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EFFECTS OF CLIMATIC FACTORS ON DIFFERENT CASHEW (*ANACARDIUM OCCIDENTALE* L.) VARIETIES

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Abstract

To know the impacts of climate change on cashew production, the correlation study of different climatic factors and growth and reproductive characters of different released varieties of cashew was conducted. Grafted plants of 24 released cashew varieties developed by different cashew research stations of India were planted at the semi arid regions of West Bengal, India in 2010.Maximum temperature and relative humidity during the pre-flowering stage has strong positive correlation with flowering intensity. Relative humidity is the major factor influencing different reproductive characters of cashew nut. Vengurla-7, Bhaskara, Ullal-3, BPP-8 and Madakkathara-II were found to be suitable for the semi arid climate.The varieties Like Bhaskara, Vengurla-7, VRI-3, BPP-6, Madakkathara-1, Kanaka, Vengurla-1, Vengurla-6, Ulla-3 and UN-50 are the varieties which were found to be more susceptible to yield loss due to less relative humidity (%) and it is better to recommend those varieties for the coastal areas. NRCC-2, Jhargram-1, Vengurla-4, BPP-4, Ullal-4, Madakkathara-2, Bhubaneswar-1, K-22-1, Chintamani-1, Goa-1, BPP-8 and Dhana may be recommended for the places where relative humidity is less during the fruiting period.

Introduction

In India, cashew (*Anacardium occidentale* L.) is grown mainly in Maharashtra, Goa, Karnataka and Kerala along the West Coast and Tamil Nadu, Andhra Pradesh, Odisha and West Bengal along the East Coast. In India, cashew grown in an area of 10.62 lakh hectares with a total production of 8.17 lakh MT of raw nuts was recorded during 2017-18. India is the largest producer of raw cashewnut contributing 20% of total global production, but the productivity of cashew in India is very low, 753 kg/ha (dccd.gov.in 2017-18). Cashew is mostly grown as a rainfed crop, and the yield and quality of nut is largely dependent on climatic and weather conditions. The relative humidity during pre- flowering stage is the key factor in explaining the yield variation in cashew plantations (Haldankar *et al.* 2003).The study on the characterization of the cashew production systems in the main growing areas carried out by Balogoun *et al*. (2014) revealed that the main constraints to the development of the cashew sector in Benin include climatic conditions which are characterized by scarcity and poor distribution of rainfall, dry winds and low temperatures. They mentioned that climate variability causes drying, abortion and the fall of flowers, leaves and even fruits, thus reducing productivity. It is therefore urgent to adopt measures and develop new strategies to avoid the worst effects of climate change (Willbanks *et al.* 2007).

The first step towards this goal is to identify suitable varieties which can cope up with different climatic conditions. Therefore, the present study was conducted to know the correlation of different climatic factors and growth and reproductive characters of different released varieties.

Materials and Methods

Grafted plants of 24 released cashew varieties developed by different cashew research stations of the country were planted at the Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya, Jhargram, West Bengal under All India Coordinated Research Project on Cashew

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(latitude 22° 45'67"N longitude 87°01'22" E and altitude 78.8 msl) with a spacing of 6m x 6m in 2010 by adopting Randomized Block Design (RBD), replicated thrice having four plants per treatment and followed recommended package of practices. Growth attributes such as height of the plant, trunk girth, canopy spread, canopy area and yield attributes e.g. flowering/m^2, nuts/m^2, nuts/panicle, nut weight, apple weight, shelling % and yield/tree were recorded from 2013-2019. The soil of the experimental plot was red lateritic in texture with pH of 5.0. The climate is semi arid in nature. Canopy spread was calculated by taking average of the diameter of both north-south and east – west direction. Canopy area was calculated using the formula πrl [where $\pi = 3.14$, r = radius of canopy, $l = \sqrt{(r^2 + h^2)}$, h(canopy height) = plant height - trunk height] The shelling % was calculated using the formula: Shelling %=(Kernel Weight/Nut weight)×100. Similarly, nut yield tree-1 was calculated by adding the total individual nut yield harvested each time. The details of the climatic parameters during 2013-2019 were taken from the web site www.world-weatheronline.com. Pearson correlations were determined to examine inter- character relationships among the parameters and with the climatic factors using the SPSS version 16.0 (2004) following the procedure outlined by (Gomez and Gomez 1984)

