Evaluation of cashew (*Anacardium occidentale* L.) genotypes under Bhubaneswar condition

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BHUBANESWAR, ODISHA-751003

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A THESIS SUBMITTED TO THE

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

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Bhubaneswar
Date:

CERTIFICATE-I

This is to certify that the thesis entitled **"Evaluation of cashew (*Anacardium occidentale* L.) genotypes under Bhubaneswar condition."** submitted in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY)** to the Odisha University of Agriculture and Technology is a faithful record of *bonafide* research work carried out by **SAKSHI SHARMA**, **Adm. No. 18122I14** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in any other form. .

It is further certified that the assistance and help received by her from various sources during the course of investigation has been duly acknowledged.

Place: Bhubaneswar
Date: 10-09-2020

(Dr. K. Sethi)
Chairman
Advisory Committee

ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

DEPARTMENT OF FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY

COLLEGE OF AGRICULTURE

BHUBANESWAR-751003, ODISHA

CERTIFICATE – II

This is to certify that the thesis entitled **"Evaluation of cashew (*Anacardium occidentale* L.) genotypes under Bhubaneswar condition"** submitted by **SAKSHI SHARMA** to the Odisha University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** in the discipline of **FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY** has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with the External Examiner.

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Bhubaneswar **SAKSHI SHARMA**

Date: 10-09-2020

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ABBREVIATIONS USED

%	:	Percentage
cm	:	Centimetre
mm	:	Millimetre
m	:	Meter
km	:	Kilometer
Kg	:	Kilogram
gm	:	Gram
°C	:	Degree Celsius
df	:	Degree of freedom
Approx.	:	Approximately
viz.	:	Namely
ha	:	Hectare
et al	:	Co-workers
GCC	:	Ground coverage by canopy
Fig.	:	Figure
i.e.	:	That is
GCV	:	Genotypic coefficient of variation
PCV	:	Phenotypic coefficient of variation
GA	:	Genetic advance
h^2	:	Heritability
SEm	:	Standard error of mean
RH	:	Relative humidity
BSH	:	Bright sunshine hours
MT	:	Metric ton

ABSTRACT

The present investigation entitled "**Evaluation of cashew (*Anacardium occidentale* L.) genotypes under Bhubaneswar condition**" was conducted during the year 2019-2020 at Cashew Research Station (AICRP on cashew), Odisha University of Agriculture and Technology, Bhubaneswar. Fifteen Cashew genotypes (V_1- BH-27, V_2- BH-105, V_3-BH2-6, V_4-BH-30, V_5-BH-19, V_6-RP-1, V_7-RP-2, V_8-VTH 711/4, V_9-Kankadi, V_{10}-M44/3, V_{11}-BBSR-1, V_{12}-BPP-8, V_{13}-NRCC Sel-2, V_{14}-Dhana, V_{15}-H-320) were planted during the year 2014 following statistical design RBD (Randomized Block Design) and the experiment was replicated twice. All standard package of practices were followed to raise the crop.

In the present investigation, vegetative parameters, yield attributes and mean annual nut yield plant^{-1} revealed a spectacular wide array of variations among the tested genotypes. Genotype, BH-19 recorded maximum plant height (5.25m), canopy spread (N-S) (6.25m) and ground coverage by canopy (26.54 m^2) among the tested genotypes. Trunk girth (56.3 cm) and apple weight (101.50g) were recorded maximum in genotype, Kankadi. Maximum nut weight was recorded in genotype, VTH-711/4(13.22g). Sex ratio was recorded maximum in genotype, M-44/3 (0.38) while nuts panicle^{-1} was recorded maximum in genotype, RP-1(15.65). Shelling % varied from minimum 23.5% in genotype Kankadi to maximum 32.2 % in genotype Bhubaneswar-1. Significantly maximum mean annual nut yield (8.25 kg plant^{-1}) as well as cum nut yield (18.45kg plant^{-1}) were recorded in genotype, BH2-6 at 4th harvest. Studies on heterosis revealed that genotype, BH-19 exhibited best standard heterosis nut weight. For shelling % and nut yield genotype, BH2-6 was identified as superior over standard check. The phenotypic and genotypic coefficient of variation ranged from minimum 13.28% and 12.74% in trunk girth to maximum in 63.81% and 63.45% in nuts panicle^{-1} respectively. Heritability estimates were recorded high for parameters viz. nuts panicle^{-1} (98.85%), apple weight (98.76%), nut yield (97.53%) and nut weight (96.55%). The genetic advance ranged from minimum 0.14 in sex ratio to maximum 42.3 in apple weight. The parameters which exhibited high genetic advance were trunk girth (11.65), ground coverage by canopy (10.91) and nuts panicle^{-1} (8.34). The genetic advance (as % of mean) was varied from as low as 13.60 in shelling % to as high as 129.95 in nuts panicle^{-1}.

Among the fifteen tested cashew genotype, BH2-6 recorded the maximum mean annual nut yield (8.25kg plant $^{-1}$), cum. nut yield (18.45kg plant^{-1}) and standard heterosis (32%) at 4th harvest (6 years old plant). Hence, the genotype may be evaluated further (upto six harvest) before recommendation for commercial cultivation in the state. Genotypes, RP-1, Kankadi, VTH-711/4 and BH2-6 recorded high heritability alongwith high genetic advance and genetic advance (as % of mean) for the yield attributing parameters viz. nuts panicle^{-1} (98.85%, 8.34, 129.95%), apple weight (98.76%,42.3, 85.15%), nut yield (97.53%,3.79, 73.08%) and nut weight (96.55%,4.48,57.96%) respectively. So, there is scope for improvement by using these genotypes as parent in future cashew breeding programme.

CHAPTER- I

INTRODUCTION

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a miracle nut crop for India's economy. It belongs to family *Anacardiaceae* comprising of 75 genera and 700 species (Nakasone& Paul,1998). Cashew is native to Brazil and was introduced into India by Portuguese with a prime objective to check soil erosion, but later on emerged as dollar earning crop of the country. Cashew produces nut (botanically a fruit) and apple (fleshy pseudo fruit) which are of world importance. Cashewnut kernel contains protein (21%), carbohydrates (22%), fat (47%), moisture (5.9 %), iron (5%), phosphorus (0.45%), calcium (0.05%) and other mineral elements. Cashew apple contains high amount of vitamin C (260 mg/100g) which is used to make squash, juice, wine (a fermented beverage "Feni" prepared from cashew apple in Goa). Other by product obtained from cashew nut of industrial importance is "CNSL". It is derived from outer shell of nut. Main constituent of oil are anacardic acid and cardol. CNSL is mainly used in adhesive for plywood, paints, ship building industry, processing aids for rubber compound, modifiers for plastic materials, textile and resin industry. In addition, cashew extracts have been used as alternative medicines because they have anesthetic and bactericidal properties (Kubo *et al.,* 2011; Kulis *et al.,* 2012; Silva *et al.,* 2013).

This crop has very significant role in India's economy. India ranks first in consumption and second in production and export of cashewnut (FAOSTAT, 2017). Presently the total cashew area in the country is 10.62 lakh hectare with raw nut production of 8.17 lakh metric tons and productivity of 753 kg ha^{-1} (DCCD, 2019). The production and productivity of cashew nut in the country is very low, India has to import large quantity of cashewnut from other countries to meet the demand of processing industries in the country. The states which are widely cultivating cashew at commercial scale are Kerala, Tamil Nadu, Goa, Maharashtra, Karnataka, Andhra Pradesh, West Bengal, Odisha and North Eastern states. Cashewnut is also a potential agricultural produce of Odisha and is now being cultivated in an area of 183.32 thousand hectare with a production of 93.9 thousand metric tonnes. Major Cashew growing district of Odisha are Dhenkanal, Khordha, Jajpur, Cuttuck, Koraput, Ganjam, Nabarangpur and Nayagarh. The productivity of cashewnut in Odisha is only 513 kg ha^{-1}, which is very less compared to the national average productivity (753 kg ha^{-1}).

The major reason for low productivity of cashew in the state is due to presence of senile orchard and use of locally available planting material of seedling origin along with traditional method of cultivation. Thus, to improve the nut productivity, it is important to select genotypes with favourable traits from the existing gene pool. Cashew, being a highly cross pollinated crop, the seedling progenies are highly heterogeneous in nature. So, genetic variability is observed within the progenies both at genotypic and phenotypic levels (Samal, 2002). Morphological variability and character associated with high productivity of cashew was reported by Dela Cruz and Fletcher (1997). Cashew breeding is based on selection of important and useful phenotypic and agronomic characters such as nut weight, nut size, apple colour, size of apple, tree canopy, length of panicle and over all nut yield production (Mneney *et al.,* 2001). The present investigation aims at identification of cashew genotype(s) with high yield potential to enhance the productivity of cashewnut in the state as well as in the country. Secondly the study was undertaken to know the extent of variability exist among the tested cashew genotypes. Thus the experiment was conducted with the following three objectives

- To evaluate cashew genotypes for growth, yield attributes and nut yield
- To identify the cashew genotypes for *per se* performance
- To study the nature and extent of genetic variability of cashew genotypes

CHAPTER-Ⅱ

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In the chapter "**Review of Literature**" all efforts have been made to assemble research findings related to vegetative growth, yield attributes, nut yield, heterosis and genetic variability on cashew investigated in India and overseas.

The details of "**Review of Literature**" are presented with the following broad headings

2.1 Vegetative growth parameters

2.2 Yield attributing parameters

2.3 Nut yield

2.4 Heterosis

2.5 Genetic variability

2.1 Vegetative growth parameters

2.1.1 Plant height (m)

Reddy *et al*. (2004) revealed that among the 52 cashew genotypes studied under Bapatla conditions, the plant height varied from 1.27 m (T.No. 30/1) to 2.62 m (T.No. 277) at the age of three years. Sindoni *et al.* (2005) conducted an experiment to evaluate the clones like CCP-76, CCP-06 and CCP-1001. They recorded plant height between 1.4m to 2.2 m and a tree crown diameter between 2.7m and 3.0m. Significant variation in tree height was observed among the entries under Chintamani conditions. The highest height of the plant was recorded in the entries NRCC-1(6.16m) and H-225 (6.16 m) followed by M 15/4 (5.98 m) and H-320 (5.90 m). Sharma *et al. (*2009) noted maximum height in the genotype CARS-10. Hanumanthappa *et al*. (2014) observed that the highest plant height (3.93m) and panicle width (26.97cm) were recorded in Ullal-1 and lowest plant height and panicle width were noticed in Ullal-3 and Vengurla-7.

Tripathy *et al.* (2015) evaluated cashew varieties under Odisha conditions at 6^{th} and 7^{th} year of planting. Amrutha, Madakkathara-2, K-22-1, BPP-4, VRI-3, Ullal-4, UN-50 and Goa-1 recorded variation in plant height from 2.58 to 4.05m. Mohapatra *et al.* (2017) observed maximum plant height in genotype H 32/4 (5.87cm) closely followed by H 2/16 (5.43cm). Minimum height was recorded in genotype K-22-1 (3.61m). Roy *et al*. (2018) reported that the plant height varied from minimum 3.47m

in RP-6 to maximum of 7.0 m in Tapanga. Genotype, Vengurla-7 recorded maximum tree height (5.45m) while genotype K22-1 (4.20 m) and VRI-3 (4.25 m) recorded the minimum plant height, indicating their suitability for high density planting (Chandrasekhar M *et al.,* 2018). Sahoo *et al.* (2019) found that F_1 progeny, BH2-6 recorded maximum plant height (5.35m) among the evaluated cashew genotypes.

2.1.2 Trunk girth (cm)

The trunk girth of cashew tree varied from 54.3 cm to 66.7 cm among the thirteen clones evaluated at Cashew Research Station, Bapatla, Andhra Pradesh, at the age of eight years (Reddy *et al.,* 2002). Maximum trunk girth was recorded in variety H-1610 (84.3 cm) while Vengurla-2 (61.8 cm) recorded the least girth at the age of fifteen years (Vishnuvardhana *et al.,* 2003).

