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Research Note

Genetic variability studies of diverse cashew (*Anacardium occidentale* L.) cultivars for growth and yield parameters in coastal zone of Karnataka

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Abstract
The present study aimed to evaluate the performance of cashew cultivars developed/collected from different cashew growing regions of the country. The experiment was conducted at Agricultural and Horticultural Research Station, Ullal, belonging to coastal zone of Karnataka during 2023-24. Fifteen year old standing cashew orchard planted with 42 diverse cashew cultivars were evaluated for 15 fruit, nut, growth and yield parameters following randomized complete block design with two replications. Highly significant variations of GCV and PCV coupled with high heritability and GAM was observed for most of the traits indicating the predominance of additive gene action and possibilities of achieving high genetic gain from selection. Character association studies revealed the importance of yield component traits like nuts per panicle, canopy surface area and canopy spread (E-W and E-W) that forms the basis for selection of promising cultivars for yield improvement in cashew. Potential high yielding varieties like Ullal 1, Bapatla 8, Gubbi 3/111, NRCC Selection 2, Ullal 3 and VRI-3 were found to be suitable in coastal zone of Karnataka. Bapatla 8, Priyanka and Vengurla 7 cultivars exhibited superiority for both nut weight and nut yield per tree. This study provides useful information on genetic control of important yield traits and choice of potential cultivars in hybridization program to explore the variability and hybrid vigor for improvement of productivity and quality in cashew.

Keywords: Cashew, coastal zone, nut yield, variability, correlation

Cashew (*Anacardium occidentale L.*) is one of the most valuable processed nuts on global commodity markets that contribute to the social and economic development of the country and the world (Bezerra *et al.,* 2007; Masawe 2009). There is an ever-increasing demand for cashew kernel both in international and domestic markets. Cashew is an ecologically flexible tree crop cultivated in a wide range of rainfall (500 - 3700 mm/year) and soils (Gupta, 1993). The cashew crop is well adapted to the humid tropical climate grown for nutritional and health benefits. True apple of the cashew is the actual nut, while the peduncle enlarges and develops in the form of a juicy carbohydrate rich cashew apple or pseudo fruit (Mothe´ *et al.,* 2006). Fresh cashew apple juice and processed juice are among the most desirable natural fruit products that that serves as a rich source of vitamin C and lipids (Costa *et al.,* 2009). In addition, cashew apple also contains important minerals like calcium and phosphorus.The kernel inside the nut is most valued part of the cashew tree as it is a rich source of high-quality protein, polyunsaturated fatty acids, carbohydrates and minerals with high levels of calcium, iron and phosphorus (Aremu *et al.*, 2006). The cashew nut shell is hard and contains a liquid referred as cashew nut shell liquid (CNSL), a valuable raw material used for paints and warmish industries (Sethi *et al.,* 2015). There are more than sixty genera and four hundred species related to the genus of *Anacardium* (Borges, 2021).

Cashew was introduced in India during 16th century with a view to prevent soil erosion (Elakkiya *et al.*, 2017). Since it can be adapted to diverse agro-climatic conditions, it has become a crop of high commercial value (Chaithra *et al.,* 2019). India was the first country to explore the importance of cashew for commercial plantation (Saroj and Mohana, 2016). India is the second largest exporter of cashew kernels in the world and earns a sizeable amount of foreign exchange (Paul and Ushadevi, 2022). Currently in India, cashew is cultivated in an area of 11.92 lakh hectares, with the production of 7.81 lakh metric tons and productivity of 766 kg/ha (DCCD, 2023). Traditionally, cashew has been an important crop of the Coastal Region (Western and Eastern) but recently it is occupying even non-traditional areas as well. In Karnataka, cashew is grown in an area of 1.38 lakh ha with production of 0.74 lakh tons and productivity of 653 kg/ha (DCCD, 2023). There is a great scope for expanding area under cashew in the plains of Karnataka (Bhat *et al.,* 2010). Udupi and Dakshina Kannada districts are the highest producers of cashew in Karnataka. However, there is a wide gap between production and demand of raw cashew nut for processing industries. The low level of productivity is the mainly due to narrow genetic base and existence of area under old and seedling based plantations in addition to poor management practices.