Results and Discussion

Pooled data revealed that maximum number of flowers/sq.m of canopy was produced by Jhargram-1 (15.08) which was on par with NRCC-2, VRI-3, Bhubaneswar-1, K-22-1, BPP-8, Amrutha, Madakkathara-II, Kanaka, Vengurla-6, Priyanka, Ullal-4, Chintamani-1 and, Vengurla-7. Number of nuts/sq.m was maximum (47.84) in Bhubaneswar-1. Most of the other varieties were on par with respect to nuts/sq.m except Priyanka, BPP-6 and Dhana where it was minimum, ranging from 11.48-15.50nuts/m^2 (Table 1). Among the cluster bearing varieties Bhubaneswar-1 had the highest number of nuts /panicle (13.47). Other cluster bearing types were Vengurla-1 (9.55), Chintamani-1 (9.37), Amrutha (8.87), Vengurla-4(8.37) and Goa-1(8.03). The lowest number of nuts/panicle was recorded in Priyanka (3.59). The varieties could be grouped into three different groups based on the nut weight i.e. bold nut having weight between (7- 9 g), medium nut weight between (5-7 g) and small nut <5g. Among the 24 varieties pooled data depicted that three varieties, namely Vengurla-7, Priyanka and UN-50 produced bold nuts. Most of the other varieties had produced medium sized nuts. Among the 24 varieties, Bhubaneswar-1 and BPP-4, produced small sized nuts having 4 - 5 g nut weight. It is established that in cashew, the nut weight is highly influenced by genetically and environmentally (Manoj and George 1993).

Significant variations were observed with respect to apple weight of the varieties. Except four varieties namely BPP-4, Madakkathara-1, Bhubaneswar-1 and Chintamani-1, most of the other varieties were on par with respect to apple weight. The range was between 45.81-66.24 g. Pooled data on shelling% showed that except Vengurla-4, BPP-8, Goa-1, Dhana and BPP-4, all other varieties had more than 30% shelling recovery and the highest was in NRCC-2 (35.01). At the age of 10 years highest yield was recorded in Vengurla-7 (10.69 kg/tree) followed by Bhaskara (8.75 kg/tree). But varieties like Chintamani 1, Madakkathara I, Jhargram1, NRCC-2, BPP-6 and Amrutha yielded less than 4 kg/tree. Pooled data showed that Vengurla-7, Bhaskara and Bhubaneswar-1 yielded an average of 5-6 kg/tree. The productivity of Bhubaneswar-1 the variety from OUAT Bhubaneswar was almost same in Odisa as well as West Bengal condition (Tripathy *et al.* 2015). Cumulative data revealed that highest yielding varieties were Vengurla-7, Bhaskara, Ullal-3, Bhubaneswar-1, BPP-8, UN- 50, Vengurla- 4, Ullal-4 and Kanaka produced more than 20kg/tree for six harvests.

Table 2 represented the correlation between different growth and reproductive parameters of cashewnut. Significant and strong positive correlation was noticed between height of cashew plant

and girth, canopy spread, canopy area, nut weight, apple weight and yield of cashew. According to Sethi *et al.*(2016) the fast growing cashew nut trees usually have enhanced plant height with reduced canopy spread and trunk diameter while, cashew plant types with apical dominance led to enlarged canopy spread and more trunk girth due to mobilization of reserve food materials towards growth of lateral branches. Besides, the excess food materials are in fact translocated to sink leading to enlarged size of nut, kernel and apple.While height, girth, canopy spread and canopy

Table 1. Pooled mean of yield attributing parameters of cashew during 2013-2019.