Reddy *et al.* (2004) noted that T.No. 71 (30 cm) recorded maximum girth which was at par with T.No. 277 (29.5 cm), T.No. 268 (29.0 cm), T.No. 4/5 (28.3 cm) and T.No. 2/3 (28.2 cm) under Bapatla conditions. Girth at collar region (45.84cm) was significantly high in Bhaskara, while the lowest girth at collar region (36.42 cm) was observed in Ullal-2 and Vengurla-4 (Hanumanthappa *et al.,* 2014).

Paikra (2016) reported highest trunk girth in H-68 (69.37cm) and lowest in VRI-2(41.62 cm) and the general mean trunk girth was 58.78 cm during the experiment conducted at IGKV, Jagdalpur, Chhattisgarh. BPP-8, Bhaskara, Vengurla-7, NRCC Sel.-2 and Ullal-3 recorded trunk girth varied from (34.73 to 54.40cm) (Tripathy *et al.,* 2015). Maximum trunk girth (1.9m) was found in AO Hat 006 and minimum in AO Hat 003 (0.45m) under an experiment performed at RARS, Hathazari, Chittagong, Bangladesh. (Ona *et al.,* 2017). Roy *et al.* (2018) observed that the girth of plant was maximum in genotype RP-3(95.40cm) among thirty evaluated cashew germplasm. Sahoo (2019) observed that cross parent, Kankadi recorded maximum trunk girth (47.62cm) among the evaluated cashew genotypes at the age of 6^{th} year of planting.

2.1.3 Canopy spread (m)

Hanamashetti *et al.* (2002) identified non-significant difference among varieties for canopy spread in N-S and E-W directions under high rainfall hill zone of Karnataka. Dorajeerao *et al.* (2002) recorded maximum spread of the canopy both in E-W (5.46 m) and N-S (5.37 m) directions in Tree No. 10/19, (5.42 m) at Cashew

Research Station, Bapatla, Andhra Pradesh. The plant spread in both the directions (N-S & E-W) was recorded maximum in T.No. 268, T.No. 12/1, T.No. 4/5, T.No. 10/2, T.No. 2/5 and T.No. 277 (Reddy *et al.,* 2004). Among the varieties Selection-1 recorded the highest spread in both directions (6.37 m and 6.83 m respectively), whereas lower spread was observed in Vengurla-6 (3.63 m and 3.43 m respectively) under hill zone of Karnataka (Mahesha *et al.,* 2005).

Singh L.S *et al.* (2010) observed that performance of Madakkathara -1 and VTH-30/4 were found superior for growth character. Maximum canopy spread was recorded in genotype, VTH-30/4 (20.70 m) followed by hybrid Dhana (1.24 m). Hanumanthappa *et al.* (2014) found that canopy spread (4.50m) was significantly high in Bhaskara, while the lowest canopy spread (3.67m) was observed in Ullal-2 and Vengurla-4. Widest canopy spread East-West and North –South direction were observed in genotype, Vengurla-4(5.25m & 5.15cm) and shortest was observed in genotype, VRI-2 (3.04 m & 2.89cm) respectively (Paikra, 2016).

Ona *et al.* (2017) recorded highest plant spread in East-W direction in cashew genotype, AO Hat 001(13.8m) while lowest was recorded in AO Hat 003 (4.8m). Plant spread at N-S direction was maximum at AO Hat 007 (16.0m) and minimum in AO Hat 003 (4.2m). Chandrasekhar M *et al.* (2018) recorded that canopy spread in North-South direction was maximum in genotype Vengurla-7(8.75m) while canopy spread in East-West direction was noted maximum in variety, BPP-8(8.75m).

Jha (2019) reported that maximum canopy spread in N-S direction was observed in variety M15/4(3.75 m) while variety, BPP3/33 (3.95 m) recorded maximum canopy spread in East-West direction.

2.1.4 Ground coverage by canopy

Rejani *et al.* (2013) revealed that ground coverage by canopy was higher in Ullal-3 (59.7%) and Bhaskara (58.9%) and was lowest in VRI-3 (36.6%). Tripathy *et al.* (2015) found that percentage of ground cover by canopy was maximum with S3 M3 (144.29%).

2.2 Yield attributing parameters

2.2.1 Sex ratio

Hallad and Sulikeri (1992) recorded the highest sex ratio (perfect to staminate flower) of 0.1 in 6/21 Moodabidri, Mysore followed by 0.11 in 2/61, Alangudi, Madras. Sena *et al*. (1995) revealed that the sex ratio ranged between the genotypes H

1600 (0.093) to BBSR C II (1.038). Lenka *et al*. (1999) studied thirteen cashew clones under Bhubaneswar condition. Staminate flower production reached peak between the weeks 3rd to 6th and perfect flower production in weeks 5th to 6th. The sex ratio in the first 3 weeks of flowering was high and then declined gradually after week 6th. Genotype, Vengurla-3 reported the highest percentage of perfect flowers (379.16 and 42.47%, respectively), as well as lowest percentage of staminate flowers (57.52%). Sex ratio was recorded maximum in Vengurla-3 (0.73) while minimum was recorded in Ullal-2 (0.07) (Hegde *et al.,* 2000).

Lakshminarayana *et al.* (2002) recorded that M-44/3 was found superior for number of panicles m^{-2} and sex ratio. Paikra (2016) reported highest sex ratio (0.27) in genotype VRI-1, VRI-2 and H-367 and the lowest (0.21) in genotype, BPP 30/1. Sreenivas *et al. (*2016) reported that maximum sex ratio (0.17) was recorded by H 303 and H 338 whereas, the minimum values were recorded by H 328 (0.11). Mohapatra *et al.* (2017) recorded highest sex ratio in genotype H 675(0.88) while lowest sex ratio was recorded in local check BPP-8 (0.18).

2.2.2 Number of nuts panicle^{-1}

Cashew genotype, M-15/4 was found superior with regard to the number of nuts panicle^{-1}. (Lakshminarayana *et al.,* 2002). Poduval (2015) reported that cultivar 'H-303' had maximum number of nuts panicle^{-1}. Sethi *et al*. (2015) recorded maximum average number of nuts panicle^{-1} in H 303 (4.19). Genotype, H-68 (5.98) recorded highest number of nuts panicle^{-1} while the lowest was observed in genotype, NRCC Sel-1 (2.91) (Paikra, 2016). Under Bhubaneswar condition variety, Bhubaneswar-1 recorded maximum nuts panicle^{-1} (9.0) among twenty five tested released cashew varieties, (Chandrasekhar M *et al.*,2018).

2.2.3 Nut weight (g)

Mahesha *et al.* (2005) reported heaviest nut weight in Selection-2 (9.76 g) which differed significantly with others (Vengurla-6 (8.57 g) and Selection-1 (8.48 g)). The least weight of nut was recorded in genotype, Vengurla-2 (4.69 g). Mean nut weight was highest in Priyanka (11.0 g) followed by T.No 15/4 (8.90 g) at Cashew Research Station, Bapatla, Andhra Pradesh (Venkataramana *et al.*, 2015).

Tripathy *et al.* (2015), found that the cashew varieties such as BPP-8, NRCC Sel-2, Vengurla-7, Bhaskara and Ullal-3 recorded nut weight varied from 7.45 to 10.10 g. According to Sreenivas *et al.* (2016) genotype H-94 recorded the highest nut weight.

Paikra (2016) observed highest nut weight in genotype H-367(10.07 g) and the lowest in genotype BPP 10/19(5.70 g).

Gajbhiye *et al.* (2018) revealed that among the 12 types/hybrid tested, maximum nut weight was recorded in cashew genotype H-367(9.98 g). Chandrasekhar M *et al.* (2018) revealed that maximum nut weight (9.6 g) and kernel weight (3.02g) was recorded in variety, Vengurla-7 under Bhubaneswar condition during evaluation of twenty five released varieties of cashew.

2.2.4 Apple weight (g)

Narayanankutty (2000) observed that the average apple weight was more than 70g in BRZ-241, Priyanka, H-1610, H-1593, Akshaya, BRZ-242, H3/17, Kanaka, V-2, V-3 and Sulabha. Abdulsalam and Joseph (2003) observed that apple weight differed considerably between varieties. Apple weight was recorded minimum in the variety V-5 (27.13 g) and the highest in the variety, M 33/2 (87.31 g) under Madakkathara conditions. Ghatge *et al.* (2009) revealed that out of 30 F_1 hybrids, H-1141 had highest weight of apple (72.72 g) and H-824 showed maximum apple to nut ratio (7.82).

Hore *et al.* (2015) recorded maximum apple weight in H-303 (68.24 g), juice content (45.84 ml) and total sugar (10.54%). Anand *et al.* (2015) reported that the weight of cashew apple varied from 34.08g (Vengurla-4) to 75.44g (Jagannath). Sreenivas *et al.* (2016) noted maximum apple weight in genotype H-116. During a study at Directorate of Cashew Research, Puttur, Karnataka it was found that apple weight and apple volume was highest in Priyanka whereas Ullal-1 recorded lowest apple weight and apple volume respectively (Mog and Nayak, 2018).

Gajbhiye *et al.* (2018) recorded highest apple weight in genotype H-367(91.33 g). Among the twelve cashew genotypes average apple weight ranged from minimum 46.20 g in BPP30/1 to maximum 98.70 g in H367 (Jha, 2019).

2.2.5 Shelling %

Maximum shelling % of 30.49 was recorded in the entry H-1594 followed by TN-139 (29.35) and minimum was in the entry TN-40 (24.95) (Shivareddy, 1996). Among the seven different cashew accessions studied at Agricultural Research Station, Chintamani, the shelling % varied from 33.5 (ARSC-15/8) to 22.2 (ARSC-12/4) (Lingaiah *et al.*, 1997).

Abdulsalam *et al.* (1997) found that the shelling % was highest with the variety Anakkayam-1 (37.00%) followed by M-44/3 (36.4%) and VTH-30/4 (36.0%) and the

lowest shelling % was in VTH-59/2 (28.1%) under Madakkathara conditions. Reddy *et al.* (2015) revealed that among fourteen cultivars/hybrids, H-320 performed better for nut weight (8.8 g), shelling (31.0%) and consistent nut yield over years under maidan parts of Karnataka. Sethi *et al.* (2015) found that among the tested hybrid significantly maximum kernel recovery was observed in A-71 (34.41%) followed by E-28 (34.21%), F-38 (33.52%), B-27 (33.42), F-16 (33.33%) and A-48 (33.20%). Minimum shelling % was recorded in J-1 (24.37%). Zachariah *et al.* (2015) revealed that hybrid "Poornima" recorded high nut weight as well as shelling (%) during evaluation under Kerala condition.

Venkataramana *et al*. (2015) noticed that shelling percentage ranged from 25.65 to 36.17% across the 40 germplasm lines evaluated at Cashew Research Station, Baptala. Maximum shelling was recorded in genotype BH-6(31.10%) followed by H1597 (31.00%) and H-675(30.40%). The lowest shelling was recorded in genotype H32/4(28.07%) (Mohapatra *et al.,* 2017).

Mog and Nayak (2018) reported that highest nut yield and shelling % was noted in Ullal-1 and Ullal-2 during the experiment conducted at Directorate of Cashew Research, Puttur, Karnataka. Gajbhiye *et al*. (2018) reported maximum shelling percentage in BPP 3/33 (31.15%) followed in H-255 (30.25%). Chandrasekhar M *et al.* (2018) noted that Kanaka recorded maximum shelling% (32.76%) among the twenty five released cashew varieties.