Research on cashew improvement had resulted in identification of 55 varieties in which 33 are direct selections and 22 are hybrids. Among these, only 42 have been recommended for cultivation (Nayak and Muralidhara, 2019). The performance of varieties vary from region to region, therefore for getting more yield potentials, the varieties should be selected based on its suitability to the region. Progress in improvement of cashew is limited due to a long gestation period needed to generate breeding materials with better performances (Adewale *et al*., 2013) and subsequent evaluation of generated material. The varieties NRCC Sel-2, Bhaskara, Ullal-I, Ullal-3, Ullal-4, Vengurla-4, Vengurla-7, Madakkathara-2, Chintamani-1 and Chintamani-2. have been recommended for cultivation in Karnataka. Performance evaluation of released varieties and hybrids in Indian condition revealed that in the states where both selections and hybrids were released for cultivation, hybrids performed better than the selections since the hybrid vigor is high and can be easily exploited in cashew due to amenability of this crop for vegetative propagation (Saroj and Mohana, 2016). Evaluation of released genotypes and germplasm collections of cashew is essential for strengthening the breeding program through selection of promising cultivars in hybridization program for development of high yielding cashew varieties and hybrids.

Proper utilization of diverse genetic resources is important in a breeding programme to improve the yield of the crop (Nandini *et al.,* 2020). Phenotypic evaluation and characterization of the genetic resources is a pre requisite for the exploration of useful traits in plant breeding (Brandolini *et al.,* 2000). The success of any breeding programme depends mainly upon the genetic variability in the base collections for further selection and utilization as parents in hybridization (Asna *et al.,* 2021). Therefore, present investigation was undertaken to evaluate the performance of 42 cashew cultivars for growth and yield parameters and to estimate the genetic variability and correlations among these traits to form the basis of selection for further utilization in hybridization for development of promising genotypes.

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The present investigation was undertaken at Agricultural and Horticultural Research station (AHRS), Ullal, Mangaluru situated in coastal zone of Karnataka during the year 2023-24. This station is located at 15m above mean sea level with 12°48'37.4"N latitude and 74°51'22.6"E longitude. Ullal is a cashew growing belt of Dakshina Kannada district. The soils of this zone are predominantly lateritic soils of acidic in nature with pH ranging from of 5.4 to 5.8. Fifteen year old uniformly grown and bearing trees of 42 diverse clonal cultivars planted at a spacing of 7.5m × 7.5m were chosen for this investigation. Experiment was constituted following a Randomized Complete Block Design replicated twice with five trees in each replication. During the fruiting period of March to May depending on the flowering and maturity of different cultivars, the uniform ripe apples and nuts from each tree were harvested separately and observed for different morphological traits. Apple characters were recorded on apple length, apple width, apple weight and TSS/Brix reading from ten ripe apples in each replication. The weight of the apple was recorded by collecting ten ripe apples per genotype. The apple length and width were measured using a Vernier calipers. TSS / Brix reading was recorded from the apple juice by using hand refractometer. Canopy spread was observed on tape measurements in east to west (EW) and north to south (NS) directions and canopy surface area was computed. Further, nut yield (kg tree-1) was recorded by collecting the nuts from all the accessions in both the replications at the rate of five trees per replication on a daily basis throughout the harvesting period, which varied among the different cultivars from January to May as per the methodology described in the experimental manual on cashew by the National Research Center for Cashew (NRCC, 2005).

The statistical analysis of data obtained from field experiment for 15 quantitative traits was subjected for analysis of variance using OPSTAT software. Critical difference (CD) was worked out at two level of significance of P=0.05 and 0.01 wherever 'F' test was significant. Further, phenotypic and genotypic variances were estimated following Baye (2002) to study the genetic variability among the cultivars for observed traits. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were computed according to Burton (1952). Heritability in broad sense was calculated

and expressed in percentage following Falconer (1981). Genetic Advance over Mean (GAM) was computed assuming the selection intensity of 5% according to the methods suggested by Johnson *et al.* (1955). Simple correlation coefficients were analyzed among 15 quantitative traits using OPSTAT statistical software to study the association of the traits with nut yield.