Varieties	Flowering /m^2	Nuts /m^2	Nuts/ panicle	Nut weight (g)	Apple weight (g)	Shelling (%)
Bhaskara	8.90 d	21.21 b	6.63 b	6.64 bcdefg	60.94 a	32.27
Madakkathara-II	12.28 abc	21.01 b	6.55 b	6.03 cdefgh	48.15 a	32.01
Bhubneswar-1	13.59 abc	47.84 a	13.47 a	4.91 h	37.77 b	32.85
K-22 -1	12.58 abc	20.19 b	7.42 b	5.91 cdefgh	48.03 a	32.10
Chintamani-1	11.03 abc	20.83 b	9.37 b	5.63 defgh	38.69 b	30.12
Ullal-4	11.06 abc	22.03 b	5.93 b	5.74 defgh	61.72 a	31.82
Vengurla-7	10.98 abc	20.53 b	5.88 b	8.04 a	62.28 a	31.88
VRI-3	13.98 abc	21.15 b	5.63 b	5.87 cdefgh	45.81 a	32.87
BPP-6	8.70 d	15.50 c	6.46 b	5.03 h	49.64 a	30.09
Amrutha	12.29 abc	25.15 b	8.87 b	5.97 cdefgh	48.22 a	31.51
Vengurla-4	9.15 d	31.00 b	8.37 b	6.05 cdefgh	50.44 a	29.99
Goa-1	9.08 d	20.25 b	8.03 b	6.27 cdefgh	55.26 a	29.48
Madakkathara-I	10.58 bc	16.05 b	4.91 b	5.27 h	39.76 b	30.99
Priyanka	11.30 abc	11.48 c	3.59 c	7.44 ab	66.24 a	27.38
BPP-8	12.46 abc	21.32 b	6.08 b	6.89 bcde	65.93 a	29.90
Kanaka	12.00 abc	21.67 b	5.11 b	5.37 gh	55.72 a	32.16
Vengurla-1	9.58 d	28.27 b	9.55 b	5.52 efgh	54.55 a	30.66
Vengurla-6	11.68 abc	21.64 b	5.55 b	5.88 cdefgh	57.70 a	30.11
Ullal-3	8.77 d	20.00 b	7.37 b	6.91 bcd	59.71 a	30.31
Dhana	8.68 d	15.58 c	6.50 b	6.75 bcdef	56.63 a	28.97
BPP-4	10.57 bc	23.05 b	7.78 b	4.95 h	43.86 b	28.70
UN-50	10.69 bc	18.71 b	6.79 b	7.14 bc	55.64 a	30.27
Jhargram-1	15.08 a	24.81 b	7.13 b	5.32 gh	51.77 a	32.77
NRCC-2	14.74 ab	23.68 b	6.28 b	6.11 cdefgh	51.98 a	35.01
S.Em ±	**0.86**	**2.74**	**0.85**	**0.24**	**3.74**	NS
C.D. at 5%	**2.41**	**8.28**	**2.58**	**0.74**	**11.31**	
CV%	**20.33**	**32.61**	**31.94**	**10.63**	**18.74**	

*Subject to DMRT.

area, all had negative but significant correlation with flowering/m^2. Similarly girth of cashew varieties were significantly and positively correlated with canopy spread, canopy area, nut weight, apple weight and yield of cashew. Flowering/m^2 showed significant and positive correlation with nuts/m^2. But data revealed that increase in flowering/m^2 reduced nut weight and apple weight significantly. As nut weight was reduced therefore, it had impact on yield also and yield was reduced significantly (Table 2).

Table 2. Correlation between different growth and reproductive parameters of cashewnut.

Parameters	Girth	Canopy spread	Canopy Area	Flowering/ m2	Nuts/ m2	Nut weight	Nuts/ panicle	Apple weight	Yield
Height	0.958**	0.969**	0.969**	-0.471**	0.108	0.339**	0.190*	0.483**	0.765**
Girth		0.950**	0.933**	-0.481**	0.072	0.389**	0.131	0.441**	0.721**
Canopy spread			0.986**	-0.448**	0.128	0.357**	0.172*	0.509**	0.790**
Canopy area				-0.444**	0.070	0.339**	0.136	0.523**	0.769**
Flowering/m2					0.245**	-0.368**	0.043	-0.260**	-0.180*
Nuts/m2						-0.287**	0.764**	-0.240**	0.532**
Nut weight							-0.236**	0.451**	0.246**
Nuts/panicle								-0.197*	0.378**
Apple weight									0.314**

*P=0.05, **P=0.01.

On the other hand, it was observed that nuts/m^2 increased positively and significantly as nuts/panicle increases. Yield was also significantly and positively correlated with the nuts/m^2.Therefore, it could be assumed that mere increase in flowering/m^2 did not support yield, as because yield is more dependent on nut retention per panicle which ultimately increased nuts/m^2 and nut weight. It was also clear that apple weight was directly related with nut weight.

Flowering in cashew depends on various climatic factors especially during the period of pre-flowering stage. In West Bengal flowering starts in February, so the climatic factors prevailing during November to January had a decisive role in flowering of cashew. Therefore, the correlation study was done between the climatic factors of November to January and Flowering /m^2 of different varieties of cashew. It is apparent that maximum temperature, rain, cloud%, relative humidity and sun hour all has significant role in deciding flowering intensity (Table 3). Whereas maximum temperature and relative humidity have strong positive correlation but rain cloud and sun hour had negative correlation. According to Balogoun *et al.* 2016, the agro-climatic stress index and amount of rainfall in September and October and the number of rainy days were main factors determining cashew trees' production.

Table 3 showed that the correlation between reproductive characters with climatic factors (February to May). As flowering in cashew in West Bengal starts from February and fruit set occurs in March and fruit development period is generally between March - May, therefore, the climate prevailing during that period has a direct impact on fruiting. So, correlation studies were carried out between fruiting and climatic factors during February - May. It was noticed that minimum temperature had a significant and strong positive correlation with nuts/m^2, nuts/panicle and yield at 1% level of significance and with shelling % at 5% level of significance (Table 4). While maximum temperature had a significant and positive correlation with nuts/m^2 and nuts/panicle but the bonding was less than minimum temperature. Maximum temperature had

negative but significant correlation with yield, it means maximum temperature is responsible for fruit drop, therefore, during harvesting in April - May, the yield data showed reduction. Similar results were observed by Balogoun *et al*. (2016) that high temperatures, dry or violent winds can cause damage of the flowers, immature fruits and also reduction of fruit number per tree. Violent winds, drought periods and rains during January and December, have affected negatively cashew

Table 3. Yield/tree (Kg) of cashew genotypes during 2013-2019.