2.3 Nut yield plant^{-1}(kg)

Dadzie *et al.* (2014) noticed significant differences in the performance of the clones in all the parameters considered. A few clones combined two or three traits (parameters) which were significantly different from the rest of the clones tested. Not a single clone was found to be significantly different from the rest in terms of all the parameters considered. However, a large proportion of the clones were found to produce yield far above average yield recorded by unselected cashew trees in farmer's fields. Clones W-266 and W-278 seem outstanding for most of the parameters considered, though not exclusive.

Reddy *et al.* (2015) assessed fourteen cultivars and recorded maximum yield in genotype H-320 (12.76 Kg tree^{-1}) followed by NRCC-2 (10.82 kg tree^{-1}). Cumulative yield over a period of 16 harvests was recorded maximum for H-320 (144.85 kg tree^{-1}) followed by NRCC Sel.-2 (127.34 kg tree^{-1}). Tripathy *et al.* (2015),observed that the cashew genotypes such as Vengurla-7, Bhaskara, NRCC Sel-

2, BPP-8 and Ullal-3 seem desirable for the reproductive traits such as nut yield plant^{-1} (4.00-6.05 kg) and cumulative nut yield (8.011.86 kg plant^{-1}) at 7th year of planting. Sethi *et al*. (2015) reported that H303 (106.8) was found having maximum cumulative nut yield (kg plant^{-1}) at 14th harvest followed by NRCC Sel.-2 (100.0), H 68 (93.1) and lowest in M 15/4 (37.5). Gajbhiye *et al.* (2018) revealed the maximum pooled yield (6 years) in H-303 (7.24 kg tree^{-1} and 1.48 t ha^{-1}) with bold nut of 8.90g.

Venkataramana *et al.* (2015) investigated forty germplasm lines of cashew at CRS, Bapatla. The highest annual mean nut yield was found in genotype T.No 275 (26.15 kg tree^{-1}) followed by T.No. 228 (14.76 kg tree^{-1}). However, cumulative nut yield are found highest with BLA 39-4 (66.48 kg tree^{-1}) followed by T.No 5/1 (60.04 kg tree^{-1}) after ninth annual harvests. Chandrasekhar M *et al.* (2018) noted that nut yield was significantly maximum in variety, BPP-8 (16.75 kg plant^{-1}) while that of lowest in variety Jharagram-1(1.60kg plant) at 7th harvest.

Roy *et al.* (2018) recorded maximum nut yield in cashew genotype BH-85(15.7kg plant^{-1}) and minimum in RP-3(1.4 kg plant^{-1}). F_1 progeny, C2-6 recorded maximum nut yield (4.5kg plant^{-1}) during the period of evaluation (Sahoo, 2019). Highest nut yield was recorded in variety, M15/4 (4.30 kg plant^{-1}) followed by H 68 (4.10 kg /plant). Lowest yield was recorded in variety BPP30/1(2.25 kg plant^{-1}) at the 3rd year harvest. Cumulative nut yield (kg plant^{-1}) of three harvest highest nut yield was recorded in variety, M 15/4 (9.20 kg plant^{-1}) followed by H 68 (9.00 kg plant^{-1}), while that of lowest in variety BPP 30/1(5.15 kg plant^{-1}). Hence, these varieties have the potential of producing higher nut yield than rest of the evaluated varieties (Jha, 2019).

2.4 Heterosis

Cavalcanti *et al.* (2007) revealed that kernel weight, nut weight, plant height and canopy diameter are under strong additive genetic control and do not present heterosis. The heritability of number of nuts and yield were higher in the broad than in the narrow sense. This indicates dominance and heterosis of these traits should be adequately exploited in cashew breeding programmes. Therefore, the best-suited breeding method to exploit heterosis is reciprocal recurrent selection using individual crosses between parents with high mean genotypic performance and high specific combining ability.

Sankaranarayan *et al.* (2015) performed an experiment with thirty genotypes of cashew and found that heterosis over 100% in three cross combinations. For vigour

index, the maximum relative heterosis of 62.80 was observed in cross combination M 44/3 × PU6. The parents M 44/3, M 3/2 and M 33/3 were good general combiners of germination % while M 10/4 and M 33/3 were the good general combiners for vigour index.

Sethi *et al*. (2016) reported that hybrids viz. A-71, C-30, B-27 and C-41 exhibited better heterosis in terms of nut weight (-0.27 to 19.68%), kernel weight (18.89 to 32.26%) and overall nut yield (15.51 to 30.70%) than rest of the tested hybrids. Sahoo *et al.* (2019) revealed that F_1 progeny, BH2-6 was found to be the best heterotic progeny for nut yield with respect to mid parent, better parent and standard check. For nut weight F_1 progeny, BH-105 showed best relative heterosis and heterobeltiosis followed by F_1 progeny, BH2-6 for shelling %, F_1 progeny, BH-30 exhibited best heterotsis over mid parent, whereas BH-19 recorded best for heterobeltiosis and standard heterosis.

2.5 Genetic variability

Lenka *et al.* (1999) noticed that traits like sex ratio, number of staminate flowers panicle^{-1}, number of perfect flowers panicle^{-1} and nut yield plant^{-1} recorded high estimates of genotypic coefficient of variation (GCV), heritability and genetic gain (advance). The best contributors to nut yield were number of flowering panicles m^{-2}, number of nuts panicle^{-1} and nut weight. Number of staminate flowers and perfect flowers recorded positive association with nut yield both at the genotypic and phenotypic levels.

Sankarnaryanan and Ahmad Shah (1999) revealed high genotype estimates for nut yield (88.87), followed by number of perfect flowers (45.67) and fruit set panicle^{-1} (30.93). The highest heritability was noted in average nut and 100 kernel weight (82.22), however, with much lower genetic advance over mean. Number of perfect flowers panicle^{-1} and number of fruits panicle^{-1}, recorded the highest genetic gain of 68.6 and 49.22 respectively with moderate heritability of 53.06 and 59.54 per cent respectively.

Lenka *et al.* (2001) revealed that the important selection criteria for improvement of nut yield in the cashew were number of staminate and perfect flowers, number of nuts panicle^{-1}, nut weight and nut yield plant^{-1}. High estimates of genotypic coefficients of variation (GCV), heritability and genetic advance were recorded for nut yield plant^{-1}, number of staminate flowers panicle^{-1}, number of perfect flowers panicle^{-1} and number of nuts panicle^{-1} indicating their reliability for effecting selections for

high nut yield. Number of flower panicles^{-1}, nut weight and number of nuts panicle^{-1} were the best contributors to nut yield and further number of staminate flowers and perfect flowers showed high positive association with nut yield both at genotypic and phenotypic levels.

Reddy *et al.* (2002) recorded the genetic and phenotypic variation, heritability and genetic advance for yield and yield attributes. For number of nuts panicle^{-1}, percentage of flowering shoots m^{-2}, nut yield, kernel yield, kernel weight, 100- nut weight, fruit weight and stem girth high PCV was recorded. While high GCV was registered for nut yield, kernel yield, number of nuts panicle^{-1}, % of flowering shoots, number of flowering shoots m^{-2}, kernel weight, 100-nut weight, fruit weight and % of hermaphrodite flowers. Very high heritability (broad sense) estimates were recorded for the number of flowering shoots m^{-2}, panicle length, fruit weight, % of flowering shoots m^{-2}, 100-nut weight, kernel weight and stem girth. The number of flowering shoots m^{-2} showed high heritability with high genetic advance.

Genetic analyses carried out in Australia, of the hybrids of NDR2-1 × Guntur, Guntur X CJ 1, CJ 1 × Guntur, Guntur × 1-2-13, 2-310 × Guntur, 5-14-4 × Guntur and 1-3-4 × Guntur, indicated that the nut yield and yield related traits had relatively higher heritability, suggesting scope for further improvement by breeding (Blaikie *et al.*, 2002). The nut count and its weight tree^{-1} contributing most towards the total divergence. The heritability and the genetic advance estimates showed clearly that total nut yield tree^{-1} can be improved through individual tree selection (Faluyi, 2006).

Ghatge *et al.* (2009) recorded high estimates of genotypic coefficient of variation, heritability and genetic gain (advance) for number of staminate flowers panicle^{-1}, number of perfect flowers panicle^{-1}, sex ratio and nut yield plant^{-1}. The best contributors to nut yield were number of flowering panicles m^{-2}, nut weight and number of nuts panicle^{-1} . Ushavani and Jayalekshmy (2009) observed that number of perfect flowers m^{-2} and number of nuts m^{-2}had high heritability.

Dasmohapatra *et al.* (2012) noticed the existence of considerable amount of genetic variability for all the characters of cashew. The sex ratio exhibited highest values of GCV and PCV fallowed by nut yield (kg tree^{-1}), nuts panicle^{-1}; however nut weight and flowering shoots m^{-2} of canopy showed moderate GCV and PCV. High heritability values were noticed for sex ratio, nut yield (kg tree^{-1}), nuts panicle^{-1}, nut weight and flowering shoots m^{-2} canopy, inferring that nut yield and its related

traits are reliable parameters for enhancing yield in cashew. High values of heritability coupled with high genetic gain were observed for sex ratio, nut yield (kg tree^{-1}) and nuts panicle^{-1} indicating that they can used directly for selection in improvement of cashew. Sethi *et al.* (2016) during an investigation reported that PCV was higher than GCV for all the traits, PCV and GCV for plant height (11.63 and 10.31), trunk girth (15.42 and 14.04), canopy spread (14.50 and 12.67 in North-South direction, 14.67 and 13.46 in East-West direction), nut weight (18.74 and 17.82), cashew apple weight (27.94 and 26.02), shelling % (4.98 and 3.11) and nut yield (kg plant^{-1}) (50.13 and 47.02) and high heritability estimates coupled with high genetic gain as % of mean was observed for nut weight (34 to 99), nut yield plant^{-1}, nuts panicle^{-1} (42.22), cashew apple weight (50.06) and nut yield plant^{-1} (90.96).

Vikram *et al.* (2016) found that the phenotypic coefficients of variation were higher than the genotypic coefficients of variation for all the characters. Higher GCV was observed for number of nuts panicle^{-1}, number of panicles m^{-2}, apple volume, apple weight and yield tree^{-1}. High PCV was recorded for plant height, crown size, number of panicles m^{-2}, number of nuts per panicle, apple volume, apple weight and yield per tree. Plant height, crown size, number of panicles m^{-2}, number of nuts panicle^{-1}, apple volume, apple weight, nut weight, nut length and yield tree^{-1} indicated higher genetic gain. Sethi *et al.* (2016) performed an experiment with 71 cashew genotypes, found that number of perfect flowers revealed maximum variability (CV=50.83%) followed by sex ratio, apple weight and nuts panicle^{-1}. Studies revealed that the traits like sex ratio, nuts panicle^{-1}, yield plant^{-1} and nuts m^{-2} have high heritability, high genetic advance together with high GCV . Therefore, these traits should be selected for crop improvement. In contrast; plant height, canopy spread (E-W), total laterals m^{-2}, nut weight, trunk girth, flowering laterals m^{-2}, flowering duration, kernel weight and apple weight showed high heritability, moderate genetic advance and moderate GCV; indicated improvement of these characters would be expected (Chandrasekhar M *et al.*, 2017) .

CHAPTER-Ⅲ

MATERIALS AND METHODS

MATERIALS AND METHODS

In this chapter the materials which are used and the methods followed to complete the research study is broadly discussed.

3.1 Experimental Site

The present investigation entitled "Evaluation of cashew (*Anacardium occidentale* L.) genotypes under Bhubaneswar condition" was performed during the year 2019-2020 at Cashew Research Station (AICRP on cashew), Odisha University of Agriculture and Technology, Bhubaneswar. The site is situated about 7 km from the College of Agriculture, Bhubaneswar. The latitude of the site is 20°15'N and 85°52'E and altitude is 25.5 m. It experiences a coastal humid climate as it is very close to Bay of Bengal (60 km away).