Variability is the prerequisite in any breeding program and the extent of genetic variability for desirable traits determines success in selection of potential genotypes. Statistical analysis of variance for the three main components of the dimensions of the cashew apple viz., apple weight, apple thickness and apple length in addition to Brix% among the 42 cashew cultivars indicated highly significant variations during the year, 2023-24 (**Table 1**). Similar results of highly significant variations for apple dimensions have been reported (Anand *et al*., 2015). Similarly, nut traits like nut weight, nut thickness and nut length also revealed highly significant variations among the cultivars. Tree growth parameters namely, panicles per m^2 , nuts per panicle, canopy spread E-W, canopy spread N-S and canopy surface area indicated highly significant differences among the studied cultivars. Nut yield per tree indicated highly significant variations among the cultivars. These results of highly significant variations for fruit, nut, growth and yield parameters are attributed to high diversity that existed among the cultivars under investigation and there is an ample scope to explore this variability for the improvement of cashew. Similar results of highly significant variations observed for nut traits (Tripathy *et al.,* 2015; Gajbhiye *et al*., 2015), growth (Hanumanthappa *et al*., 2014; Tripathy *et al*., 2015) and yield parameters (Hore *et al*., 2015; Tripathy *et al*., 2015) among different cashew cultivars are evident from the previous reports.

Genetic variability among these diverse cashew cultivars for different quantitative traits was studied in terms of range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation, broad sense heritability (h^2) and genetic advance over mean (GAM) (**table 2)**. Wide range of variation was observed for all the traits under study. Among apple traits, highest value for apple weight was observed in cultivar Nairobi (163.36 g) and minimum was observed in Puttur local (23.30 g). Apple thickness was highest in variety Vengurla 7. Long apple types were observed in UN-50 variety. Very short apples were observed in Puttur local. TSS% was highest for Kanaka variety with 13.88%. Dimensions of the cashew apples are higher than those of the cashew nuts as the apple is more voluminous than the nut. The difference in dimensions of the apples revealed various shapes in different cultivars. The variability in the dimensions of the cashew apple indicate the volume of the fruits of the various localities that allow to make varietal selections (Dakuyo *et al.,* 2022). High genotypic and phenotypic coefficients of variations coupled with high heritability and GAM were recorded for apple weight and length. However, moderate estimates of GCV and PCV coupled with high heritability and GAM was revealed for apple thickness and Brix%. This high variability observed for fruit parameters may be attributed to wide genetic backgrounds of these cultivars contributed through introduction, domestication and improvement of open-pollinated progenies that serves as the primary source for development of these diverse cashew genotypes (Aliyu, 2012). High genetic variability observed among the cultivars indicated scope for selection of potential candidates for breeding program.

Nut parameters recorded for 42 cultivars revealed higher mean (7.98 g) with wide variation (**Fig. 1**) ranging from 4.24 (Puttur local) to 15.33 (Moodabidri local). Bold nut

Table 1. Analysis of variance for growth and yield parameters in cashew

Trait	Mean Sum of Squares			S.EM	CV (%)	CD (5%)	CD (1%)
df	Genotype	Replication	Error				
	41	1	41				
Apple weight	1681.558**	31.592	23.655	3.44	7.96	9.82	13.14
Apple thickness	110.353**	9.407	7.46	1.93	6.43	5.52	7.38
Apple length	268.140**	2.987	12.305	2.48	6.48	7.08	9.48
Brix%	3.629**	0.242	0.443	0.47	6.46	1.34	1.8
Nut weight	10.879**	0.259	0.331	0.41	7.16	1.16	1.55
Nut thickness	24.077**	0.094	0.875	0.66	4.5	1.89	2.53
Nut length	80.877**	2.298	0.974	0.7	3.13	1.99	2.67
Panicles per m^2	18.240**	3.789	3.576	1.34	16.63	3.82	5.11
Nuts per panicle	7.376**	0.728	0.455	0.48	17.77	1.36	1.82
Canopy spread E-W (m)	3.798**	0.042	0.499	0.5	9.12	1.43	1.91
Canopy spread N-S (m)	5.005**	0.02	0.516	0.51	9.37	1.45	1.94
Canopy surface area (m^2)	1049.259**	32.934	119.876	7.74	13.65	22.11	29.57
Yield (kg/tree)	26.669**	2.535	1.868	0.97	13.32	2.76	3.69

