content was found in T_6 (20.44%). Foliar spray of nutrients had a substantial impact on protein content of cashew kernel. The maximum and minimum protein content of kernel were found in T_5 (22.89%) and minimum in T_6 (21.58%). T_5 was found statistically at par with T_4 (22.75%), T_3 (22.39%) and T_2 (22.30%). Both starch and moisture content of cashew kernel was found non-significant and maximum and minimum starch and moisture content were reported in T_5 and T_6 respectively. Foliar spraying of macro, secondary and micronutrients resulted in improvement in quality traits of cashew kernel. Foliar spraying enhanced translocation of nutrients and minerals to the fruits improving quality of fruits and deficiency of nutrients resulted in poor quality fruit production. This study is in consistent with Lakhmipathi *et al.* (2023) in cashew and Sabahat *et al.* (2021) in starwberry where macronutrients along with micronutrients, namely zinc, boron and iron, enhanced reproductive features, primarily fruiting parameters and quality attributes.

Correlation study of nutrient management on yield and yield attributing traits and biochemical properties of cashew nut and apple

Pearson correlation coefficient analysis was performed among yield and yield attributing traits and biochemical parameters under nutrient analysis for pooled data (Fig 1). The data presented in the figure indicate that nut physical characters like nut length was found positively correlated with nut breadth, nut weight, nut yield plant^{-1}, nut yield hectare^{-1}, kernel weight, shelling percentage, apple breadth, apple weight, fat content and starch content at P<0.01%; ascorbic acid content and titarble acidity at <0.05% and carbohydrate content of kernel at <0.001%. Whereas, moisture content of kernel was found negatively correlated

Table 3: Effect of nutrient management on chemical properties of cashew kernel cv. Balabhadra.

Treatment	Fat (%)	Carbohydrate (%)	Protein (%)	Starch (%)	Moisture (%)
T_1	44.64	20.86	21.84	7.94	6.94
T_2	44.95	21.30	22.30	8.07	6.83
T_3	45.57	22.09	22.39	8.49	6.79
T_4	45.79	22.58	22.75	8.42	6.64
T_5	46.18	22.78	22.89	8.98	6.58
T_6	43.11	20.44	21.58	7.87	7.21
Mean	45.04	21.67	22.29	8.30	6.83
SE(m) ±	0.19	0.28	0.22	0.28	0.11
CD @ 5%	0.55	0.81	0.62	NS	NS
CV %	1.19	3.65	2.73	9.67	4.65



NL: Nut length; NB: Nut breadth; NW: Nut weight; NYP: Nut yield plant^{-1}; NYH: Nut yield hectare^{-1}; KW: Kernel weight; SP: Shelling percentage; AL: Apple length; AB: Apple breadth; AW: Apple weight; TSS: Total Soluble Solid of apple; TS: Total sugar of apple; AA: Ascorbic acid of apple TA: Titratable acid of apple; FC: Fat content of kernel; CC: Carbohydrate content of kernel; PC: Protein content of kernel; SC: Starch content of protein and MP: Moisture percentage of kernel.

Fig 1: Correlation analysis of nutrient management with yield and yield attributing traits and biochemical properties of nut and apple of cashew cv. Balabhadra.