Varieties	2013	2014	2015	2016	2018	2019	Pooled	DMRT	Cumulative yield for 6 harvests (Kg/tree)
Bhaskara	1.11	1.91	3.77	9.67	9.62	8.75	5.81	a	34.85
Madakkathara-II	0.30	1.75	2.37	3.21	6.51	5.09	3.21	abcd	18.36
Bhubneswar-1	1.68	1.52	4.76	7.02	13.54	4.83	5.56	abc	24.72
K-22-1	1.02	1.45	2.58	6.38	7.87	4.08	3.90	abcd	19.30
Chintamani -1	0.68	1.18	2.02	4.24	9.63	3.99	3.62	abcd	16.68
Ullal-4	1.50	1.41	4.38	5.53	7.20	4.66	4.11	abcd	23.04
Vengurla -7	0.57	1.80	7.53	3.91	9.00	10.69	5.58	ab	36.93
VRI-3	1.28	0.91	3.56	4.46	4.32	3.30	2.97	bcd	18.47
BPP-6	0.47	1.38	2.16	3.80	4.93	3.68	2.74	bcd	15.88
Amrutha	1.90	1.81	1.94	3.64	5.84	3.35	3.08	bcd	18.08
Vengurla-4	1.28	1.77	5.10	4.20	10.91	5.05	4.72	abcd	23.14
Goa-1	0.83	1.55	2.14	4.53	8.90	5.22	3.86	abcd	18.90
Madakkathara-I	0.46	0.54	1.27	4.01	2.92	3.99	2.20	cd	14.22
Priyanka	0.38	0.55	3.25	4.04	5.89	4.68	3.13	abcd	17.68
BPP-8	1.76	0.65	3.91	7.05	8.26	5.02	4.44	abcd	23.66
Kanaka	1.16	0.95	2.74	4.40	4.11	6.05	3.24	abcd	22.06
Vengurla-1	1.30	0.95	1.72	5.27	5.92	5.48	3.44	abcd	19.67
Vengurla-6	1.13	0.51	2.64	4.80	6.81	4.81	3.45	abcd	17.87
Ullal-3	1.17	0.34	4.17	6.95	9.17	7.68	4.91	abcd	27.78
Dhana	1.03	0.84	2.19	3.90	7.04	5.27	3.38	abcd	19.54
BPP-4	0.64	0.92	1.57	5.71	7.67	3.09	3.27	abcd	15.54
UN-50	0.78	1.87	1.86	4.19	6.68	6.81	3.70	abcd	23.15
Jhargram -1	1.50	1.00	1.95	4.71	7.80	3.86	3.47	abcd	16.82
NRCC-2	1.11	1.97	1.50	5.37	10.08	3.74	3.96	abcd	17.84
S.Em ±	**0.15**	**0.25**	**0.49**	**0.80**	**1.53**	**0.59**	**0.50**		
C.D. at 5%	**0.43**	**0.71**	**1.37**	**2.26**	**4.33**	**1.67**	**1.50**		
CV%	**29.44**	**21.01**	**32.80**	**31.81**	**20.69**	**23.06**	**34.30**		

**In 2017 Crop damaged due to hail storm.

productivity by causing the drop and drying of the flowers. Rain during the fruiting season had a significant and strong positive correlation with nut weight and apple weight but it was negatively correlated with nuts/m^2 and nuts/panicle. Actually, during this part of the year rain is mostly associated with strong wind due to which nuts were damaged and fell down and thus nuts/m^2 and nuts/panicle showed negative correlation with rain. The findings of Rupa *et al.* (2013) also supported the fact, according to them flowers exposed to heavy rains accompanied with high wind velocity resulted in flower drop and occurrence of fungal diseases during flowering phase.

Table 4. Correlation between flowering and climatic factors (November to January).

Climatic factors	Flowering/m^2
Maximum temperature (ºC)	0.233**
Minimum temperature (ºC)	- 0.119
Rain (mm)	- 0.381**
Cloud (%)	- 0.174*
Relative humidity (%)	0.253**
Sun hour	-0.489**

*P=0.05, **P=0.01.