Table 2. Genetic variability for growth and yield parameters in cashew

Character	Maximum	Minimum	Mean	GCV (%)	PCV (%)	h^2 (%)	GAM (%)
Apple weight (g)	163.36	13.30	61.11	47.11	47.78	97.23	95.69
Apple thickness (g)	62.78	25.11	42.47	16.89	18.07	87.34	32.51
Apple length (mm)	82.69	25.64	54.11	20.90	21.88	91.22	41.12
Brix (%)	13.88	7.50	10.19	12.26	13.86	78.25	22.34
Nut weight (g)	15.33	4.24	8.03	28.58	29.46	94.09	57.10
Nut thickness (mm)	44.10	12.02	31.50	20.06	20.31	97.62	40.83
Nut length (mm)	13.87	7.50	10.29	12.26	13.86	78.25	22.34
Panicles per m^2	20.50	4.50	11.37	23.81	29.05	67.21	40.22
Nuts per panicle	34.25	16.56	20.78	16.39	17.00	92.99	32.55
Canopy spread E-W (m)	12.05	5.45	7.74	16.58	18.92	76.78	29.93
Canopy spread N-S (m)	14.20	4.55	7.66	19.54	21.67	81.30	36.30
Canopy surface area (m^2)	155.19	48.88	80.18	26.88	30.15	79.49	49.38
Yield (kg/tree)	18.19	3.95	10.25	34.33	36.83	86.91	65.93

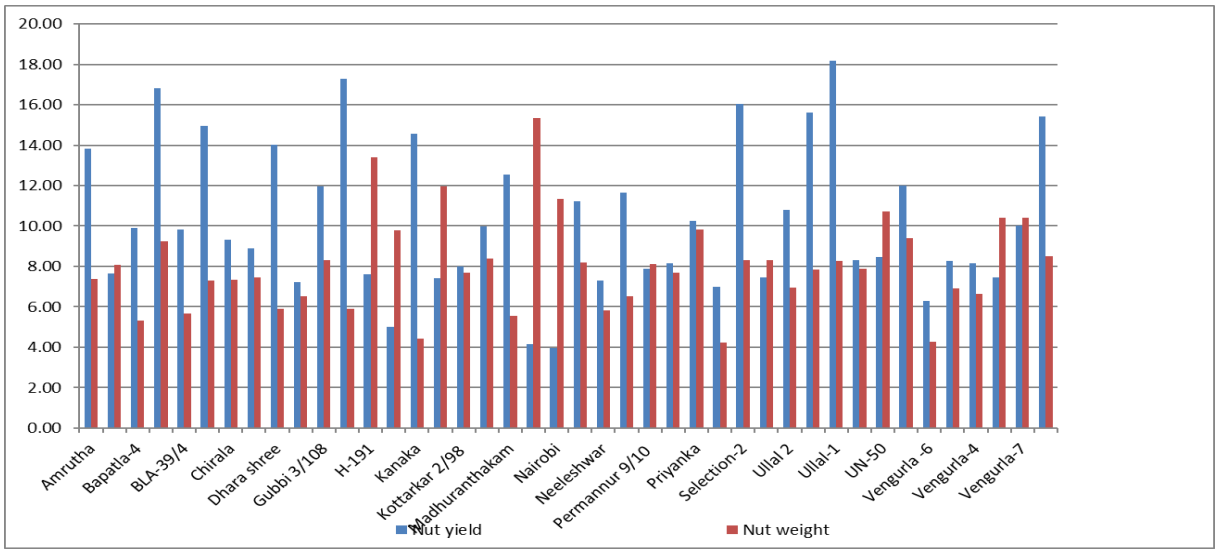

Fig. 1. Variability and performance of 42 cashew cultivars for nut yield per tree and nut weight