3.2 Climate

Climate of the research station is characterized by warm moist climate with mild winter. The mean annual rainfall of the region was 1423.6 mm. Major portion of rainfall (85%) is received from June to October. The mean maximum temperature varied from 28.4°C to 37.2°C and the mean minimum temperature varied from 15.6°C to 26.6°C. The mean relative humidity was 81.58%. Maximum relative humidity was recorded in August and September while lowest relative humidity was recorded from the month of February to April during the research study. The maximum and minimum bright sunshine hour (BSH) per day was 8.4 and 3.5 respectively. Maximum sunshine hour was recorded in the month February (8.4 hours) while minimum in July (3.5 hours). The meteorological data recorded monthly during the cropping season at meteorological observatory of Odisha University of Agriculture and Technology, Bhubaneswar is presented in Table 3.1**.**

Table 3.1. Weather data of Cashew Research Station, Bhubaneswar from June, 2019 to May, 2020

Month/Year	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	No. of rainy days	Bright sunshine hours
	Mean Max.	Mean Min.				
June ,2019	35.5	26.6	90	144.6	9	6.4
July, 2019	32.2	25.2	88	317	18	3.5
August, 2019	31.6	25.1	90	389	19	4.1
September, 2019	32.1	24.8	91	241	17	5
October, 2019	32.2	23.0	87	127	9	7.2
November, 2019	30.4	19.4	80	48	2	7.3
December, 2019	28.4	15.6	78	9	1	8.2
January, 2020	28.7	15.6	76	0	0	8.2
February, 2020	31.4	18.7	72	27	2	8.4
March, 2020	34.9	22.2	75	28	3	7.7
April, 2020	36.9	25.0	75	26	3	8
May, 2020	37.2	26.2	77	67	5	7.8
Total / Mean	**32.63**	**22.28**	**81.58**	**1423.6**	**7.33**	**6.82**

3.3 Experimental Details

Fifteen Cashew genotypes (V_1- BH-27, V_2- BH-105, V_3-BH2-6, V_4-BH-30, V_5-BH-19, V_6-RP-1, V_7-RP-2, V_8-VTH 711/4, V_9-Kankadi, V_{10}-M44/3, V_{11}-BBSR-1, V_{12}-BPP-8, V_{13}-NRCC Sel-2, V_{14}-Dhana, V_{15}-H-320) were planted in Cashew Research Station, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha during the year 2014 following statistical design Randomized Block Design (RBD) and the experiment was replicated twice. The layout of experimental plot is illustrated in Figure 3.2.

Table 3.2: Cross details of tested cashew hybrids

Hybrids	Cross parents	Hybrids	Cross parents
BH-27	RP-1 x VTH -711/4	BH2-6	RP- 2 x Kankadi
BH-30	RP-2 x Kankadi	BH-105	Bhubaneswar-1 x BPP-8
BH-19	M-44/3 x VTH- 711/4		

