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K Sethi
AICRP on Cashew, Directorate of Research, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

S Sahoo
PG Scholar, Department of Fruit Science and Horticulture Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

M Dash
Department of Plant Breeding and Genetics, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

R Kumari
PG Scholar, Department of Fruit Science and Horticulture Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

PK Panda
AICRP on Cashew, Directorate of Research, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Mohanna GS
Directorate of Cashew Research, Puttur, Karnataka, India

TN Raviprasad
Directorate of Cashew Research, Puttur, Karnataka, India

Corresponding Author:
K Sethi
AICRP on Cashew, Directorate of Research, Mohanpur, nadla, West Bangal, India

Evaluation of cashew (*Anacardium occidentale* L.) germplasm based on morpho-economic traits

K Sethi, S Sahoo, M Dash, R Kumari, PK Panda, Mohanna GS and TN Raviprasad

Abstract

The present investigation entitled “Evaluation of Cashew (*Anacardium occidentale* L.) Germplasm based on morpho-economic traits” was carried out during the year 2020-2021 at Cashew Research Station (CRS), Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The experiment was laid out during the year 2003 following the statistical design RBD (Randomized Block Design) using thirty five cashew germplasm as treatment and each germplasm were replicated twice. All standard management practices were followed to raise a healthy crop. These thirty five germplasm were evaluated for various morpho-economic traits. Evaluation results revealed that plant height varied from minimum 3.05m in genotype RP-5 to maximum 6.05 m in genotype V-2. The genotype, H2/16 recorded maximum spread 6.85m in East-West direction and mean annual nut yield (6.71 kg plant^{-1}) among the evaluated germplasm. Nut weight (14.83 g), apple weight (144.0 g) and shelling % (30.5) were recorded maximum in genotype RP-5. Number of flowering laterals was recorded maximum in genotype H-68 (23.0) while sex ratio was recorded maximum in genotype, BPP-30/1(0.36). Nuts planicl^{-1} were counted maximum (10.0) in *Anacardium microcarpum.* Genotype, BH-105 recorded maximum nuts m^{-2}(36.99). The phenotypic and genotypic coefficient of variance recorded minimum for shelling (4.14 & 3.33) % and maximum for sex ratio (81.96 & 43.53). Genetic advance as percent of population mean also recorded similar result. The heritability estimates ranged from 28.36% in sex ratio to 98.40% in nut weight. High heritability estimates coupled with high genetic advance were observed for all the characters except for plant height, trunk girth, can opy spread (East-West), canopy spread (North-South), ground coverage by canopy and shelling %. Nut yield plant^{-1} had positive significant correlation with plant height (0.360) and canopy spread in East-West direction (0.424) while negative significant association with apple weight (0.389) both at phenotypic and genotypic level. Thus utilizing this findings, breeding programme can be formulated for development of high yielding or hybrid varieties of cashew which in turn will be helpful for increasing the production and productivity of the crop as a whole.

Keywords: cashew nut, evaluation, correlation and morpho-economic traits

Introduction

The ‘Gold mine in waste land’, the cashew is native to Eastern Brazil and was introduced in India by the Portuguese nearly five century ago. Initially, it was used for soil conservation and afforestation. But later on in early 1960’s, cashew became a crop with high economic value and attained the status of an export oriented commodity. Our country is the pioneer in cashew trade and processing in the world. India accounts for 65% of global cashew exports. Although India occupying largest area under cashew cultivation (20.30%), but contributes only 16.1% in production (Nayak *et al.* 2018) [16]. India is lagging behind in productivity of raw cashew nut (782kg ha^{-1}) compared to other cashew growing countries of the world (Nayak *et al.* 2018) [16]. India is able to meet roughly half of the domestic demand of cashew nut in the country. To run the cashew nut processing industries in the country, India requires approximately 1.3-1.4 million tons of raw cashew nuts annually. So there is urgent need to enhance domestic raw cashew nut production. This can be possible by increasing the productivity of cashew nut by introduction of high yielding varieties with adoption of Good Agricultural Practice (GAP). So in the present experiment an attempt has been made to evaluate thirty five diverse cashew germplasm which can be utilized in future breeding programme for development of trait specific F_1 progenies.