types with nut weight of more than 9g was recorded in eight cashew cultivars namely H-191 (13.40 g), Kerala Genetic stock 1(12.00 g), Nairobi (11.34 g), Vengurla 7 (10.40), UN 50 (10.22 g), Priyanka (10.04 g), H-216 (9.8 g) and Bapatla 8 (9.25g). Vengurla 6 variety revealed very low nut weight of 4.27 g. Other parameters like nut length and nut thickness also revealed wide range of variations. Nut thickness was highest for Kottarkar 2/98 (34.25 mm). Nut length was highest in Moodabidri local (44.11 mm). Very low nut thickness and nut length were observed in Vengurla 6 (916.56 mm) and Puttur local (12.03 mm) respectively. High estimates of GCV and PCV was observed for nut weight and nut length, while moderate estimates of GCV and PCV were recorded for nut thickness. All the nut parameters revealed high heritability coupled with high GAM. High variability for all these nut parameters indicated high genetic gain and scope for selection of best genotypes for further breeding. Similar reports of high variability coupled with high Heritability and GAM for nut weight has been reported (Eradasappa *et al.,* 2020).

Tree growth parameters namely panicles per m^2, nuts per panicle, canopy spread E-W, canopy spread N-S and canopy surface area revealed high variability in terms of mean, range and moderate to high estimates of GCV, PCV coupled with high heritability and GAM for all the traits. Highest number of panicles per m^2 and nuts per panicle was recorded in VRI 3 (20.50 and 9.0) and lowest values were observed in Moodabidri local (4.5 and

Table 3. Correlation coefficients for growth and yield parameters in cashew

Traits	Apple weight	Apple thickness	Apple length	Brix%	Nut weight	Nut thickness	Nut length	Panicles per m^2	Nuts per panicle	Canopy spread E-W (m)	Canopy spread N-S (m)	Canopy surface area (m^2)	Yield (kg/tree)
Apple weight	1.000												
Apple thickness	0.663**	1.000											
Apple length	0.563**	0.500**	1.000										
Brix%	0.154^{NS}	-0.022^{NS}	-0.111^{NS}	1.000									
Nut thickness	0.220^{NS}	0.144^{NS}	0.070^{NS}	0.079^{NS}	1.000								
Nut weight	0.565**	0.504**	0.582**	-0.011^{NS}	1.000	0.266^{NS}							
Nut length	0.468**	0.477**	0.664**	0.070^{NS}	0.685**	-0.255^{NS}	1.000						
Panicles per m^2	-0.028^{NS}	0.049^{NS}	-0.063^{NS}	0.118^{NS}	-0.304*	0.090^{NS}	-0.308*	1.000					
Nuts per panicle	-0.123^{NS}	-0.013^{NS}	0.016^{NS}	0.066^{NS}	-0.210^{NS}	-0.170^{NS}	-0.001^{NS}	0.265^{NS}	1.000				
Canopy spread E-W (m)	-0.107^{NS}	-0.076^{NS}	-0.091^{NS}	0.154^{NS}	-0.104^{NS}	-0.168^{NS}	-0.093^{NS}	0.015^{NS}	-0.101^{NS}	1.000			
Canopy spread N-S (m)	-0.154^{NS}	-0.017^{NS}	-0.166^{NS}	-0.033^{NS}	-0.017^{NS}	-0.103^{NS}	-0.082^{NS}	-0.061^{NS}	-0.124^{NS}	0.686**	1.000		
Canopy surface area (m^2)	-0.265^{NS}	-0.129^{NS}	-0.282^{NS}	0.032^{NS}	-0.115^{NS}	-0.161^{NS}	-0.129^{NS}	0.021^{NS}	-0.214^{NS}	0.807**	0.706**	1.000	
Yield (kg/tree)	-0.314*	-0.150^{NS}	-0.195^{NS}	0.248^{NS}	-0.327*	-0.184^{NS}	-0.152^{NS}	0.218^{NS}	0.439**	0.522**	0.338*	0.610**	1.000

1.5). The results on canopy spread in both North-South and East-West directions as well as canopy surface area exhibited significant variations among the cultivars. Canopy spread is crucial parameter for the management of canopy and for selection of potential cultivars suitable for high density planting system (Adiga *et al.,* 2020). The canopy spread in East-West direction ranged from 5.45m (Ullal 4) to 12.05 m (Kottarkar 7/91). Similarly, the canopy spread in North-South direction ranged from 4.55m (Bhaskara) to 14.20m (Kottarkar 7/91). Highest canopy surface area was recorded in the variety Brazil (155.19 m^2) and lowest was observed in UN-50 (48.80 m^2). Canopy management has a direct influence on plant vigour which plays an important role to regulate vegetative growth, flowering and yield in fruit trees (Srilatha ***et al.***, 2015). Similar results of moderate to high estimates of variability coupled with moderate to high heritability and GAM are evident for number of nuts per panicle and canopy spread in both the directions as evident from the previous reports (Ramteke *et al.,* 2024 and Eradasappa *et al.,* 2020).