Pollinating insect activity also reduced to the minimum, resulting in poor setting of nuts. It has been estimated that the total nut yield losses were 50% with heavy loss (65%) during peak harvesting period with poor quality due to unseasonal rains received in March 2008. But in case of relative humidity, it was significantly and positively correlated with all the reproductive parameters studied. Sun hour also showed significant and positive correlation with nut weight, apple weight and yield (Table 5).

Table 5.Correlation between Reproductive characters with Climatic factors(February to May).

Fruiting attributes	Max. temp. (ºC)	Min. temp. (ºC)	Rain (mm)	Cloud (%)	Relative humidity (%)	Sun hour
Nuts/m^2	0.258**	0.434**	-0.374**	0.029	0.196*	-0.005
Nut wt	-0.162	0.045	0.319**	0.410**	0.368**	0.248**
Nuts/panicle	0.202*	0.379**	-0.072	0.204*	0.260**	0.010
Apple wt	-0.323**	0.090	0.271**	0.307**	0.360**	0.465**
Shelling %	0.040	-0.178*	-0.198*	-0.220**	-0.236**	-0.189*
Yield	-0.248**	0.432**	-0.092	0.395**	0.664**	0.657**

*P=0.05, **P=0.01.

The different climatic parameters of the red and laterite zone of West Bengal varied between 15-18°C in minimum temperate, 27-30°C in maximum temperature, 2-28 mm in case of rain, 44-53% in relative humidity and 4-12% in cloud cover. According to Rupa *et al.*(2013) cashew required relatively dry atmosphere and mild winter (15–20°C minimum temperature)coupled with moderate dew during night for profuse flowering. Table 4 represented the correlation between flowering/m^2 of individual varieties with climatic factors (November to January). It is apparent

from the Table 6 that maximum temperature during November to January had a positive though not significant impact on flowering intensity of cashew in most of the varieties except BPP-6, BPP-8 and Vengurla-1.While minimum temperature had a negative though not significant impact on flowering intensity in most of the varieties except in Kanaka, Vengurla-1, Ullal- 3, BPP-4, Jhargram-1 and NRCC-2. Rain during the period also had a negative impact on flowering intensity and in some varieties like Madakkathara-2, Chintamani-1, Vengurla-7 and Amrutha the correlation significantly negative. It was also evident that except Jhargram-1and Kanaka in case of all other varieties relative humidity was very much important during the pre-flowering period to boost up flowering intensity. Therefore, it can be predicted that for high intensity of flowering cashew needs high maximum temperature, low minimum temperature, less rain but high relative humidity and less cloud cover during the pre-flowering stage i.e November to January.

Table 6. Correlation between flowering/m^2 of cashew varieties with climatic factors(November to January)

Varieties	Max. temp. (ºC)	Min. temp. (ºC)	Rain (mm)	Cloud (%)	Relative humidity (%)
Bhaskara	0.235	-0.088	-0.358	-0.380	0.567
Madakkathara-2	0.513	-0.525	-0.959**	-0.606	0.648
Bhubneswar-1	0.757	-0.241	-0.756	-0.322	0.160
K-22 -1	0.216	-0.376	-0.737	-0.273	0.439
Chintamani -1	0.731	-0.100	-0.864*	-0.281	0.510
Ullal -4	0.373	-0.291	-0.715	-0.402	0.560
Vengurla -7	0.467	-0.539	-0.891*	-0.443	0.334
VRI-3	0.455	-0.325	-0.765	-0.225	0.218
BPP-6	-0.219	-0.458	-0.400	-0.336	0.443
Amrutha	0.589	-0.365	-0.859*	-0.391	0.367
Vengurla-4	0.466	-0.081	-0.600	-0.083	0.190
Goa-1	0.171	-0.270	-0.329	-0.333	0.223
Madakkathara-1	0.164	-0.270	-0.398	-0.154	0.055
Priyanka	0.005	-0.296	-0.452	-0.144	0.247
BPP-8	-0.144	-0.277	-0.343	-0.367	0.635
Kanaka	0.252	0.156	-0.301	0.220	-0.003
Vengurla-1	-0.072	0.205	0.004	0.064	0.284
Vengurla-6	0.375	-0.030	-0.564	-0.118	0.383
Ullal-3	0.115	0.169	-0.029	-0.017	0.177
Dhana	0.187	-0.004	-0.151	-0.408	0.548
BPP-4	0.546	0.224	-0.360	0.087	0.058
UN-50	0.009	-0.146	-0.192	-0.242	0.302
Jhargram-1	0.558	0.291	-0.105	0.054	-0.104
NRCC-2	0.225	0.166	0.020	-0.059	0.056

*P= 0.05, **P=0.01.