Materials and Method

The present investigation entitled “Evaluation of Cashew (*Anacardium occidentale* L.) germplasm based on morpho-economic traits” was conducted during the year 2020-2021 at

Cashew Research Station (CRS), Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The experiment was laid out following the statistical design RBD (Randomized Block Design) with two replications. The experiment was planted in the year 2003. All standard management practices were followed to raise a healthy crop of cashew. The morpho-economic traits *viz.* plant height, trunk girth, canopy spread (E-W & N-S) nuts panicle^{-1}, number of nuts m^{-2}, nut weight, apple weight, kernel weight, shelling %, nut yield and cumulative nut yield were recorded following the Experimental Manual in Cashew published by Directorate of Cashew Research, Putter, Karnataka (Bhat *et al.*, 2005) [4]. Data on various morpho-economic traits were analysed statistically following the procedure stated by Panse and Sukahtme (1985) [29]. Genetic parameters were calculated according to Johnson *et al.* (1995) [30]. The correlation coefficients for each pair of characters were computed and the path co-efficient (direct and indirect effects) were calculated as per Dewey and Lu (1959) [8].

Result and Discussion

Vegetative growth characters

The cashew germplasm evaluated for various growth parameters exhibited significant variations with respect to morpho-economic traits (Table 1). The plant height varied from minimum 3.05 m in genotype RP-5 to maximum 6.05 m in genotype V-2. Trunk girth was measured maximum in the cashew genotype Dutiyanuapalli (99.87 cm) closely followed by Vet ore 56 (93.12 cm), M35/4 (91.75 cm), BPP-2 (89.86 cm), Jhargram-1 (89.63 cm) and Ransighpur Bold Nut (89.27 cm) which were *statistically at par*. Minimum trunk girth was recorded in the genotype RP-5 (52.90 cm). Canopy spread in East-West c (E-W) and North-South (N-S) direction were recorded maximum in genotype, H-2/16 (6.8 5m in both directions). The variations in various growth characters of evaluated germplasm is mainly due to their differences in genetic potential. The climatic factors and management practices adopted during crop growth phase also influence the vegetative growth parameters in cashew. Similar variations in different growth characters have been reported by Hanumanthappa *et al*. (2014) [10], Gajbhiye *et al*. (2015) [9], Tripathy *et al*. (2015) [26] and Sahoo *et al.* (2019) [21].

Yield attributing character

Data recorded on various yield attributing characters presented in Table 2 revealed that number of flowering laterals m^{-2} varied from minimum 8.34 in genotype S-25 to maximum 23.0 in genotype H-68. Sex ratio was recorded maximum in genotypes BPP-30/1 (0.36) followed by H-1598 (0.24), RP-5 (0.22), H-367 (0.22), H-303 (0.145) and Jhargram-1 (0.135). The minimum sex ratio was recorded in genotype, T. No. 274 (0.08). Data presented on number of nuts panicle^{-1} were counted significantly maximum in genotype *A. microcarpum* (10.0). The genotype S-20 (2.7) recorded the lowest nuts panicle^{-1}. Number of nuts m^{-2} ranged from minimum 4.49 in genotype Ullal-3 to maximum 36.99 in genotype BH-6. Similarly, nut weight varied from maximum 14.82 g in genotype RP-5 to minimum 4.15 g in *A. microcarpum*. Significantly highest apple weight was recorded in genotype RP-5 (144 g) while the lowest was recorded in genotype V-2 (26.8 g). Kernel weight showed the similar trend as that of nut weight. Maximum kernel weight was recorded in genotype RP-5 (4.42 g) followed by BT-4 (3.41 g) which were *statistically at par*. Minimum kernel weight was recorded in genotype *A. microcarpum* (1.24 g). Shelling varied from maximum 30.5% in genotype RP-5 to minimum 25.65% in genotype, Vetore-56. The differences in yield attributing characters among the evaluated germplasm are controlled genetically. The genotype (s) showing the best results with respect to different yield attributing parameters can be utilized as parent in the crop improvement programme of cashew. Similar variations in yield attributing traits have been reported by Laxman *et al.* (2015) [28], Hore *et al.* (2015) [11], Poduval *et al.* (2015) [1], Sreenivas *et al*. (2016) [25] and Sahoo *et al.* (2019) [21].