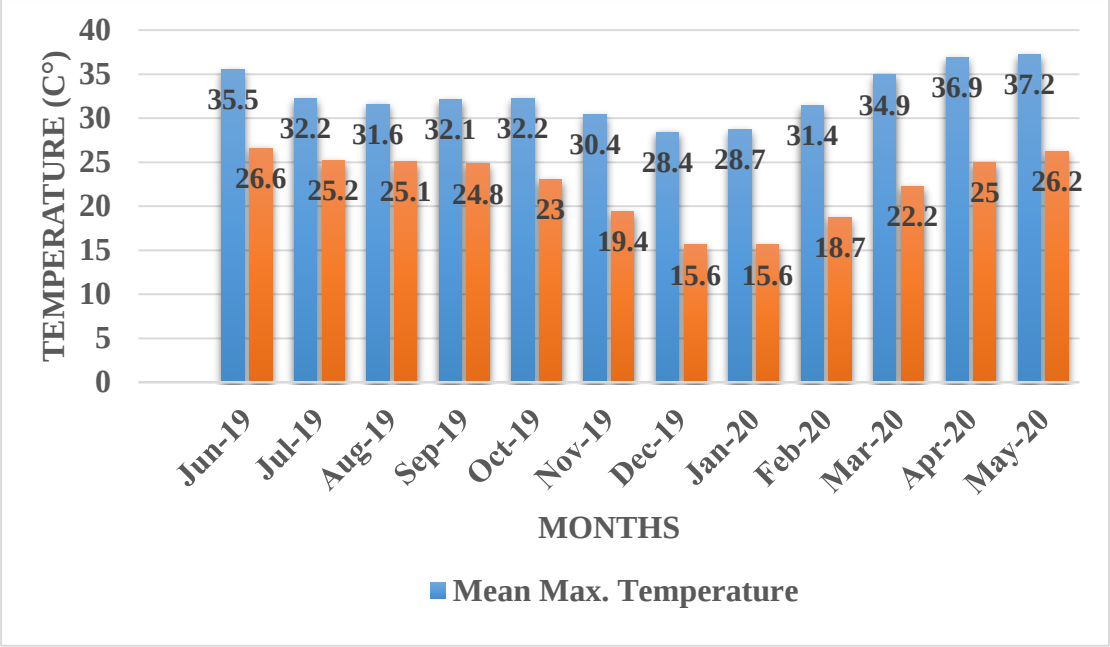

Fig. 3.1 Mean of maximum and minimum temperature from June, 2019 to May,2020

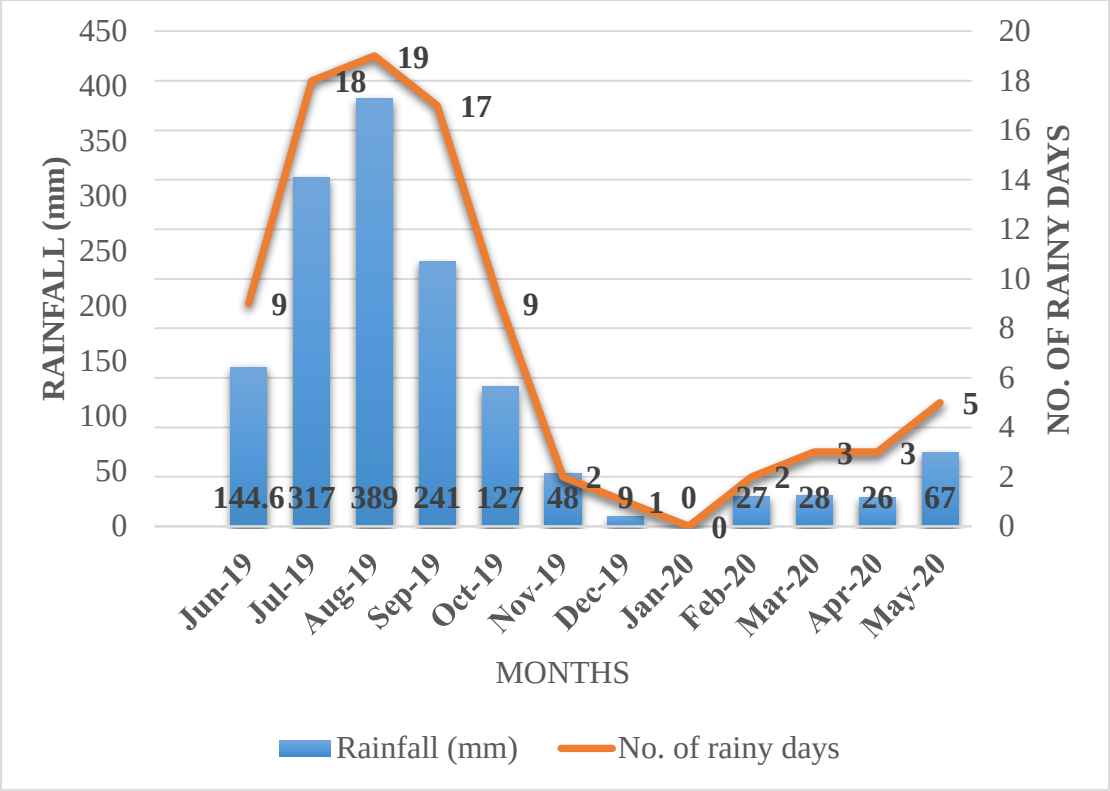

Fig. 3.2 Annual rainfall(mm) and no. of rainy days from June,2019 to May,2020

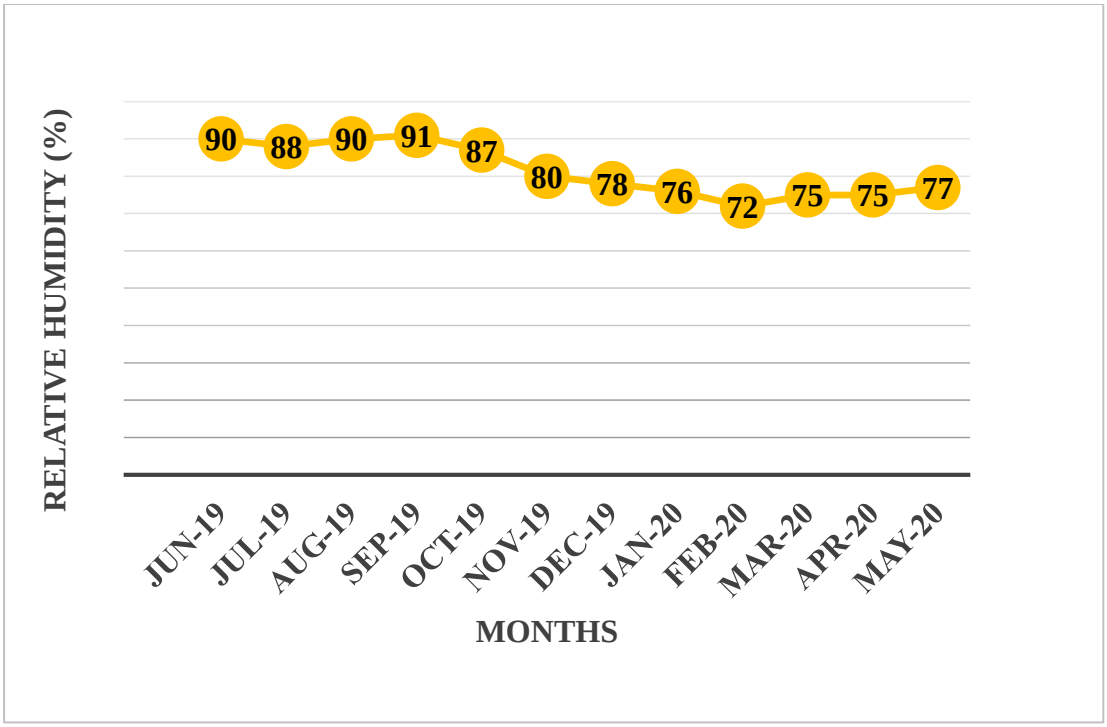

Fig. 3.3 Relative humidity from June,2019 to May,2020

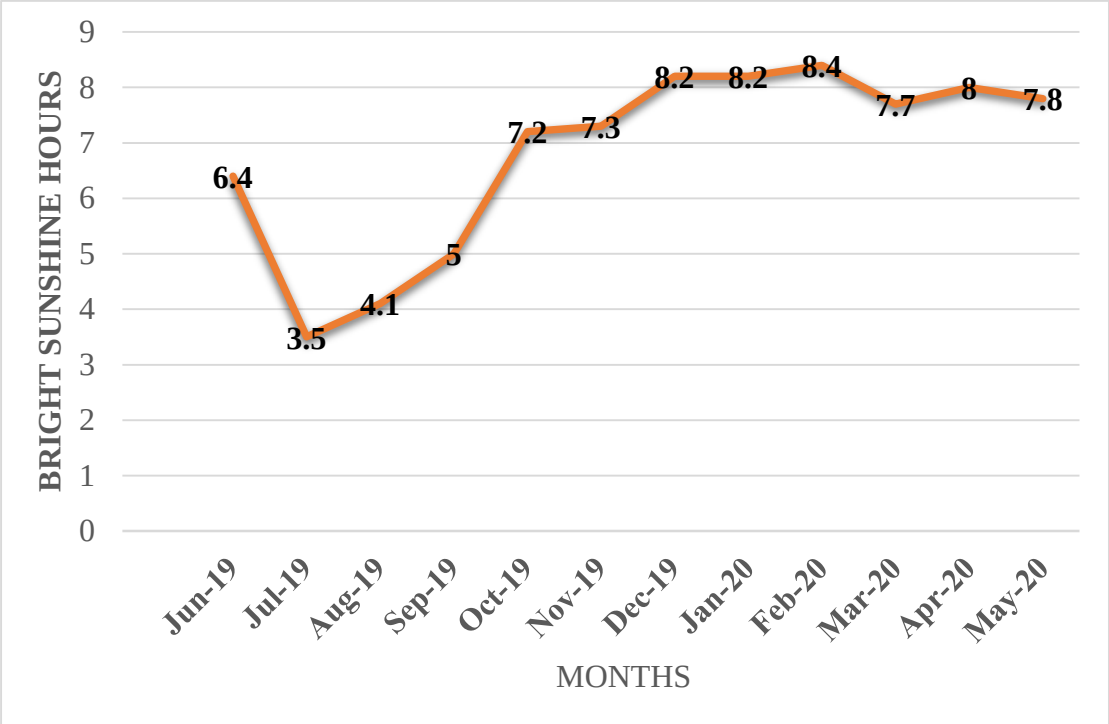

Fig. 3.4 Bright sunshine hour from June,2019 to May,2020

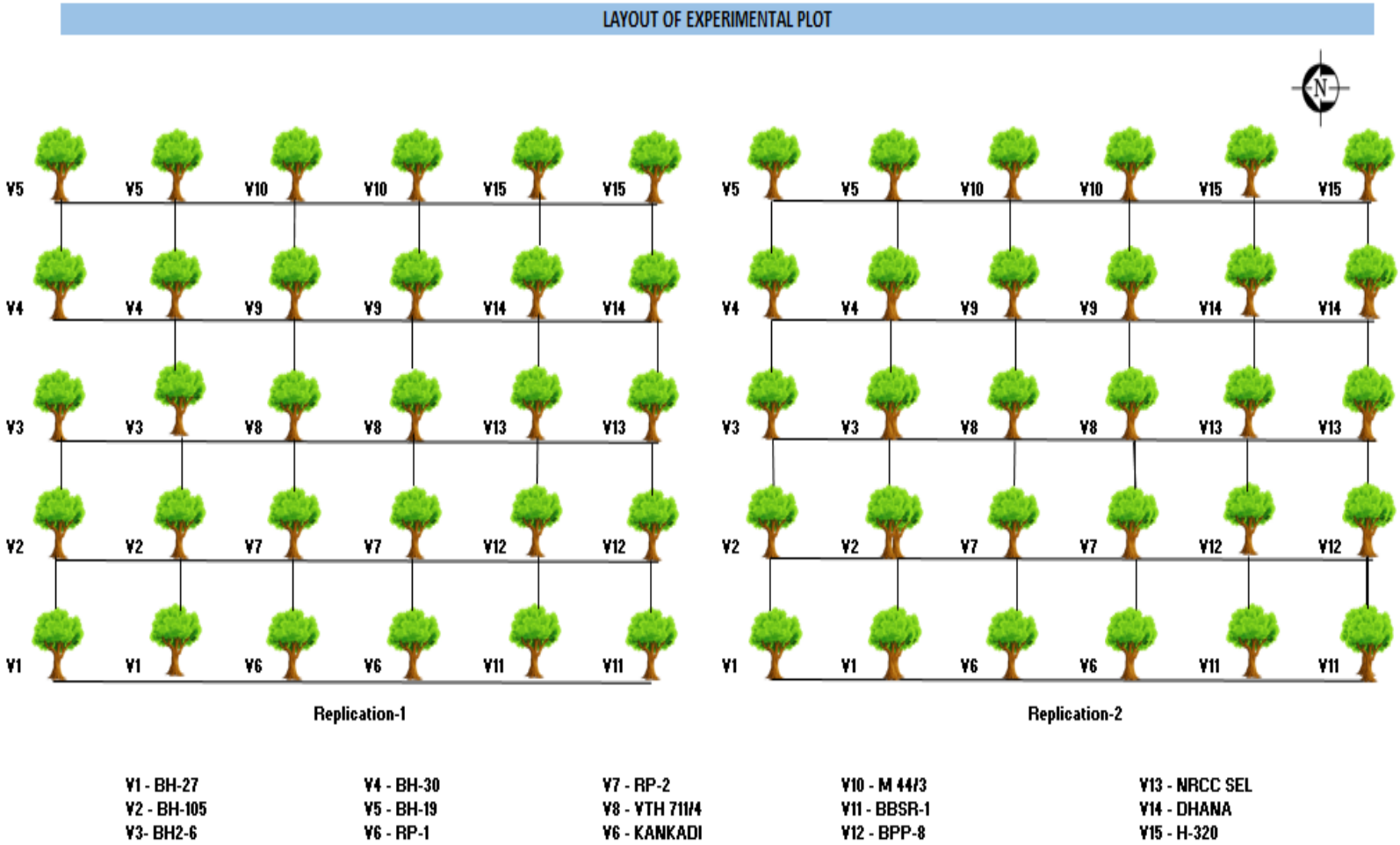

Figure 3.5 Layout of experimental plot

Fig. 3.6 Field view of experimental plot

3.4. Observation recorded

3.4.1. Vegetative parameters

3.4.1.1. Plant Height (m)

For measuring the height of the plant from the ground level to the top of the tree vertically marked bamboo stick or PVC pole (in meters) were used.

3.4.1.2. Trunk girth (cm)

The circumference of the tree trunk was measured by using measuring tape (in centimetre) leaving 15 cm from the ground level.

3.4.1.3. Canopy spread (m)

Canopy spread was measured as average of two directions (East-West and North- South) spread which are being measured in meters using a measuring tape.

3.4.1.4. Ground coverage by canopy (m^2)

Ground area covered by plant canopy was estimated by following formula

Ground area covered by plant canopy = πr^2

Where, r = radius of canopy in meter (Canopy diameter/2= r)

Canopy diameter = (length of canopy in E-W direction + length of canopy in N-S direction)

3.4.2. Yield attributing Characters

3.4.2.1. Sex Ratio

Number of hermaphrodite and staminate flowers appearing in each of the four panicles selected in all the directions are counted and removed from the panicles every alternate day. Sex ratio was recorded till the end of flowering period. Mean of hermaphrodite flowers and staminate flowers per panicle is determined. The sex ratio was obtained by dividing mean number of bisexual flowers with the total number of flowers.

3.4.2.2. Number of nuts panicle^{-1}

Ten inflorescences were selected during the peak fruiting stage from each genotype in all directions and number of nuts per panicle were counted.

3.4.2.3. Nut weight (g) (Mean of 50 nuts)

From selected genotype 50 raw cashew nuts were collected for drying in sun for 2-3 days. Weight of 50 nuts was recorded in grams. Mean weight of one cashew nut was obtained by dividing the total weight of nuts by number of nuts.

3.4.2.4. Apple weight (g) (Mean of 10 apple)

From the individual tree 10 ripened cashew apples was collected and their weight was calculated in grams. Mean weight of one cashew apple was taken out by dividing the total weight of apples by number of apples.

3.4.2.5. Shelling %(Mean of 50 nuts)

From the selected varieties about 50 raw cashew nuts were taken and sundried for about 2-3 days. To shell these nuts shelling machine was used and weight was recorded in grams. Then the ratio of kernel weight and number of nuts was calculated and multiplied by 100 to get shelling %.

3.4.2.6. Nut yield (kg plant^{-1})

Total weight of raw cashew nuts obtained from each of the plants during the entire season, was calculated in kilogram and was expressed as nut yield plant^{-1} in kilogram.

3.5 Statistical analysis

The above mentioned traits were statistically evaluated in a randomized block design (RBD) by the methods given by Panse and Sukhatme (1985). Observations on ten parameters were recorded for variability and other genetic parameters in relation to yield attributing characters and nut yield.

3.5.1. Analysis of variance

The variance was evaluated at 5% level of significance. Standard errors of mean and critical difference (0.05) were calculated for comparing the mean value. The significance of difference between any two means tested through computation of critical difference (CD).

The RBD analysis was done according to $Y_{ij} = \mu + T_1 + \beta j + e_{ij}$ i= 1, 2……

i = 1, 2… .....r

Where: Y_{ij} = Yield corresponding to i^{th} treatment in j^{th} replication μ = General effect

t_i= Additional effect due to i^{th} treatment

$\sum t_i = 0$

βjj = Additional effect due to j^{th} replication,

$\sum \beta j = 0$

e_{ij}= Random error component assumed to be independently normally distributed with mean zero and constant variance.

Here, the null hypothesis is H_0 ($T_1 = T_2 = T_3$.....= T_v) i.e., all the treatments are equally effective against alternative hypothesis H_1 ($T_1 \neq T_2 \neq T_3 \neq \neq T_v$)

Table 3.3: Analysis of variance (ANOVA)

Source of variation	Sum of squares	Degrees of Freedom	Mean Square	F_0
Treatments	$SS_{Treatments}$	a-1	$\frac{\text{SS Treatments}}{a-1}$	$\frac{\text{MSTreatments}}{a-1}$
Blocks	SS_{Blocks}	b-1	$\frac{\text{SS Blocks}}{b-1}$	
Error	SS_E	(a-1)(b-1)	$\frac{\text{SSg}}{(a-1)(b-1)}$	
Total	SS_r	N-1		

Test statistics is $F = \frac{\text{Tr. MS}}{\text{EMS}}$ Where, d.f. = (t-1), (r-1), (e-1)

Where, t = number of genotypes

r = number of replications

If calculated F is significant, i.e. H_0 cannot be accepted, the testing of significant differences between individual treatments should be done, otherwise not. This can be done by computing critical differences (C.D) at 5% level of significance.

Critical Difference

To compare the means of various entries, we have to calculate the critical difference (C.D) by the formula given below.

$$C.D = SE_{(diff.)} \times t\alpha \text{ error d.f}$$

Where, $SE_{(diff)}$ = standard error of difference between treatments means to be compared and is equal to

$$SE_{(diff)} = \frac{\sqrt{2EMS}}{r}$$

With EMS as error mean sum of squares and 'r' as the number of replications and't' as the tabulated value at 5% level of significance for the error degree of freedom.

Thus

$$C.D = \sqrt{\frac{2EMS}{}} \times t_{0.05,} \text{ error d.f}$$

3.5.2. Heterosis

Based on heterosis over mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard variety (Standard heterosis) the selected cashew genotypes were evaluated for the yield attributing traits and nut yield tree^{-1} , using the following formula suggested by Briggle (1963) and Hayes *et al.* (1965).

$$\text{Relative heterosis} = \frac{F1-MP}{MP} 100$$

$$\text{Heterobeltiosis} = \frac{F1-BP}{BP} x\ 100$$

$$\text{Standard heterosis} = \frac{F1-CV}{CV} x\ 100$$

Where,

F1 = Performance of F1 genotype

BP = Better parent value

CV = Check/standard variety

MP = Mid parent value

3.5.3. Co-efficient of variation

For comparing the variability between two or more than two characters, co-efficient of variation were calculated by using the formula given below

$$C.V. = \frac{SD}{X} \times 100 = \sqrt{EMS}/X \times 100$$

Where, S.D. = standard deviation which is the square root of mean square due to error (EMS)

X = Experimental mean

From the structure of the analysis of variance

Error variance = σe^2 = ME

$$\text{Genotypic variance} = \sigma^2_g = \frac{M_G - M_E}{r}$$

$$\text{Phenotypic variance} = \sigma^2_p = \frac{M_G}{r} = \frac{\sigma^2_g + \sigma^2_e}{r}$$

The genotypic co-efficient of variation (GCV) and the phenotypic coefficient of variation (PCV) were calculated by the formula given by Burton (1952).

$$GCV = \frac{\textbf{Genotypic Standard Deviation}}{\textbf{Grand Mean}} \times 100$$

$$PCV = \frac{\textbf{Phenotypic Standard Deviation}}{\textbf{Grand Mean}} \times 100$$

3.5.4. Heritability (broad sense)

The heritability estimates were used to measure the degree of correspondence between phenotypic value and breeding value. It is worked out by using the formula suggested by Lush (1949) and Burton and Devance (1953) and expressed in percentage according to Weber and Moorthy (1952).

$$h^2 \text{ (broad sense)} = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

$$h^2 \text{ (broad sense in percentage)} = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100$$

3.5.5. Genetic advance (GA)

$$GA = K.\ h^2 \sigma p$$

Where,

K = Selection differential in standard units (which is 2.06 per 5% selection intensity).

h^2 = Heritability in broad sense

σp = Phenotypic standard deviation

$$\text{GA expressed as percentage of mean} = \frac{GA}{\text{Mean}}$$

CHAPTER-Ⅳ

RESULTS

RESULTS

The results obtained from the present study entitled "Evaluation of Cashew (*Anacardium occidentale* L.) genotypes under Bhubaneswar condition" are assembled under following broad headings in this chapter.