Nut yield per tree also revealed high variation ranging from 3.95kg to 18.19kg per tree (**Fig. 1**) and 592.72 to 2729.27 kg per hectares in varieties Nairobi and Ullal 1, respectively. Many other varieties recorded very high nut yield per tree (>15 kg) namely Bapatla 8 (16.82 kg), Gubbi 3/111 (17.3 kg), NRCC Selection 2 (16.03 kg), Ullal 3 (15.63 kg) and VRI-3 (15.40 kg). Similarly, very low yields (<6 kg) per tree were observed for two varieties namely Moodabidri local and H-216 (5.01kg). High genetic variability (GCV and GCV) coupled with high heritability and GAM was revealed for nut yield per tree indicating the presence of potential variability for selection of promising cultivars for large scale cultivation and use as genetic resource in future breeding program. All the fruit parameters, nut parameters, growth parameters and yield parameters revealed high GCV and PCV values with narrow difference indicative of inherent variability among the genotypes for most of the observed traits is arising mainly due to genetic cause and proved to be highly useful for breeders in improvement of targeted traits. Findings of Sethi *et al.* (2016), Chandrasekhar *et al.* (2018), Eradasappa *et al.* (2020) and Rametke *et al.* (2024) also reported less sensitivity to the environmental influence for most of the quantitative traits in cashew and variation observed has the strong genetic base.

Phenotypic correlation coefficients among fruit, nut, growth and yield parameters with nut yield are presented in **Table 3**. Among the fruit parameters, apple weight revealed significant negative association with nut yield. Whereas, apple thickness, apple length and brix% revealed non- significant association with nut yield. Negative significant correlation of apple weight with nut yield suggests that selection of apple weight may lead to reduction in nut yield. Among nut parameters, nut weight showed negative significant association with nut yield

(**Fig. 1**) indicating the possibility of yield reduction if the selection is aimed only at the bold nut cashew varieties. Contrary to this, non significant association of nut weight with nut yield has been reported (Aliyu, 2012). Other nut parameters like nut thickness and nut length revealed non-significant association with nut yield. All the growth parameters exhibited positive significant association with nut yield except number of panicles per m^2 which revealed positive but not significant association. Among the growth parameters, canopy surface area was found to be highly associated with nut yield (0.611) followed by canopy spread in E-W (0.522) and canopy spread in N-S (0.338). The positive significant association of nuts per panicle and canopy spread in E-W and N-S (Ramteke *et al.,* 2024) are in accordance with the earlier reports. Therefore, selection for highly associated component traits like canopy surface area, canopy spread in E-W and N-S would significantly contribute to yield improvement in cashew.

Evaluation of 42 diverse cashew cultivars identified potential high yielding varieties like Ullal 1, Bapatla 8, Gubbi 3/111, NRCC Selection 2, Ullal 3 and VRI-3 that are suitable for cultivation in coastal zone of Karnataka. Bapatla 8, Priyanka and Vengurla 7 varieties were found to be promising for both nut weight and nut yield. Hence, these potential genotypes with higher nut yield or nut yield combined with bold nut types may be considered in breeding program aimed at yield improvement in cashew. This study also revealed that genotypes with bold nut (>12g) had lower nut yields and selection for only bold nut types may cause reduction in nut yield in cashew. High heritability coupled with high genetic advance revealed for all the quantitative traits in a panel of 42 diverse cultivars indicated the prevalence of additive gene action and possibilities of achieving high genetic gain from selection. Character association studies indicated the importance of yield component traits like nuts per panicle, canopy surface area and canopy spread (E-W and E-W) that must be considered as basis of selection in cashew breeding program.