Mean annual and cumulative nut yield

Data presented on annual nut yield (kg plant^{-1}) and cumulative nut yield (kg plant^{-1}) (Table 2) revealed that genotype, H2/16 recorded maximum mean annual nut yield (6.71 kg plant^{-1}) as well as cumulative nut yield (28.71 kg plant^{-1}) among the evaluated cashew germplasm. So, the genotype H-2/16 can be selected as parent in crop improvement programme for development of high yielding F_1 progenies in cashew. The variation in nut yield in a population is genetically controlled. As cashew is a perennial tree crop, nut yield is also influenced by environmental factors. This result corroborates with the findings of Laxman *et al.* (2015) [28], Reddy *et al*. (2015) [2], Sethi *et al*. (2015) [26] and Venkataramana *et al*. (2015) [27].

Genetic variability of different morpho-economic traits

The genetic variability is the key for selection of superior genotype from the base population. In the present study the evaluated germplasm revealed significant variations with respect to growth, yield attributes and nut yield. From the Table 3 it is observed that phenotypic coefficient of variance (PCV) was higher compared to the genotypic coefficient of variance (GCV). The PCV ranged from minimum 4.14% (shelling %) to maximum 81.96% (sex ratio) and the GCV from minimum 3.33% (Shelling %) to maximum 45.47% (nuts m^{-2}). Higher magnitude of PCV and GCV contribute towards the genetic variability. High GCV as well as PCV were recorded in component characters *viz.* sex ratio, nuts panicle^{-1}, nuts m^{-2} apple weight and nut yield. Heritability is a measure of the genetic relationship existing between parent and off- spring.

The heritability estimates is influenced by genetic variation in the population and the environment. The heritability estimates ranged from 28.36% in sex ratio to 98.40% in nut weight indicating varied seasonal effect on character expression. High estimates of heritability (>60%) indicates predominance of heritable components of variation. So, selection of characters on the basis of phenotypic expression will be beneficial. Heritability estimates along with genetic gain is more reliable in predicting the effect of selection. Expected genetic advance for different characters expressed as percent of population mean ranged from 5.51% in shelling% to 89.33% in nuts m^{-2} at 10% selection intensity. High heritability estimates coupled with high genetic advance were observed for all the characters except for plant height, trunk girth, can opy spread (E-W), canopy spread (N-S), ground coverage by canopy and shelling %. This indicated the presence of additive gene effects for these characters. Dasmohapatra *et al*. (2012) [7], Sethi *et al.* (2016) [24], Chandrasekhar *et al*. 2018 [5], Dadzie *et al.* (2020) [6] and Sethi *et al*. (2020) [23] reported similar findings while working on cashew.