4.1 Vegetative growth parameters

4.2 Yield attributing parameters

4.3 Nut yield

4.4 Heterosis

4.5 Genetic variability

4.1 Vegetative growth parameters

4.1.1. Plant Height (m)

From the Table 4.1.1 it is revealed that the plant height varied from 2.67m to 5.25m. The maximum plant height was recorded by the cashew genotype BH-19 (5.25m) followed by BH2-6 (5.15m) which were *statistically at par*. The lowest plant height was measured in the genotype Bhubaneswar-1 (2.67m).

Table 4.1.1 Mean of plant height of tested cashew genotypes

Genotypes	**Plant height (m)**
BH-27	3.70
BH-30	4.32
BH-19	**5.25**
BH2-6	5.15
BH-105	3.40
Bhubaneswar-1	**2.67**
RP-1	4.37
RP-2	3.52
M-44/3	3.45
Kankadi	4.40
VTH-711/4	4.30
NRCC Sel.-2	3.45
H-320	3.82
Dhana	4.17
BPP-8	3.37
SEm(±)	**0.17**
CD (P=0.05)	**0.54**

4.1.2. Trunk girth (cm)

It is observed from the Table 4.1.2 that, maximum trunk girth was measured in the cashew genotype Kankadi (56.3 cm) closely followed by Dhana (55.2 cm) and BH-19 (54.25 cm) which were *statistically at par.* Minimum trunk girth was recorded by the genotype NRCC Sel-2 (36.75 cm).

Table 4.1.2 Mean of trunk girth of tested cashew genotypes

Genotypes	**Trunk girth (cm)**
BH-27	44.15
BH-30	49.50
BH-19	54.25
BH2-6	47.40
BH-105	40.25
Bhubaneswar-1	43.35
RP-1	45.95
RP-2	45.65
M-44/3	41.35
Kankadi	**56.30**
VTH-711/4	47.50
NRCC Sel.-2	**36.75**
H-320	37.40
Dhana	55.20
BPP-8	49.05
SEm(±)	**1.22**
CD (P=0.05)	**3.71**

4.1.3 Canopy spread (East-West) (m)

From the Table 4.1.3 canopy spread in East-West (E-W) direction revealed differences among the tested cashew genotypes. The genotype, VTH-711/4 (5.6m) recorded maximum canopy spread in East-West direction followed by Kankadi (5.55m), BH-30 (5.42m), BH-19(5.37m) and RP-2(5.15m). Minimum canopy spread in East-West direction was observed in genotype M-44/3 (3.02 m).

Table 4.1.3 Mean of canopy spread (E-W) of tested cashew genotypes

Genotypes	Canopy spread (E-W)(m)
BH-27	3.70
BH-30	5.42
BH-19	5.37
BH2-6	4.35
BH-105	3.42
Bhubaneswar-1	4.20
RP-1	4.35
RP-2	5.15
M-44/3	**3.02**
Kankadi	5.55
VTH-711/4	**5.60**
NRCC Sel.-2	4.45
H-320	3.25
Dhana	4.62
BPP-8	4.50
SEm(±)	**0.22**
CD (P=0.05)	**0.67**

4.1.4. Canopy spread (North-South) (m)

From the Table 4.1.4 it is revealed that canopy spread in North-South(N-S) direction was recorded maximum by the cashew genotype BH-19 (6.25 m) followed by Dhana (6.17m) which were *statistically at par.* Minimum canopy spread in North-South direction was measured in genotype H-320 (3.2 m).

Table 4.1.4 Mean of canopy spread (N-S) of tested cashew genotypes

Genotypes	Canopy spread (N-S)(m)
BH-27	3.25
BH-30	4.30
BH-19	**6.25**
BH2-6	4.05
BH-105	4.30
Bhubaneswar-1	3.50
RP-1	5.20
RP-2	4.00
M-44/3	4.15
Kankadi	5.45
VTH-711/4	4.30
NRCC Sel.-2	3.60
H-320	**3.20**
Dhana	6.17
BPP-8	4.35
SEm(±)	**0.16**
CD (P=0.05)	**0.51**

4.1.5 Ground coverage by canopy (m^2)

Ground coverage by canopy (GCC) recorded in different cashew genotypes exhibited significant differences during the period of investigation (Table 4.1.5). Significantly maximum GCC was recorded in genotype BH-19 (26.54 m^2) followed by Kankadi (23.76m^2) and Dhana (22.89m^2) while the minimum GCC was recorded in genotype, H-320 (8.20 m^2).

Table 4.1.5 Mean of ground coverage by canopy of tested cashew genotypes

Genotypes	Ground coverage by canopy (m^2)
BH-27	9.48
BH-30	18.56
BH-19	**26.54**
BH2-6	13.84
BH-105	11.73
Bhubaneswar-1	11.63
RP-1	17.93
RP-2	16.43
M-44/3	10.10
Kankadi	23.76
VTH-711/4	19.23
NRCC Sel.-2	12.47
H-320	**8.20**
Dhana	22.89
BPP-8	15.38
SEm(±)	**0.96**
CD (P=0.05)	**2.91**

4.2 Yield attributing parameters

4.2.1. Sex ratio

A perusal of Table 4.2.1 revealed significant differences among the genotypes with respect to sex ratio. Maximum sex ratio was recorded in genotypes M-44/3 (0.38) followed by RP-1 (0.29) and BH2-6 (0.29) while minimum sex ratio was recorded in genotype, Kankadi (0.10).

Table 4.2.1 Mean of sex ratio of tested cashew genotypes

Genotypes	Sex ratio (Number of hermaphrodite flowers : total number of flowers)
BH-27	0.19
BH-30	0.27
BH-19	0.23
BH2-6	0.29
BH-105	0.21
Bhubaneswar-1	0.28
RP-1	0.29
RP-2	0.17
M-44/3	**0.38**
Kankadi	**0.10**
VTH-711/4	0.13
NRCC Sel.-2	0.18
H-320	0.15
Dhana	0.17
BPP-8	0.19
SEm(±)	**0.01**
CD (P=0.05)	**0.04**

4.2.2. Nuts panicle^{-1}

Data recorded on number of nuts panicle^{-1} (Table 4.2.2) revealed that maximum nuts were counted in genotype RP-1 (15.65) closely followed by RP-2 (15.55) which were *statistically at par.* The lowest nuts panicle $^{-1}$ was recorded in cashew genotype Kankadi (1.0).

Table 4.2.2 Mean of nuts panicle^{-1} of tested cashew genotypes

Genotypes	**Nuts panicle^{-1}**
BH-27	4.16
BH-30	5.90
BH-19	5.75
BH2-6	5.90
BH-105	5.25
Bhubaneswar-1	7.35
RP-1	**15.65**
RP-2	15.55
M-44/3	6.90
Kankadi	**1.00**
VTH-711/4	2.00
NRCC Sel.-2	5.90
H-320	5.05
Dhana	5.65
BPP-8	4.25
SEm(±)	**0.31**
CD (P=0.05)	**0.93**

4.2.3. Nut weight (g)

The result obtained on average nut weight presented in Table 4.2.3 revealed that the highest nut weight was recorded in genotype VTH-711/4 (13.22g) followed by Kankadi (11.96g) while minimum nut weight was recorded in genotype RP-2 (5.17 g). The genotypes which recorded > 7.0g nut are Kankadi (11.96g), BH-19 (8.31g), BH-27(8.13g), BH-105(7.75g), BPP-8(7.67g), Dhana(7.5g) and H-320(7.3g).

Table 4.2.3 Mean of nut weight of tested cashew genotypes

Genotypes	Nut weight (g)
BH-27	8.13
BH-30	6.80
BH-19	8.31
BH2-6	8.05
BH-105	7.75
Bhubaneswar-1	6.01
RP-1	5.22
RP-2	**5.17**
M-44/3	5.62
Kankadi	11.96
VTH-711/4	**13.22**
NRCC Sel.-2	7.41
H-320	7.30
Dhana	7.50
BPP-8	7.67
SEm(±)	**0.29**
CD (P=0.05)	**0.89**

4.2.4. Apple weight (g)

The result obtained on average apple weight presented in Table 4.2.4 revealed that the highest apple weight was recorded in genotype Kankadi (101.50g) followed by VTH-711/4 (92.0g) while minimum apple weight was measured in genotype Dhana (29.0 g).

Table 4.2.4 Mean of apple weight of tested cashew genotypes

Genotypes	Apple weight (g)
BH-27	51.50
BH-30	42.50
BH-19	44.50
BH2-6	50.00
BH-105	47.00
Bhubaneswar-1	41.00
RP-1	29.50
RP-2	36.00
M-44/3	33.50
Kankadi	**101.50**
VTH-711/4	92.00
NRCC Sel.-2	51.50
H-320	41.50
Dhana	**29.00**
BPP-8	54.15
SEm(±)	**1.63**
CD (P=0.05)	**4.95**

4.2.5. Shelling %

Shelling % of tested cashew genotypes varied from 23.5% (Kankadi) to 32.2% (Bhubaneswar-1) among the tested cashew genotype. Bhubaneswar-1(32.2%) recorded highest shelling followed by RP-2 (32.05%) which were *statistically at par*. The genotypes which recorded shelling above 30.0% are NRCC-Sel-2 (30.06%), BH-19 (30.35%), VTH-711/4 (30.50%), RP-1 (30.53%), BH-30 (30.78%) and BH2-6 (31.07%) (Table 4.2.5).

Table 4.2.5 Mean of shelling % of tested cashew genotypes

Genotypes	Shelling %
BH-27	29.38
BH-30	30.78
BH-19	30.35
BH2-6	**31.07**
BH-105	29.14
Bhubaneswar-1	32.22
RP-1	30.53
RP-2	32.05
M-44/3	**28.52**
Kankadi	23.50
VTH-711/4	30.50
NRCC Sel.-2	30.06
H-320	28.75
Dhana	29.45
BPP-8	28.67
SEm(±)	**0.36**
CD (P=0.05)	**1.10**

4.3 Nut yield (kg plant^{-1} at 4th harvest)

A perusal of Table 4.3 revealed significant differences among the genotypes with respect to nut yield (kg plant^{-1}). Significantly maximum nut yield was recorded in genotypes BH2-6 (8.25kg plant^{-1}). Minimum nut yield was recorded in genotype, Kankadi (1.37 kg plant^{-1}). Other genotypes which recorded nut yield above 6 kg plant^{-1} are BH-30(6.25kg plant^{-1}), RP-2(6.25kg plant^{-1}), BPP-8(6.25kg plant^{-1}), Dhana (6.30kg plant^{-1}), BH-19(7.45kg plant^{-1}) and BH2-6(8.25kg plant^{-1}). Similarly, genotype BH2-6 recorded maximum cum. nut yield (18.45kg plant^{-1}) followed by BH-19(16.48kg plant^{-1}) and Dhana (14.35 kg plant^{-1}).