Table 7 (i-v) represented the correlation between reproductive characters of individual variety with climatic factors (February to May). Though not significant, but in most of the varieties intensity of nut production had positive correlation with maximum temperature, minimum temperature and relative humidity. Significant and positive correlation with minimum temperature and nuts/m^2 was observed in Bhaskara, Kanaka, Vengurla-1 and Madakkathara-1. In case of nut weight, most of the varieties were significantly and positively correlated with cloud cover (%) and relative humidity (%) during February to May, while maximum and minimum temperature had shown non-significant, negative correlation with nut weight. According to Prasada Rao *et al.* (2010), the maximum temperature plays a crucial role on nut size and kernel weight of cashew during the nut development stage. In case of other parameters, no such trend was observed. Yield of cashew and relative humidity (%) during February - May was significantly and positively correlated with most of the varieties. Haldankar *et al.* (2003) also reported that the relative humidity during pre-flowering phase is the main factor which explains yield variation in cashew plantations.

Table 7(i). Correlation between nuts/m^2 of cashew varieties with climatic factors (February to May).

Varieties	Maximum temp. (°C)	Minimum temp. (°C)	Rain (mm)	Cloud (%)	Relative humidity (%)
Bhaskara	0.52	0.95**	-0.33	0.24	0.50
Madakkathara-2	0.15	0.29	-0.36	-0.09	0.19
Bhubneswar-1	0.23	0.55	-0.41	0.29	0.46
K -22 -1	0.49	0.78	-0.66	0.06	0.38
Chintamani-1	0.35	0.65	-0.82*	-0.18	0.21
Ullal- 4	0.30	0.42	-0.44	0.09	0.17
Vengurla-7	0.26	0.32	-0.10	0.42	0.41
VRI -3	0.65	0.61	-0.36	0.18	0.19
BPP-6	0.46	0.23	-0.70	-0.34	-0.16
Amrutha	0.34	-0.02	-0.88*	-0.90*	-0.70
Vengurla-4	0.38	0.59	-0.67	0.00	0.24
Goa -1	0.01	0.34	-0.83	-0.37	0.08
Madakkathara-1	0.80*	0.93**	-0.53	0.07	0.30
Priyanka	0.37	0.52	-0.42	0.25	0.38
BPP-8	0.18	0.26	-0.34	0.01	0.03
Kanaka	0.82*	0.92**	-0.35	0.20	0.31
Vengurla-1	0.62	0.87*	-0.39	0.13	0.31
Vengurla-6	0.26	0.64	-0.47	0.14	0.35
Ullal -3	0.08	0.48	-0.15	0.46	0.54
Dhana	0.22	0.73	-0.51	0.23	0.55
BPP-4	0.20	0.67	-0.57	0.09	0.42
UN-50	0.32	0.15	-0.76	-0.73	-0.40
Jhargram1	0.07	0.64	-0.51	0.12	0.48
NRCC-2	0.30	0.64	-0.79	-0.19	0.21

* P= 0.05, **P=0.01.

Table 7(ii). Correlation between nut weight of cashew varieties with climatic factors.

Varieties	Maximum temp. (ºC)	Minimum temp. (ºC)	Rain (mm)	Cloud (%)	Relative humidity (%)
Bhaskara	-0.37	0.18	0.46	0.83*	0.84*
Madakkathara-2	-0.02	0.54	0.20	0.77	0.89*
Bhubneswar-1	-0.03	0.01	0.16	0.48	0.37
K -22 -1	-0.49	-0.57	0.36	0.16	0.04
Chintamani-1	-0.37	0.03	0.55	0.80*	0.73
Ullal- 4	0.57	0.74	-0.19	0.45	0.54
Vengurla-7	-0.39	-0.17	0.77	0.73	0.54
VRI -3	0.01	0.40	0.61	0.69	0.67
BPP-6	-0.51	-0.01	0.65	0.81*	0.76
Amrutha	-0.14	0.46	0.25	0.83*	0.90*
Vengurla- 4	-0.15	-0.02	0.93**	0.83*	0.50
Goa -1	0.11	0.20	0.72	0.79	0.54
Madakkathara-1	-0.51	0.05	0.79	0.92**	0.82*
Priyanka	-0.59	-0.01	0.67	0.86*	0.81*
BPP-8	-0.13	0.32	0.72	0.99**	0.84*
Kanaka	-0.15	-0.01	0.75	0.59	0.44
Vengurla-1	0.04	-0.28	-0.06	-0.32	-0.30
Vengurla-6	-0.40	0.08	0.88*	0.89*	0.74
Ullal -3	-0.32	0.16	0.67	0.87*	0.81*
Dhana	-0.67	-0.32	0.69	0.71	0.50
BPP-4	-0.07	-0.16	0.23	-0.03	-0.02
UN-50	-0.33	0.29	0.56	0.94**	0.89*
Jhargram1	-0.38	-0.67	0.06	-0.16	-0.39
NRCC-2	-0.58	-0.18	0.51	0.46	0.50

*P=0.05, **P=0.01.