Magnitude and direction of association among component traits and nut yield

The correlation coefficients provide useful information for choice of characters in a breeding programme. Phenotypic (0.988) as well as genotypic (0.991) correlation coefficients were recorded maximum (0.988 and 0.991) significant positive association between kernel weight and nut weight (Table 4). Plant height was significantly positively correlated with trunk girth, canopy spread (both in East-West and North-South direction), ground coverage by canopy while it had significantly negative correlation with apple weight both at phenotypic and genotypic level (Table 4). Trunk girth was significantly positively correlated with canopy spread (East-West and North-South direction) and ground coverage by canopy at genotypic level. But it had negative significant correlation with apple weight (-0.432) at phenotypic level. Canopy spread in East-West direction exhibited significant positive association with canopy spread in North-South (0.547) direction and ground coverage by canopy (0.840) both at genotypic and phenotypic level. Canopy spread in North-South direction showed positive significant association with ground coverage by canopy (0.983), nut weight (0.270) and kernel weight (0.255) at genotypic level. Flowering laterals m^{-2} exhibited negative significant association with shelling % (-0.260) while sex ratio exhibited significant positive association with shelling % (0.332) at genotypic level. Nuts panicle^{-1} recorded negative significant association with nuts m^{-2} (-0.387), nut weight (-0. 564) and kernel weight (-0.559) at both the levels. Nuts m^{-2} had positive significant correlation with nut weight (0.248) and kernel weight (0.257) at genotypic level only. Apple weight had a very strong positive significant correlation with nut weight (0.544) and kernel weight (0.589) while it had negative significant correlation with nut yield (-0.389) at both the levels. A positive significant correlation was observed between nut weight and kernel weight (0.991) both at phenotypic and genotypic level. A negative significant correlation was observed between kernel weight and nut yield (-0.248) at genotypic level only. Nut yield plant^{-1} had positive significant correlation with plant height (0.360) and canopy spread in East-West direction (0.424) while negative significant association with apple weight (-0.389) both at phenotypic and genotypic level (Table 4). Aliyu and Awopetu (2011) [3], Madeni *et al.* (2017) [1], Mohapatra *et al*. (2018) [15] reported that plant height, canopy spread (E-W), nuts panicl^{-1} were positively correlated with nut yield and could be used as primary components for improving yield in cashew.

Direct and indirect effects of different component traits on nut yield

The association between yield and its thirteen component traits was further subjected to path analysis to partition into direct and indirect effect of the component traits on nut yield at phenotypic level (Table 5). Nut weight had the highest positive direct effect (4.323) on yield followed by shelling % (0.624) and canopy spread in East-West direction (0.571). Similarly kernel weight had highest negative direct effect (-4.413) on yield followed by ground coverage by canopy (-0.658) and trunk girth (-0.204).

Plant height had positive significant correlation (r=0.334) with mean annual nut yield but its direct effect on yield was found to be small (0.273). This small direct effect was enhanced by positive indirect effect via characters like canopy spread in E-W & N-S directions, flowering laterals m^{-2}, kernel weight, shelling % and nut weight. In such situations, the indirect causal factors are to be considered simultaneously for selection. Canopy spread in East-West direction had high positive direct effect (0.571) on yield as well as high positive significant correlation (0.339) with nut yield. The high magnitude of correlation coefficient was due to the positive indirect effect via plant height, canopy spread (North-South), apple weight, kernel weight and shelling %. Canopy spread in North-South direction and nuts panicle^{-1} had small positive direct effect as well as small positive correlation (non-significant) with nut yield. Direct selection through these traits will be effective as the correlation exhibit true relationship. The low degree of negative direct effect was due to nullifying effects of positive indirect effect via other characters.

Nut weight (4.323) and shelling % (0.624) had the highest positive direct effect on yield but their correlation with nut yield were negative (non-Significant). Here, direct selection based on nut weight and shelling % will be beneficial to reduce the undesirable indirect effect. Kernel weight had highest negative direct effect (-4.413) as well as negative (non-significant) correlation (-0.229). Here correlation is due to indirect effect of the characters though nut weight. So, selection of such characters will be effective in crop improvement. Shelling % also exhibited the similar trend like nut weight. Apple weight had negative direct effect (-0.108) as well as negative significant correlation (-0.349) with nut yield.

Thus, it is evident from both direct and indirect effects of the characters at phenotypic level that plant height, canopy spread (East-West) and shelling % would be of more value while selecting for yield. Also the indirect causal factors should be considered simultaneously for yield improvement. A direct selection for yield through plant height and canopy spread (E-W) will be more effective. Piria *et al.* (2001) [18], Aliyu (2006) [2], Abraham *et al.* (2007) [1], Sethi *et al*. (2016) [24] and Sethi *et al.* (2020) [23] reported similar positive direct effect of different vegetative growth and yield attributing characters on nut yield of cashew.