Table 4.3 Mean of annual nut yield (at 4th harvest) of tested cashew genotypes

Genotypes	Yield (kg plant^{-1}at 4th harvest)	Cum. nut yield (kg tree^{-1}) (for 4 harvests)
BH-27	5.30	10.48
BH-30	6.23	12.92
BH-19	7.45	16.48
BH2-6	**8.25**	**18.45**
BH-105	5.75	12.81
Bhubaneswar-1	5.40	12.36
RP-1	5.20	11.8
RP-2	6.20	13.41
M-44/3	3.28	10.33
Kankadi	**1.37**	**2.18**
VTH-711/4	3.25	4.24
NRCC Sel.-2	5.20	10.22
H-320	2.40	6.03
Dhana	6.30	14.35
BPP-8	6.24	13.87
SEm(±)	**0.20**	**-**
CD (P=0.05)	**0.63**	**-**

4.4 Heterosis

The results on heterosis for the yield attributing parameters viz. nut weight, shelling% and nut yield are presented in the Table 4.4.1 to 4.4.3**.**

4.4.1 Heterosis for nut weight (g)

Relative heterosis, heterobeltiosis and standard heterosis estimates for nut weight is presented in Table 4.4.1.

The magnitude of heterosis for nut weight over mid parent ranged between (-) 20.56% (BH-30) to 13.30% (BH-105). The heterobeltiosis ranged from -43.14% (RP-2) to 1.04% (BH-105) and standard heterosis ranged from -11.34% (BH-30) to 8.34% (BH-19). Genotype BH-105 exhibited maximum positive relative heterosis (13.30) and heterobeltiosis (1.04) among the tested hybrids. Positive standard heterosis was recorded by all the tested cashew hybrids except the genotype BH-30 which

Six years old plant of cashew hybrid BH2-6

Fruiting of mother plant of cashew hybrid BH2-6

Bearing nuts in cluster

Nuts of hybrid BH2-6

Apple of cashew hybrid BH2-6

Kernel of cashew hvbrid BH2-6

Fig. 4.1 Performance of the best hybrid BH2-6

recorded negative standard heterosis (-11.34) during evaluation. Hybrid BH-19 recorded maximum standard heterosis (8.34) followed by BH-27(5.99) and BH2-6 (4.95).

Table 4.4.1 Heterosis for nut weight of tested cashew hybrids

Hybrids	Relative heterosis	Heterobeltiosis	Standard heterosis
BH-27	-11.82	-38.50	5.99
BH-30	-20.56	-43.14	-11.34
BH-19	-11.78	-37.14	8.34
BH2-6	-5.95	-32.69	4.95
BH-105	13.30	1.04	1.04

***Nut weight of standard variety :7.67g**

4.4.2 Heterosis for Shelling %

Relative heterosis, heterobeltiosis and standard heterosis estimates for shelling % is presented in Table 4.4.2**.**

Relative heterosis for shelling % ranged from minimum -4.27% (BH-105) to maximum 11.88% (BH 2-6). Hybrids BH2-6 (11.88%) recorded maximum relative heterosis followed by hybrid BH-30 (10.83%) and BH-19 (2.84%). Negative heterobeltiosis was recorded for all the tested genotype which varied from -9.55(BH-105) to -0.49(BH-19) for shelling. The magnitude of standard heterosis for shelling % ranged from minimum 1.63% (BH-105) to maximum 8.37% (BH2-6).

Table 4.4.2 Heterosis for shelling % of tested cashew hybrids

Hybrids	Relative heterosis	Heterobeltiosis	Standard heterosis
BH-27	-3.70	-3.76	2.47
BH-30	10.83	-3.96	7.35
BH-19	2.84	-0.49	5.85
BH2-6	11.88	-3.05	8.37
BH-105	-4.27	-9.55	1.63

***Shelling % of standard variety: 28.67**

4.4.3 Heterosis for nut yield (kg plant^{-1})

Relative heterosis, heterobeltiosis and standard heterosis estimates for nut yield is presented in Table 4.4.3.

The magnitude of relative heterosis for nut yield ranged from minimum-1.20% (BH-105) to maximum 129.23% (BH-19). The magnitude of heterobeltiosis was recorded minimum in hybrid BH-105(-8.0) and maximum in cashew hybrid BH-19(96.05%). Standard heterosis for the tested hybrids ranged from minimum -15.2% (BH-27) to maximum 32% (BH2-6). Regarding standard heterosis hybrids BH2-6 recorded maximum (32.00%) while genotype BH-27 recorded the minimum value (-15.20%).

Table 4.4.3 Heterosis for nut yield of tested cashew genotypes

Hybrids	Relative heterosis	Heterobeltiosis	Standard heterosis
BH-27	25.59	1.92	-15.20
BH-30	64.04	0.00	0.00
BH-19	129.23	96.05	19.20
BH2-6	116.53	32.00	32.00
BH-105	-1.20	-8.00	-8.00

***Nut yield of standard variety: 6.25 kg plant^{-1}**

On the basis of above presented data (Table 4.4.1 to 4.4.3), superior genotypes for nut weight, shelling % and nut yield were identified. For nut weight BH-19 hybrid exhibited best standard heterosis. For shelling % and nut yield BH2-6 was identified as superior genotype over standard check while, BH-19 exhibited best heterobeltiosis for nut yield. So, this genotypes may be evaluated further (up to 6th harvest as per variety release norm in cashew) before recommendation for commercial cultivation in the state.

4.5 Genetic variability

Data presented in Table 4.5.1 to Table 4.5.3 represent the genotypic coefficient of variance, phenotypic coefficient of variance, heritability %, genetic advance and genetic advance value (as % mean) for eleven parameters of fifteen tested genotypes.

4.5.1. Genotypic and Phenotypic coefficient of variance

Wide range of variation were seen both in phenotypic and genotypic coefficient of variation among all the component parameters of cashew genotypes. Table 4.5.1 clearly shows that phenotypic coefficient of variance was higher than the genotypic coefficient of variance for all the parameters. The phenotypic and genotypic coefficient

of variance ranges from minimum 13.28% and 12.74% in trunk girth to maximum in 63.81% and 63.45% in nuts panicle^{-1} respectively. The other traits which recorded high phenotypic co-efficient of variation(PCV) and genotypic co-efficient of variation (GCV) are apple weight (41.85% & 41.59%), nut yield (36.37% & 35.92%), ground coverage by canopy (35.41% & 34.36%) and sex ratio (34.62% & 32.94%).

Table 4.5.1 Genotypic and phenotypic coefficient of variations of different component characters in cashew

Characters	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)
Plant height(m)	17.07	18.23
Trunk girth(cm)	12.74	13.28
Canopy spread (E-W)(m)	18.27	19.60
Canopy spread (N-S)(m)	21.45	22.13
Ground coverage by canopy(m^2)	34.36	35.41
Sex ratio	32.94	34.62
No. of nuts panicle^{-1}	63.45	63.81
Nut weight(g)	28.63	29.14
Apple weight(g)	41.59	41.85
Shelling %	6.81	7.03
Nut yield(kg plant^{-1})	35.92	36.37

4.5.2. Heritability %

Heritability estimates were recorded high for parameters like nuts panicle^{-1} (98.85%), apple weight (98.76%), nut yield (97.53%), nut weight (96.55%). Other parameters which recorded moderate heritability % were ground coverage of canopy (94.13%), canopy spread (N-S) (93.98%), shelling % (93.91%) and trunk girth (92.02%). Canopy spread (E-W) (86.86%) recorded the lowest heritability among the eleven parameters.

Table 4.5.2 Heritability % of different component characters in cashew

Characters	Heritability %
Plant height(m)	87.66
Trunk girth(cm)	92.02
Canopy spread (East-West)(m)	86.86
Canopy spread (North-South)(m)	93.98
Ground coverage of canopy(m^2)	94.13
Sex ratio	90.57
No. of nuts panicle^{-1}	98.85
Nut weight(g)	96.55
Apple weight(g)	98.76
Shelling %	93.91
Nut yield(kg plant^{-1})	97.53

4.5.3. Genetic advance and Genetic advance (as % mean)

Estimation of genotypic and phenotypic coefficient of variation revealed a wide range of variation for component character in cashew. The genetic advance ranged from 0.14 in sex ratio to 42.3 in apple weight. The parameters which exhibited high genetic advance were trunk girth (11.65), GCC (10.91) and nuts panicle^{-1} (8.34). Rest of the traits such as plant height (1.30), canopy spread (East-West) (1.56), canopy spread (North-South) (1.88), nut yield (3.79), shelling% (4.03) and nut weight (4.48) expressed low value for genetic advance.

Similarly, the genetic advance (as % mean) was varied from as low as 13.60 in shelling % to as high as 129.95 in nuts/panicle. Other traits which showed moderate genetic advance (as % mean) were apple weight (85.15%), nut yield (73.08%), GCC (68.68%), sex ratio (64.59%) and nut weight (57.96) (Table 4.5.3).

Studies on variations and genetic parameters from the above mentioned data (Table 4.5.1 to 4.5.3) revealed that traits like nuts panicle^{-1}, apple weight, nut yield, GCC, sex ratio and nut weight showed high heritability coupled with high PCV & GCV, genetic advance and genetic gain as % of mean. So, the genotypes, RP-1, Kankadi, VTH-711/4, BH2-6, BH-19 and M-44/3 may be selected for future breeding programme in cashew.

Table 4.5.3 Genetic advance and Genetic advance (as % mean) of different component characters in cashew

Characters	Genetic advance	Genetic advance(as % mean)
Plant height(m)	1.303	32.92
Trunk girth(cm)	11.65	25.19
Canopy spread (E-W)(m)	1.56	35.08
Canopy spread (N-S)(m)	1.88	42.84
Ground coverage by canopy(m^2)	10.91	68.68
Sex ratio	0.14	64.59
No. of nuts panicle^{-1}	8.34	129.95
Nut weight(g)	4.48	57.96
Apple weight(g)	42.30	85.15
Shelling %	4.03	13.60
Nut yield(kg plant^{-1})	3.79	73.08

CHAPTER- Ⅴ

DISCUSSION

DISCUSSION

Cashew is the major edible tree nut with increasing demand in the global market. The nut and the fruit, both have multiple uses thus, the cashew producing countries are focusing more on boosting the production. Cashew has very important role in India's economy as India leads in consumption and second largest producer and exporter in the world (FAOSTAT, 2017). Cashew is a potential crop in Odisha as farmers are widely adopting cultivation of cashew due to its valuable nut. Considering the importance of cashew in Odisha's economy, an attempt was made to evaluate the fifteen cashew genotypes under Bhubaneswar's agro-climatic condition. The results presented in the previous chapter under different sections are discussed here in this chapter.

5.1 Vegetative parameters

Vegetative parameters such as plant height, trunk girth, canopy spread and ground coverage of canopy were found statistically significant among the fifteen tested cashew genotypes. It is revealed from the Table 4.1.1 that the plant height varied from minimum 2.67m (Bhubaneswar-1) to maximum 5.25m (BH-19). Genotype, Kankadi (56.3 cm) recorded maximum trunk girth closely followed by Dhana (55.2 cm) and BH-19 (54.25 cm) which were *statistically at par.* Minimum trunk girth was recorded by the genotype NRCC Sel-2 (36.75 cm) (Table 4.1.2). The canopy spread were found statistically significant among the fifteen tested cashew genotypes in both the directions i.e. East-West (E-W) and North-South (N-S). Canopy spread in East-West direction ranges from 3.02m in genotype M-44/3 to 5.60m in genotype, VTH-711/4 (Table 4.1.3). From the Table 4.1.4**,** it is revealed that canopy spread in North-South direction was recorded minimum in genotype H-320 (3.2m) and maximum in the genotype BH-19 (6.25 m). Ground coverage of canopy (GCC) were found statistically significant in different cashew genotypes. Maximum GCC was recorded in genotype BH-19 (26.54 m^2), while the minimum GCC was recorded in genotype, H-320 (8.20m^2) (Table 4.1.5). Similar differences in vegetative growth parameters in cashew was also reported by Tripathy *et al.* (2015), Mohapatra *et al.* (2017), Roy *et al.* (2018), Chandrasekhar *et al.* (2018), Jha (2019) and Sahoo *et al.* (2019). The variations in vegetative growth parameters in different cashew genotypes may be due to genetic as well as environmental effect. Response of cashew genotypes to different cultural practices followed during the crop growth period also influence the vegetative growth parameters in cashew.