REFERENCES

Adewale, B.D., Ibiremo, O.S., Odoh, N.C. and Adeyemi, E.A. 2013. Genetic estimates and trend analysis of some growth parameters of cashew (*Anacardium occidentale* L.) as influenced by nine nutrient combinations. *J. Agric. Biotech. Sust. Dev*., **5**(1): 6–11. [Cross Ref]

Adiga, D.J., Veena, G.L., Thondaiman, V. and Babli M. 2020. An overview of canopy management in cashew (*Anacardium occidentale* L.) *J. Hortic. Sci.,* **15**(2): 127-135. [Cross Ref]

Aliyu, O.M 2012. Genetic diversity of nigerian cashew germplasm, genetic diversity in plants. prof. mahmut caliskan (Eds), ISBN: 978-953-51-0185-7.

Anand, A., Sahu, G.S. and Mishra, N. 2015. Physico-chemical Characteristics of Cashew. *Res. J. Agric. Sci.,* **6**(3): 656-658.

Aremu M.O *et al* (2006) Compositional studies and physicochemical characteristics of cashew nut (*Anarcadium occidentale*) flour. *Pak. J. Nutr*., **5**(4):328–333. [Cross Ref]

Asna A.C., Jalaja S.M. and Smitha M.S. 2021. Phenotypic diversity and clustering of germplasm accessions of cashew for utilization and conservation. *Electron. J. Plant Breed.,* **12**(4): 1218 - 1226. [Cross Ref]

Baye, T. 2002. Genotypic and phenotypic variability in *Vernonia galamensis* germplasm collected from Eastern Ethiopia, *Ethiop. J. Agric. Sci.,* **139**: 161-168. [Cross Ref]

Bezerra, M.A., de Lacerda, C.F., Filho, E.G., de Abreu, C.E.B. and Prisco, J.T. 2007. Review: Physiology of cashew plants grown under adverse conditions. *Braz. J. Plant Physiol.,***19**: 449-461. [Cross Ref]

Bhat, M.G., Nagaraja, K.V. and. Rupa T.R. 2010. Cashew research in India. *J. Hortic. Sci.,* **5** (1): 1-16. [Cross Ref]

Borges, J. 2021. Cashew tree (*Anacardium occidentale*): Possible applications in dermatology. *Clin. Dermatol.,* **39** (3): 493−495. [Cross Ref]

Brandolini, A., Castagna, R. and Empilli. 2000. Morphoagronomic variability of the diploid wheat *Triticum monococcum* L. *Plant Genet. Resour. Newsl.* **124**: 36-40.

Burton, G.M. 1952. Quantitative analysis in the Interpretation of Numerical Plantation Data. *New Zealand J. Sci*., **6**: 35-39.

Chaithra, M., Pramit, P. and Bishvajit, B. 2019. Forecasting of area and production of Cashew nut in dakshina kannada using arima and exponential smoothing models *J. Reliab. Stat. Stud*., **12**(2): 61-76. [Cross Ref]

Chandrasekhar, M., Sethi, K., Tripathy, P., Das, T. R., Das, M. and Roy, A. 2018. Studies on variability, heritability and genetic advance for quantitative and qualitative traits in cashew (*Anacardium occidentale* L.). *E-Planet* **16**(2): 139-146

Costa, J.M.C., Felipe, F.M.F., Maia, G.J., Hernandez, F.F.F. and Brasil, I.M. 2009. Production and characterization of the cashew apple (*Anacardium occidentale* L.) and guava (Psidium guajava L.) fruit powders. *J. Food Process. Preserv*., **33**: 299–312. [Cross Ref]

Dakuyo, R., Konate, K., Bazie, D., Sanou, A., Kabore,

K., Sama, H., Santara, B., Konkobo, F.A. and Dicko, M.H. 2022. Correlating the morphology of Anacardium occidentale L. fruits from 30 orchards with their physicochemical and nutritional properties. *Front. Plant Sci*., **13**:1033577. [Cross Ref]

Directorate of Cashew nut and Cocoa Development, Area and production 2022-2023**.** *https://dccd.gov.in* › area-and-production-2022-2022

Elakkiya, E., Sivaraj, P. and Prabhakar, V.A. 2017. Growth and Performance of Cashew Nut in India – An analysis, *Int. J. Curr. Microbiol. Appl. Sci.,* **6**(6): 1817-1823. [Cross Ref]

Eradasappa, E., Adiga, J. D. and Mohana, G. 2020. Hybrid vigour and variability for key growth characters and yield in cashew (*Anacardium occidentale* L.). *J. Plant Crops,* **48**(2): 71–81. [Cross Ref]

Falconer, D. S. 1981. Introduction to Quantitative Genetics. 2nd Edition, Longman Group Ltd., London, PP. 1-133.