Considering the main four yield characters i.e. nut weight, shelling (%), yield/tree and cumulative yield/tree for recommending varieties Vengurla-7, Bhaskara, Ullal-3, BPP-8 and Madakkathara-II were found to be suitable for the semi-arid climate. On the other hand it can be concluded that maximum temperature and relative humidity during the pre-flowering stage has strong positive correlation with flowering intensity. Among the climatic parameters relative humidity is the major factor with regard to different reproductive characters of cashew nut. The increase in relative humidity during the fruiting season would definitely be supporting higher yield (Fig. 1). Therefore, the varieties like Bhaskara, Vengurla-7, VRI-3, BPP-6, Madakkathara-1, Kanaka, Vengurla-1, Vengurla-6, Ulla-3 and UN-50 are the varieties which are more susceptible

to yield loss due to less relative humidity (%) and it is better to recommend those varieties for the places where high humidity prevails during the fruiting season i.e the coastal areas. Other varieties like NRCC-2, Jhargram-1, Vengurla-4, BPP-4, Ullal-4, Madakkathara-2, Bhubaneswar-1, K-22-1, Chintamani-1, Goa-1, BPP-8 and Dhana apart from the coastal areas are also suitable for the places where relative humidity is less during the fruiting period, though the yield would be less but not significantly reduced.

Table 7(iii). Correlation between nut/panicle of cashew varieties with climatic factors.

Varieties	Maximum temp. (ºC)	Minimum temp. (ºC)	Rain (mm)	Cloud (%)	Relative humidity (%)
Bhaskara	0.74	0.83*	-0.28	0.07	0.18
Madakkathara-2	0.63	0.49	-0.41	0.05	0.15
Bhubneswar-1	0.53	0.59	0.03	0.46	0.35
K -22 -1	0.57	0.65	-0.12	0.47	0.45
Chintamani-1	0.06	0.75	-0.33	0.31	0.67
Ullal- 4	0.23	0.03	0.18	0.34	0.06
Vengurla-7	0.83*	0.71	-0.18	0.29	0.25
VRI -3	0.66	0.64	-0.06	0.40	0.31
BPP-6	-0.09	0.59	-0.11	0.36	0.61
Amrutha	0.16	-0.22	-0.06	-0.46	-0.61
Vengurla- 4	0.05	0.57	-0.11	0.60	0.77
Goa -1	0.47	0.87*	-0.60	0.03	0.42
Madakkathara-1	0.68	1.00	-0.30	0.29	0.51
Priyanka	0.12	0.12	0.36	0.64	0.39
BPP-8	-0.17	-0.09	0.40	0.44	0.18
Kanaka	0.68	0.70	0.19	0.50	0.36
Vengurla-1	0.64	0.67	-0.20	0.11	0.11
Vengurla-6	0.25	0.67	-0.31	0.32	0.49
Ullal-3	-0.01	0.53	0.10	0.73	0.79
Dhana	-0.10	0.69	0.01	0.57	0.848
BPP-4	-0.15	0.66	0.13	0.67	0.89*
UN-50	0.34	0.15	-0.72	-0.67	-0.37
Jhargram1	-0.46	-0.01	0.69	0.54	0.43
NRCC-2	-0.06	0.73	-0.05	0.55	0.85*

*P=0.05, **P=0.01.

Table 7(iv). Correlation between apple weights cashew varieties with climatic factors.

Varieties	Maximum temp. (ºC)	Minimum temp. (ºC)	Rain (mm)	Cloud (%)	Relative humidity (%)
Bhaskara	-0.52	0.18	0.64	0.70	0.76
Madakkathara-2	-0.32	0.33	-0.24	0.11	0.41
Bhubneswar-1	-0.31	0.24	0.63	0.61	0.58
K-22 -1	0.02	0.05	0.78	0.46	0.18
Chintamani-1	-0.17	0.27	0.15	0.25	0.30
Ullal- 4	-0.35	0.39	0.43	0.73	0.89*
Vengurla-7	-0.20	0.04	-0.22	-0.19	-0.07
VRI -3	0.28	0.42	-0.07	0.03	0.04
BPP-6	-0.72	0.03	0.46	0.57	0.70
Amrutha	-0.34	0.31	-0.09	0.18	0.43
Vengurla- 4	-0.33	0.14	0.65	0.54	0.47
Goa -1	-0.16	0.23	0.74	0.62	0.50
Madakkathara-1	-0.30	0.14	-0.01	0.07	0.19
Priyanka	-0.67	0.07	0.30	0.41	0.59
BPP-8	-0.29	0.37	0.60	0.78	0.85*
Kanaka	-0.71	-0.01	0.51	0.52	0.61
Vengurla-1	-0.71	-0.31	0.17	0.26	0.39
Vengurla-6	-0.58	0.06	0.71	0.70	0.70
Ullal-3	0.71	0.09	-0.54	-0.50	-0.60
Dhana	-0.51	-0.18	0.48	0.24	0.16
BPP-4	-0.70	-0.06	0.48	0.45	0.51
UN-50	-0.24	0.35	0.25	0.37	0.47
Jhargram1	-0.85*	-0.39	0.32	0.12	0.18
NRCC-2	-0.50	-0.45	0.96**	0.51	0.20