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Table 1: Vegetative growth characters of evaluated cashew germplasm

Sl. No.	Name of the accessions	Plant height (m)	Trunk girth (cm)	Canopy Spread (m)	
				E-W	N-S
1	M35/4	4.85	91.75	5.70	5.55
2	T. No. 274	5.80	80.65	6.25	6.15
3	K25-2	4.90	87.31	5.95	6.30
4	T. No. 275	4.25	88.67	5.45	4.90
5	Ransighpur Bold Nut	5.20	89.27	5.90	6.10
6	*A. microcarpum*	3.60	89.86	5.85	5.35
7	Ullal-3	5.05	81.95	6.25	5.90
8	Dutiyanuapalli	5.05	99.87	6.20	6.65
9	Ullal-4	5.35	79.75	6.25	5.65
10	Goa-11/6	5.05	83.73	6.10	6.30
11	S-25	4.10	73.82	5.60	5.30
12	S-24	4.05	71.88	5.75	5.50
13	S-20	4.56	73.82	6.00	5.45
14	BT-4	5.15	88.99	5.80	6.85
15	BT-65	4.25	69.56	5.55	5.85
16	Vetore-56	4.10	93.12	5.70	6.00
17	V-2	6.05	91.22	6.75	6.75
18	H-2/16	5.90	53.99	6.85	6.85
19	H-255	5.50	89.93	5.75	6.20
20	H-303	4.10	60.72	6.10	5.70
21	H-367	3.90	77.00	5.70	5.50
22	H-68	4.80	77.78	6.30	5.75
23	BPP-3/28	4.30	63.77	5.80	5.85
24	H-1598	4.45	62.86	5.75	5.75
25	BPT-40	4.85	77.76	5.80	5.70
26	H-2/15	4.40	78.95	6.40	5.95
27	BH-6	4.40	58.78	6.15	4.75
28	BH-105	4.85	72.84	6.25	5.70
29	Jharagram-1	5.35	89.63	5.90	5.50
30	BPP-30/1	4.40	82.26	6.15	5.70
31	BPP-1	4.35	50.64	3.70	4.05
32	BPP-2	4.10	89.86	5.75	5.65
33	BPP-6	5.40	82.83	5.90	5.75
34	BPP-9	5.10	83.13	6.05	5.70
35	RP-5	3.05	52.90	4.85	5.55
	SEm (±)	0.15	7.56	0.26	0.38
	CD (0.05)	0.46	22.90	0.81	1.18

Table 2: Yield attributing characters and nut yield of evaluated cashew germplasm

Sl. No.	Name of the accessions	No. of nuts panicle^{-1}	No. of nuts m^{-2}	Nut weight (g)	Kernel weight (g)	Shelling %	Mean annual nut yield (kg plant^{-1})	Cumulative nut yield (kg plant^{-1}) for 7th harvest
1	M35/4	6.80	14.78	4.43	1.26	28.60	4.63	13.98
2	T. No. 274	6.75	13.12	6.03	1.82	30.20	4.59	13.26
3	K25-2	7.20	12.75	4.95	1.42	28.75	3.68	12.37
4	T. No. 275	6.10	11.87	7.12	2.12	29.80	4.91	15.12
5	Ransighpur Bold Nut	2.80	15.87	8.91	2.61	29.35	3.63	12.105
6	*A. microcarpum*	10.00	8.23	4.15	1.24	29.90	3.10	14.87
7	Ullal-3	6.70	4.49	7.15	1.98	27.80	4.30	15.31
8	Dutiyanuapalli	3.90	18.88	6.25	1.89	30.35	4.15	14.38
9	Ullal-4	2.75	13.86	7.05	2.09	29.70	2.80	11.77
10	Goa-11/6	4.05	11.30	6.25	1.80	28.90	4.95	15.48
11	S-25	3.20	15.00	8.85	2.63	29.75	3.35	13.66
12	S-24	3.60	22.99	6.78	1.97	29.05	3.55	12.33
13	S-20	2.70	12.62	9.80	2.72	27.80	4.19	12.715
14	BT-4	3.05	19.75	12.15	3.41	28.15	1.80	9.05
15	BT-65	7.85	6.95	11.15	2.15	27.90	1.10	8.22
16	Vetore-56	5.10	30.00	8.95	2.29	25.65	1.60	8.99
17	V-2	2.75	23.15	10.10	3.00	29.80	3.25	16.38
18	H-2/16	5.75	8.87	8.80	2.48	28.30	6.71	28.93
19	H-255	5.75	15.71	9.15	2.72	29.80	3.40	11.72
20	H-303	5.20	11.08	10.05	2.78	27.70	5.75	16.91
21	H-367	3.60	20.32	8.48	2.33	27.55	3.65	15.65