at P value < 0.001% and apple length and TSS were non-correlated with nut length. Similarly, nut breadth and nut weight were found positively correlated with most of the characters except moisture content which is negatively correlated at P value <0.01% and apple length was observed non-correlated with nut breadth and nut weight. Nut yield plant^{-1} and nut yield hectare^{-1} were positively correlated with nut length, breadth, weight, kernel weight, shelling percentage, apple breadth, apple weight, carbohydrate content, protein content; starch, total sugar and ascorbic acid content of cashew apple as well as fat content of kernel. Apple length, TSS and titratable acid content of cashew apple were non-correlated and moisture percentage of cashew kernel was found negatively correlated with nut yield (P<0.5%). Kernel weight was reported positively correlated with nut length, nut breadth, nut weight, nut yield plant^{-1}, nut yield hectare^{-1}, ascorbic acid content of apple, fat, carbohydrate and starch content of kernel at P<0.01%. Shelling percentage, apple breadth, apple weight and carbohydrate content were positively correlated with kernel weight and moisture content of kernel was found negatively correlated at P value<0.01%. Apple length exhibited non-correlated relationship with all the factors. Apple breadth and apple weight showed positive correlation with most of the characters except apple length which is non-correlated and moisture content of cashew kernel which was found negatively correlated at P<0.01%. TSS content of cashew apple was found non-correlated with most of characters except nut breadth, nut weight, kernel weight, shelling percentage, apple breadth, apple weight, ascorbic acid, titratable acidity, carbohydrate content and protein content and negatively correlated with moisture content at P<0.5%. Titratable acidity, ascorbic acid content and total sugar established positive correlation with most of the characters except moisture content which was found negatively correlated to these traits. Biochemical trait of cashew kernel like fat was found positively correlated with nut length, breadth, weight, kernel weight, shelling percentage, apple weight, carbohydrate content, protein content of kernel. Total sugar and ascorbic acid content showed positive correlation and nut yield plant^{-1}, nut yield hectare^{-1}, titratable acidity and starch content expressed positive correlation at P value 0.5%. Other biochemical parameters of cashew kernel like carbohydrate content, protein content and starch content were found positively correlated with most of the yield and yield attributing traits. Moisture content of cashew kernel was found negatively correlated with all the characters.

CONCLUSION

The current study reported that treatment consisting of soil nutrient management with recommended dose of fertilizes (500: 250: 250 g NPK/plant/year) and FYM @ 10 kg/plant/year as well as foliar application of macro, secondary and micronutrients (3% urea+0.5% MAP+1% K_2SO_4)+Foliar spray of secondary and micro-nutrients (0.5% $ZnSO_4$ + 0.1% Solubor + 0.5% $MgSO_4$) on cashew during flowering to fruit set had significantly influenced yield attributing characters of cashew cultivar Balabhadra like nut length, breadth, nut weight, kernel weight, shelling percentage, nut yield per plant and nut yield per hectare and biochemical properties of cashew kernel such as fat, carbohydrate, proteins and starch content and TSS, total sugar and titratable acidity of cashew apple due to efficient utilization of applied nutrients by the plant and increase in photosynthates. The result was validated with correlation co-efficient analysis study considering yield and yield attributing traits as well as biochemical parameters and it inferred that most of the traits are positively correlated with each other which will be helpful for further future study on foliar fertilization in cashew.

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Authors' contribution

Conceptualization: Pramod Kumar Panda, Chinmaya Jena; methodology: Chinmaya Jena, Pramod Kumar Panda and Kabita Sethi; software: Pramod Kumar Panda, Rajendra Kumar Panda and Kartik Pramanik; formal analysis: Chinmaya Jena and Chandan Kumar Rout; investigation: Chinmaya Jena; writing- original draft preparation: Chinmaya Jena, Pramod Kumar Panda and Kartik Pramanik, writing-review and editing: Pramod Kumar Panda and Rajendra Kumar Panda; supervision: Pramod Kumar Panda, Kabita Sethi, Rabindra Kumar Nayak and Rajendra Kumar Panda; validation: Pramod Kumar Panda, Rabindra Kumar Nayak, Rajendra Kumar Panda and Kabita Sethi.

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Research content

The research content of manuscript is original and has not been published elsewhere.

Ethical approval

The research design, data collection and analysis procedures were guided by established ethical principles. No ethical concerns arose during the course of this study.

Data availability

The data used to support the findings of the study are included within the article.

Consent to publish

All authors agree to publish the paper in Agricultural Science Digest.

Conflict of interest

The authors declare that is there is no conflict of interest.

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