* P=0.05, **P=0.01.

Table 7(v). Correlation between yields of cashew varieties with climatic factors.

Varieties	Maximum temp. (ºC)	Minimum temp. (ºC)	Rain (mm)	Cloud (%)	Relative humidity (%)
Bhaskara	-0.06	0.73	-0.04	0.55	0.858*
Madakkathara-2	-0.44	0.37	-0.02	0.47	0.79
Bhubneswar-1	-0.31	0.36	-0.36	0.20	0.55
K -22 -1	-0.09	0.63	-0.34	0.28	0.65
Chintamani-1	-0.41	0.32	-0.29	0.20	0.57
Ullal- 4	-0.17	0.57	-0.17	0.50	0.78
Vengurla-7	-0.48	0.23	0.37	0.79	0.90*
VRI -3	0.06	0.71	-0.10	0.60	0.81*
BPP-6	-0.18	0.62	-0.15	0.47	0.81*
Amrutha	-0.38	0.36	-0.27	0.19	0.56
Vengurla- 4	-0.47	0.21	-0.22	0.31	0.61
Goa -1	-0.41	0.38	-0.17	0.32	0.68
Madakkathara-1	0.03	0.77	0.16	0.67	0.88*
Priyanka	-0.27	0.53	0.02	0.63	0.89*
BPP-8	-0.11	0.62	-0.18	0.46	0.74
Kanaka	-0.18	0.60	0.38	0.83*	0.97**
Vengurla-1	-0.21	0.61	0.05	0.54	0.82*
Vengurla-6	-0.29	0.52	-0.05	0.52	0.81*
Ullal-3	-0.26	0.56	0.06	0.63	0.88*
Dhana	-0.45	0.39	0.02	0.50	0.79
BPP-4	-0.11	0.58	-0.39	0.19	0.57
UN-50	-0.41	0.42	0.14	0.55	0.84*
Jhargram1	-0.33	0.42	-0.25	0.26	0.61
NRCC-2	-0.31	0.37	-0.41	0.07	0.48

*P=0.05, **P=0.01.

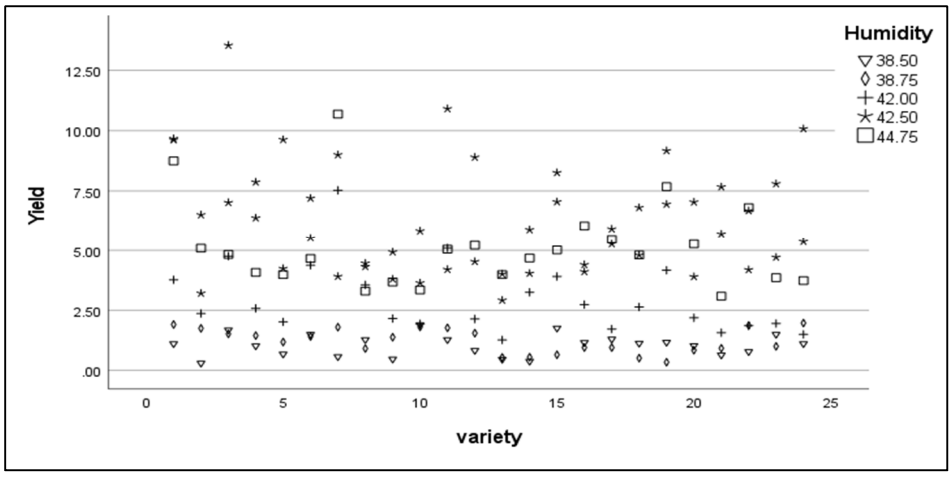

Fig 1. Effect of relative humidity on yield of cashew varieties.

According to Rupa (2017) the rainfed cashew crop is highly sensitive to changes in climate and weather, especially during reproductive phase. High temperature and low relative humidity and rainfall are the major climatic factors that influence the productivity of cashew.

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