22	H-68	5.55	7.49	6.63	1.98	29.85	3.93	12.13
23	BPP-3/28	6.05	25.93	6.80	2.04	30.15	3.67	10.92
24	H-1598	4.25	21.40	8.14	2.39	29.40	3.85	11.22
25	BPT-40	6.20	17.90	7.20	2.14	29.85	3.69	14.55
26	H-2/15	7.25	5.20	8.22	2.42	29.55	3.87	16.36
27	BH-6	3.20	27.47	6.87	2.05	29.90	2.96	18.16
28	BH-105	5.75	36.99	6.78	2.02	29.85	5.46	27.48
29	Jharagram-1	2.80	13.00	6.54	1.88	28.80	4.18	14.37
30	BPP-30/1	6.15	10.95	4.45	1.35	30.35	5.29	16.66
31	BPP-1	3.70	12.00	6.50	1.85	28.55	3.75	11.47
32	BPP-2	3.25	14.37	8.56	2.35	27.55	5.64	12.86
33	BPP-6	6.05	10.00	6.50	1.80	27.75	5.31	17.38
34	BPP-9	4.25	23.23	8.56	2.47	28.85	6.105	18.32
35	RP-5	3.65	18.65	14.83	4.52	30.50	1.10	6.46
	SEm (±)	0.35	1.60	0.54	0.07	0.50	0.22	-
	CD (0.05)	1.07	4.86	1.60	0.22	1.53	0.67	-

Table 3: Genetic variability of different morpho-economic characters of evaluated cashew germplasm

Characters	Range	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability	Genetic advance	Genetic advance as % mean
Plant height (m)	3.05-6.05	13.50	14.16	90.97	1.25	26.53
Trunk girth (cm)	50.64-99.87	12.90	18.80	47.12	14.29	18.25
Canopy spread (E-W) (m)	3.70-6.85	7.68	10.05	58.45	0.71	12.10
Canopy spread (N-S) (m)	4.05-6.85	7.05	11.86	35.29	0.49	8.62
Ground coverage by canopy (m^2)	11.90-36.93	13.14	18.24	51.88	5.25	19.50
Flowering laterals m^{-2}	8.34-23.00	23.25	24.86	87.46	6.42	44.80
Sex ratio	0.03-0.40	43.65	81.96	28.36	0.07	47.90
Nuts panicle^{-1}	2.70-10.00	35.44	36.86	92.45	3.48	70.20
Nuts m^{-2}	3.20-36.99	45.47	47.68	90.94	14.14	89.33
Apple wt. (g)	26.80-144.00	37.18	38.92	91.22	38.43	73.15
Nut wt. (g)	10.15-14.83	29.03	29.26	98.40	4.51	59.32
Kernel wt. (g)	1.16-4.52	29.21	29.61	97.34	1.30	59.38
Shelling (%)	25.65-30.50	3.33	4.14	64.53	1.59	5.51
Nut yield (kg plant^{-1})	1.00-6.71	32.91	33.89	94.34	2.59	65.86

Table 4: Genotypic and phenotypic association among component characters of evaluated cashew germplasm