Gajbhiye, R. C., Pawar, S. N., Salvi, S. P. and Zote, V. K. 2015. Early performance of cashew (*Anacardium occidentale* L.) genotypes under Konkan region of Maharashtra. *J. Indian Society of Coastal Agric. Res.,* **33**(2): 58-61.

Gupta, R.K. 1993. Multipurpose trees for agroforestry and wasteland utilisation. Oxford IBH Publishing Co.

Hanumanthappa, M., Patil, R.S., Sudhir Kamath, K.V., Vinod V. R, Dhananjaya, B. and Shankar, M. 2014. Performance of different cashew cultivars in coastal Karnataka. *Environm. Ecol.,* **32**(3): 891-895.

Hore, J.K, Murmu, D.K, Chattopadhyay, N. and Alam, K. 2015. Evaluation of cashew germplasms in West Bengal. *Acta Hortic*, **1080**: 135-141. [Cross Ref]

Johnson, H.W., Robinson, H.F. and Comstock, R. E. 1955. Genotypic and Phenotypic Correlation in Soybean and Their Implication in Selection. *Agron. J*. **47**: 477-480. [Cross Ref]

Masawe, P.A.L. 2009. Modern Agro-Practices in cashew. *J. Sci. Technol. Manag*., **2**(2): 9-16.

Mothe, C.G., Correia, D.Z. and Silva, T.C. 2006. Potencialidades do cajueiro. Publit, Rio de Janeiro

Nandini, C., Bhat, S., Saritha, H.S., Pandey, C.D., Pandey, S., Prabhakar, B.L. and Gowda, J. 2020. Characterization of barnyard millet (Echinocloa frumentaceae (Roxb.) germplasm for quantitative traits to enhance its utilization. *Electron. J. Plant Breed,* **110**(04): 1066-1072.

Nayak, M.G. and Muralidhara, B.M. 2019. Cashew Varieties: Recent Developments in India Cashew Technology Handbook

NRCC, 2005. *Experimental Manual on Cashew.* National Research Centre for Cashew, Puttur, Karnataka. 19-26.

Paul, H. and Ushadevi K. N. 2022. The Trend in Area, Production, Productivity of Cashew Nut in India with Special Reference to Kerala". *Asian J. of Agric. Extension Economics & Sociol.,* **40** (3):1-8. [Cross Ref]

Ramteke, V., Paikra, M.S., Netam, R.S., Kerketta, A., Nirala, Y.S., Singh, D.P., Veena, G.L., Adiga, J.D., Mohana, G.S. and Raviprasad, T.N. 2024. Genetic variability, trait association, and path analysis studies for nut yield and yield-related traits in cashew (*Anacardium occidentale* L.). *J. Agric. Sci. Technol*., **26** (2): 403-414.

Saroj, P.L. and Mohana, G.S. 2016. Cashew improvement in India: retrospect and prospects. *Int. J. Innov. Hortic.,* **5**(1): 14-22.

Sethi, K., Lenka, P.C. and Tripathy, S.K. 2015. Evaluation of cashew hybrids for vegetative parameters and nut yield. *Journal of Crop and Weed*., **11**(1):152-156.

Sethi, K., Tripathy, P. and Mohapatra, K. C. 2016. Variability and heritability of important quantitative characters in cashew (*Anacardium occidentale* L.). *Environ. Ecol*., **34**(4): 1795-1798.

Srilatha, V., Reddy, Y.T.N., Upreti, K.K. and Jagannath, S. 2015. Pruning and paclobutrazol induced vigour, flowering and hormonal changes in mango (*Mangifera indica* L.). *The Bioscan,* **10**(1): 161- 166.

Tripathy, P., Sethi, K. and Mukherjee, S. K. 2015. Evaluation of released cashew varieties under Odisha condition. *Int. J. of Bio-resource Stress Manag,* **6**(5): 566-571. [Cross Ref]