5.2 Yield attributing parameters and nut yield

The data recorded on sex ratio revealed significant wide variations among the cashew genotypes (Table 4.2.1)**.** Maximum sex ratio was recorded in genotypes M-44/3 (0.38) followed by RP-1 (0.29) and BH2-6 (0.29) while minimum sex ratio was recorded in genotype, Kankadi (0.10). Sreenivas *et al.* (2016) revealed that sex ratio ranged from 0.11 in genotype H-328 to 0.17 in genotype H-303 & H-338. Data recorded on number of nuts panicle^{-1} revealed that maximum nuts were counted in genotype RP-1 (15.65) closely followed by RP-2 (15.55) which were *statistically at par*. The lowest nuts panicle^{-1} was recorded in cashew genotype Kankadi (1.0) (Table 4.2.2). Maximum nut weight was recorded in genotype VTH-711/4 (13.22g) while, minimum nut weight was recorded in RP-2 (5.17g) (Table 4.2.3). The result obtained on average apple weight presented in Table 4.2.4 revealed that the highest apple weight was recorded in genotype Kankadi (101.50g) followed by VTH-711/4 (92.0g) while minimum apple weight was measured in genotype Dhana (29.0g). Shelling % of tested cashew genotypes varied from 23.5% (Kankadi) to 32.2% (Bhubaneswar-1) among the tested cashew genotype (Table 4.2.5). Similar variations with regards to nuts panicle^{-1}, nut weight, apple weight and shelling % were reported by Sethi *et al.* (2015), Venkataramana *et al.* (2015), Paikra (2016), Gajbhiye *et al.* (2018) and Mog & Nayak (2018). Sex ratio, nut panicle^{-1}, apple weight and shelling % are the varietal traits which are also greatly influence by weather parameters. Nuts panicle^{-1} and nut weight are inversely proportional to each other in cashew. The cashew genotype(s) which has medium nut weight (8.0 to 10.0g), 6 to 8 numbers of nuts panicle^{-1} and high nut yield (10 kg plant^{-1} at 6th harvest) are preferred for commercial cultivation.

Yield is the ultimate target of any varietal evaluation programme. In cashew, nut yield is the produce of commerce. In the present investigation it is revealed that (Table 4.3) genotype, BH2-6 (8.25 kg) recorded significantly maximum nut yield among the tested genotypes at 4th harvest (6 years old plant). This genotype also recorded the maximum cumulative nut yield (18.45 kg plant^{-1}) at 4 harvest among the tested genotypes which indicates that the genotype BH2-6 is showing consistency in production of nuts over the years. It seems the genotype has the stability in yield performance over different environments. Hence, it is suggested to evaluate the genotype till 6th harvest before release for commercial cultivation in the state. Genotypes which recorded nut yield above 6.0 kg plant^{-1} are BH-19 (7.45kg plant^{-1}), Dhana (6.30kg plant^{-1}), BH-30 (6.25kg plant^{-1}), RP-2 (6.25kg plant^{-1}) and BPP-8 (6.25kg plant^{-1}). Similar variations in mean annual nut yield were reported by Dadzie *et al.* (2014), Tripathy *et al.* (2015), Reddy *et al.* (2015) and Roy *et al.* (2018). This

variation in nut yield may be due to the difference in genetic potential among the genotypes, influence of weather parameters and cultural practices followed during the crop growth stage.

5.3 Heterosis

In the present investigation, superior genotypes for nut weight, shelling % and nut yield were identified. For nut weight, BH-19 hybrid exhibited best standard heterosis. For shelling % and nut yield BH2-6 was identified as superior genotype over standard check while, BH-19 exhibited best heterobeltiosis for nut yield. This is in accordance with the findings of Cavalcanti *et al.* (2007), Sankarnarayan *et al.* (2015), Sethi *et al.* (2016) and Sahoo *et al.* (2020).

5.4 Genetic variability

For efficient selection of superior genotype from the base population it is important to have knowledge about genetic variability. The present result stated that the eleven traits of fifteen genotypes of cashew showed significant variations which denote the presence of abundant genetic variability in the tested genotypes. Table 4.5.1 clearly shows that phenotypic coefficient of variance and genotypic coefficient of variance ranges from minimum 13.28% and 12.74% in trunk girth to maximum in 63.81% and 63.45% in nuts panicle^{-1} respectively. The other traits which recorded high PCV and GCV are apple weight (41.85% & 41.59%), nut yield (36.37% & 35.92%), GCC (35.41% & 34.36%) and sex ratio (34.62% & 32.94%). Heritability estimates were recorded high for parameters like nuts panicle^{-1} (98.85%), apple weight (98.76%), nut yield (97.53%), nut weight (96.55%). Canopy spread (E-W) (86.86%) recorded the lowest heritability among the eleven parameters. The genetic advance ranged from 0.14 in sex ratio to 42.3 in apple weight. The parameters which exhibited high genetic advance were trunk girth (11.65), GCC (10.91) and nuts panicle^{-1} (8.34). Similarly, the genetic advance (as % mean) was varied from as low as 13.60 in shelling % to as high as 129.95 in nuts panicle^{-1} (Table 4.5.3). Thus, traits like nuts panicle^{-1}, apple weight, nut yield, GCC, sex ratio and nut weight showed high heritability along with high PCV and GCV, genetic advance and genetic gain as % of mean. So, the genotypes, RP-1, Kankadi, VTH-711/4, BH2-6, BH-19 and M-44/3 may be selected for future breeding programme in cashew. Results of the present study corroborates with the findings of Lenka *et al.* (2001), Reddy *et al.* (2002), Faluyi(,2006), Ghatge *et al*. (2009), Ushavani and Jayalekshmy (2009), Dasmohapatra *et al.*(2012), Vikram *et al*. (2016) and Sethi *et al.* (2016).

CHAPTER-VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The major cause of low productivity of cashew in India as well as in Odisha is the use of non-descriptive planting materials. The present investigation was therefore undertaken for identification of high yielding cashew genotypes suitable for cultivation under the agro-climatic condition of Odisha.

The salient findings arising from the present investigation are as follows.

- The plant height was recorded maximum in cashew genotype BH-19 (5.25m) while minimum in genotype Bhubaneswar-1 (2.67 m).

- The maximum trunk girth was measured in the cashew genotype, Kankadi (56.3 cm). Minimum trunk girth was recorded by the genotype, NRCC Sel-2 (36.75 cm).
- In East-West direction canopy spread was recorded maximum in genotype, VTH-711/4 (5.6m) while minimum in genotype M-44/3 (3.02 m).
- Significantly maximum canopy spread in North-South direction was recorded by the cashew genotype BH-19 (6.25 m) followed by Dhana (6.17m) which were *statistically at par.* Minimum canopy spread in North-South direction was measured in genotype H-320 (3.2 m).
- Significantly maximum ground coverage by canopy (GCC) was recorded in genotype BH-19 (26.54 m^2) followed by Kankadi (23.76m^2) and Dhana (22.89m^2) while the minimum GCC was recorded in genotype, H-320 (8.20 m^2).
- Sex ratio was recorded maximum in genotypes M-44/3 (0.38) while minimum in genotype, Kankadi (0.10).
- Maximum nuts panicle^{-1} were counted in genotype RP-1 (15.65) closely followed by RP-2 (15.55) which were *statistically at par*. The lowest nuts panicle $^{-1}$ was recorded in cashew genotype Kankadi (1.0).
- Highest nut weight was recorded in genotype VTH-711/4 (13.22g) followed by Kankadi (11.96g) while minimum nut weight was measured in genotype RP-2 (5.17g).

- The highest apple weight was recorded in genotype Kankadi (101.50g) followed by VTH-711/4 (92.0g) while minimum apple weight was measured in genotype Dhana (29.0 g).
- Genotype, Bhubaneswar-1(32.2%) recorded highest shelling % while genotype Kankadi (23.5%) recorded the minimum shelling %.
- Significantly maximum nut yield was recorded in genotypes BH2-6 (8.25 kg plant^{-1}) while minimum nut yield was recorded in genotype, Kankadi (1.37 kg/plant) at 4th harvest.
- Similarly, genotype BH2-6 recorded maximum cum. nut yield (18.45kg plant^{-1}) followed by BH-19(16.48kg plant^{-1}) and Dhana(14.35 kg plant^{-1}).
- The magnitude of relative heterosis for nut weight ranged between -20.56% (BH-30) to 13.30% (BH-105).
- The heterobeltiosis for nut weight ranged from -43.14% (RP-2) to 1.04% (BH-105) while standard heterosis ranged from -11.34% (BH-30) to 8.34% (BH-19).
- Relative heterosis for shelling % ranged from -4.27% (BH-105) to 11.88% (BH2-6).
- Negative heterobeltiosis was recorded for all the tested genotype which varied from 9.55(BH-105) to -0.49 (BH-19).
- The magnitude of standard heterosis for shelling % ranged from minimum 1.63% (BH-105) to maximum 8.37% (BH2-6).
- The magnitude of relative heterosis for nut yield ranged from minimum -1.20% (BH-105) to maximum 96.05% (BH-19).
- The magnitude of heterobeltiosis for nut yield ranged between -8% (BH-105) to 129.23% (BH-19).
- Standard heterosis ranged between -15.2% (BH-27) to 32% (BH 2-6).
- For shelling % and nut yield BH2-6 was identified as superior genotype over standard check while, BH-19 exhibited best heterobeltiosis.
- The phenotypic and genotypic coefficient of variance ranges from minimum 13.28% and 12.74% in trunk girth to maximum in 63.81% and 63.45% in nuts/panicle respectively.
- Heritability estimates were recorded high for parameters like nuts/panicle (98.85%), apple weight (98.76%), nut yield (97.53%), nut weight (96.55%).

- ❖ Canopy spread (E-W) (86.86%) recorded the lowest heritability among the eleven parameters.
- ❖ The genetic advance ranged from 0.14 in sex ratio to 42.3 in apple weight. The parameters which exhibited high genetic advance were trunk girth (11.65), GCC (10.91) and nuts/panicle (8.34).
- ❖ Similarly, the genetic advance (as % mean) varied from as low as 13.60 in shelling % to as high as 129.95 in nuts/panicle.

Evaluation of fifteen cashew genotypes during the fruiting season 2019-20 revealed that genotype, BH2-6 recorded the maximum mean annual nut yield (8.25kg plant^{-1}), cum nut yield (18.45 kg plant^{-1}) and standard heterosis (32.0%) at 4th harvest (6 years old plant). Hence, the genotype may be evaluated further (upto six harvest) before recommendation for commercial cultivation in the state of Odisha. Studies on variability revealed that genotypes, RP-1, Kankadi, VTH-711/4 and BH2-6 recorded high heritability alongwith high genetic advance and genetic gain (as % of mean) for the yield attributing parameters viz. nuts panicle^{-1} (98.85%, 8.34, 129.95%), apple weight (98.76%,42.3, 85.15%), nut yield (97.53%,3.79, 73.08%) and nut weight (96.55%, 4.48,57.96%) respectively. So, there is scope for improvement by using these genotypes as parent in future cashew breeding programme.

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