Characters	PH	TG	CS (E-W)	CS (N-S)	GCC	FL/M^2	SR	N/P	N/M^2	AW	NW	KW	SH%	Correlation
PH	1	0.270*	0.474**	0.483**	0.573**	-0.195^{NS}	-0.033^{NS}	-0.069^{NS}	-0.061^{NS}	-0.432**	-0.137^{NS}	-0.134^{NS}	0.054^{NS}	0.334**
TG	0.469**	1	0.219^{NS}	0.210^{NS}	0.205^{NS}	-0.217^{NS}	0.001^{NS}	0.086^{NS}	-0.037^{NS}	-0.274*	-0.185^{NS}	-0.205^{NS}	-0.079^{NS}	0.015^{NS}
CS (E-W)	0.646**	0.499**	1	0.547**	0.840**	0.025^{NS}	0.029^{NS}	0.073^{NS}	-0.033^{NS}	-0.199^{NS}	-0.080^{NS}	-0.083^{NS}	0.060^{NS}	0.339**
CS (N-S)	0.719**	0.839**	0.903**	1	0.905**	-0.128^{NS}	0.123^{NS}	0.043^{NS}	0.018^{NS}	0.044^{NS}	0.169^{NS}	0.159^{NS}	-0.032^{NS}	0.080^{NS}
GCC	0.758**	0.675**	0.959**	0.983**	1	-0.069^{NS}	0.089^{NS}	0.048^{NS}	-0.015^{NS}	-0.097^{NS}	0.065^{NS}	0.057^{NS}	0.009^{NS}	0.232^{NS}
FL/M^2	-0.177^{NS}	-0.275*	-0.019^{NS}	-0.095^{NS}	-0.061^{NS}	1	0.118^{NS}	-0.016^{NS}	0.083^{NS}	0.169^{NS}	-0.082NS	-0.119^{NS}	-0.191^{NS}	0.021^{NS}
SR	-0.094^{NS}	-0.001^{NS}	-0.120^{NS}	-0.116^{NS}	-0.175^{NS}	0.234^{NS}	1	0.024NS	-0.111^{NS}	0.100^{NS}	-0.061NS	-0.042^{NS}	0.110^{NS}	-0.079^{NS}
N/P	-0.063^{NS}	0.096^{NS}	0.149^{NS}	0.053^{NS}	0.091^{NS}	0.003^{NS}	0.143^{NS}	1	-0.361**	-0.037^{NS}	-0.532**	-0.518**	0.073^{NS}	0.079^{NS}
N/M^2	-0.111^{NS}	-0.058^{NS}	-0.003^{NS}	-0.027^{NS}	-0.031^{NS}	0.090^{NS}	-0.208^{NS}	-0.387**	1	0.134^{NS}	0.226NS	0.222^{NS}	0.002^{NS}	-0.136^{NS}
AW	-0.452**	-0.411**	-0.301*	-0.004^{NS}	-0.198^{NS}	0.171^{NS}	0.192^{NS}	-0.026^{NS}	0.153^{NS}	1	0.521**	0.555**	0.130^{NS}	-0.349**
NW	-0.137^{NS}	-0.301*	-0.094^{NS}	0.270*	0.092^{NS}	-0.097^{NS}	-0.163^{NS}	-0.564**	0.248*	0.544**	1	0.988**	-0.086^{NS}	-0.218^{NS}
KW	-0.131^{NS}	-0.323**	-0.091^{NS}	0.255*	0.086^{NS}	-0.136^{NS}	-0.114^{NS}	-0.559**	0.257*	0.589**	0.991**	1	0.065^{NS}	-0.229^{NS}
SH %	0.103^{NS}	-0.064^{NS}	0.149^{NS}	-0.056^{NS}	0.056^{NS}	-0.260*	0.332**	0.063^{NS}	0.131^{NS}	0.206^{NS}	-0.131^{NS}	-0.004^{NS}	1	-0.001^{NS}
NY	0.360**	0.055^{NS}	0.429**	-0.000^{NS}	0.246*	0.015^{NS}	-0.139^{NS}	0.088^{NS}	-0.159^{NS}	-0.389**	-0.233^{NS}	-0.248*	-0.017^{NS}	1

*****:Significant at 5% level, **: Significant at 1% level PH: Plant height (m), TG: Trunk Girth (cm), CS (E-W): Canopy Spread (East-West) (m), CS (N-S): Canopy Spread (North-South) (m), GCC: Ground coverage by canopy (m^2), FL/M^2: Flowering laterals m^{-2},SR: Sex ratio, N/P: Nuts panicle^{-1}, N/M^2: Nuts m^{-2}, AW: Apple weight (g), NW: Nut weight (g), KW: Kernel weight (g), SH%: Shelling %, NY: Nut yield (kg plant^{-1})

Table 5: Direct and indirect effect of component characters on nut yield of cashew germplasm at phenotypic level

Characters	PH	TG	CS (E-W)	CS (N-S)	GCC	FL/M^2	SR	N/P	N/M^2	AW	NW	KW	SH %	Correlation with NY
PH	0.273	-0.055	0.270	0.134	-0.376	0.002	0.001	-0.001	0.007	0.047	-0.592	0.590	0.034	0.334**
TG	0.073	-0.204	0.124	0.058	-0.134	0.002	-0.001	0.001	0.004	0.030	-0.798	0.906	-0.050	0.015^{NS}
CS (E-W)	0.129	-0.044	0.571	0.151	-0.552	-0.000	-0.001	0.001	0.004	0.022	-0.344	0.367	0.038	0.339**
CS (N-S)	0.131	-0.042	0.312	0.278	-0.595	0.001	-0.007	0.001	-0.002	-0.005	0.730	-0.703	-0.020	0.080^{NS}
GCC	0.156	-0.041	0.480	0.251	-0.658	0.001	-0.005	0.001	0.002	0.011	0.282	-0.252	0.005	0.232^{NS}
FL/M2	-0.053	0.044	0.014	-0.035	0.045	-0.011	-0.007	-0.000	-0.009	-0.018	-0.357	0.526	-0.12	0.021^{NS}
SR	-0.008	-0.000	0.016	0.034	-0.058	-0.001	-0.055	0.000	0.012	-0.011	-0.263	0.187	0.070	-0.079^{NS}
N/P	-0.018	-0.017	0.041	0.011	-0.032	0.000	-0.001	0.020	0.040	0.004	-2.300	2.287	0.046	0.079^{NS}

N/M2	-0.016	0.007	-0.018	0.004	0.009	-0.001	0.006	-0.007	-0.108	-0.014	0.978	-0.979	0.002	0.136^{NS}
AW	-0.117	0.055	-0.113	0.012	0.063	-0.001	-0.006	-0.001	-0.014	-0.108	2.250	-2.45	0.081	-0.349^{**}
NW	-0.037	0.037	-0.045	0.046	-0.042	0.001	0.003	-0.010	-0.024	-0.056	4.323	-4.359	-0.054	-0.218^{NS}
KW	-0.036	0.041	-0.047	0.044	-0.037	0.001	0.002	-0.010	-0.024	-0.060	4.279	-4.413	0.040	-0.229^{NS}
SH %	0.014	0.016	0.034	-0.008	-0.005	0.002	-0.006	0.001	-0.000	-0.014	-0.372	-0.287	0.624	-0.001^{NS}

P (R) =0.723 PH: Plant height (m), TG: Trunk Girth (cm), CS (E-W): Canopy Spread (East-West) (m), CS (N-S): Canopy Spread (North - South) (m), GCC: Ground coverage by canopy (m^2), FL/M^2: Flowering laterals m^{-2},SR: Sex ratio, N/P: Nuts panicle^{-1}, N/M^2: Nuts m^{-2}, AW: Apple weight (g), NW: Nut weight (g), KW: Kernel weight (g), SH%: Shelling %, NY: Nut yield (kg plant^{-1})

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