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RESEARCH ARTICLE

Study on Flowering Behavior of Some Local Coconut (*Cocos nucifera* L.) Genotypes under Assam Condition

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Flowering behavior of thirteen local coconut genotypes was studied in the winter period (October-January) during 2013-14, 2014-15 and 2015-16 at ICAR-Central Plantation Crops Research Institute, Research Centre, Kahikuchi. Floral traits *viz*., inflorescence length, stalk length, number of spikelet per inflorescence, girth of stalk, length of spikelet bearing portion, number of male and female flowers, sex-ratio, duration of male and female flowers, intra-spadix overlapping and number of inflorescence produced per month were recorded. Analysis of the mean data, indicated significant differences for all recorded traits, except the number of inflorescences produced during the four months observation period. Average monthly inflorescence production per palm was higher in KKHC-4 (0.90) and KKHC-3 (0.81) genotypes.

Average female flower production (inferred from the number of female flowers per inflorescence) was found to be significantly higher in KKHC 3 (29.26) and KKHC 4 (27.69) genotypes, with lowest in KKHC 13 (6.85). Percentage of female to male flowers, among the genotypes varied from 0.60% (KKHC 3) to 0.27% (KKHC 13), with KKHC 3, KKHC 1 and KKHC 4 showing significantly higher ratio as compared to the rest of the accessions. Interestingly, though these are all tall genotypes, intra-spadix overlapping of the male and female phases was observed in all the genotypes, indicating the uniqueness of the coconut population in Assam, with higher duration of overlapping observed in KKHC 4 (3.60).

Key Words: Coconut, floral biology, traits, weather, genotypes

Introduction

Coconut (*Cocos nucifera* L.) is an important plantation crop grown in Assam mostly by small and marginal farmers. Area under coconut in Assam is estimated to be 20.71 thousand hectare with a production of 1,577.80 lakh nuts and productivity of 7,861 nuts/ha (CDB, 2018). Nagaon, Barpeta, Kamrup, Sonitpur, Nalbari, Golaghat, Cachar, Karimganj, Morigaon, Udalguri, Darang, Bongaigaon, Baksa and Shivsagar are the leading coconut growing and producing districts in Assam (Gopalakrishnan, 2013). Assam Tall is the most popular variety of coconut grown in this region. An annual average yield of about 105 nuts per palm per year has been reported in Assam Tall variety (Nath, 2017). However, winter season seems to be a limiting factor affecting coconut production (Patel, 1938). The climatic condition of Assam is characterized by warm humid sub tropical climate with prolonged summer and mild to severe winter. Winter season begins from October month with a fall in temperature below 20˚C. Coconut requires warm humid tropical climate with ideal temperature range from 26˚C to 27˚C and diurnal variation of 7-8˚C for its optimum growth and development (Marar and Pandalai, 1958; Child 1964). Effect of temperature in coconut palm has been reported by various workers (Thampan, 1981; Bhaskaran and Leela, 1983; Vanaja and Amma, 2002; Timothy, 2010). Towards development of improved varieties for specific agro-climatic zones, it is necessary to characterize the local coconut populations and identify adaptive features for utilization in the coconut improvement programme. Characterization of coconut populations/cultivars/germplasm has been undertaken based on fruit traits (Whitehead, 1968; Harries, 1978; Niral *et al.*, 2009), botanical and agronomic traits

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(Sugimura *et al*., 1997; Niral *et al.*, 2008). Descriptors of coconut germplasm have also been developed based on morphological characterization of the conserved accessions and farmers varieties (Bourdeix and Batugal, 2005; Bourdeix *et al*., 2010; Ratnambal *et al*., 1995, 2000). A better understanding of climatic factors and floral biology of coconut in specific regions will help to provide key information for choice of parents and adoption of breeding methods. Taking this into consideration, the present study was conducted to assess the flowering behavior of some local coconut genotypes in winter under Assam condition.

Material and Methods

Study was conducted for three consecutive years during 2013-14, 2014-15 and 2015-16 at ICAR-Central Plantation Crops Research Institute, Research Centre, Kahikuchi, Guwahati, Assam. Fifteen year old palms of thirteen coconut genotypes collected from Assam and field planted at the Research Centre were used for conducting the experiment. The experiment design was Randomized Block Design (RBD) with three replications. Three palms per replication were used for recording the data. Inflorescences produced in each palm were tagged during October-January and data for floral traits *viz*., inflorescence length, girth of stalk, stalk length, length of spikelet bearing portion, length of spikelet, number of spikelet per inflorescence, number of male and female flowers, number of inflorescence per palm, duration of male and female phase and intra-spadix overlapping of male and female phases were recorded as per coconut descriptors (Ratnambal *et al*., 1995, 2000). Data were statistically analyzed using MSTAT software.

Results and Discussion

Inflorescence length

Inflorescence length among the genotypes varied from 43.56cm to 67.55cm (Table 1). Genotype KKHC 4 recorded significantly higher inflorescence length (67.55cm) followed by KKHC 5 (65.54cm). Lesser inflorescence length was observed in KKHC 13 (43.56cm). Based on a study of 27 coconut accessions, comprising eight dwarfs and 19 talls, at ICAR-CPCRI Kasaragod (Niral *et al*., 2008) reported inflorescence length varying from 56-120cm, with tall accessions having relatively larger inflorescences than dwarf accessions. Further, seasonal variation in the number of spathes produced and opening of spadices has been reported (Vijayaraghavan *et al*., 1993). In the present study, most of the genotypes produced shorter length of inflorescence, possibly due to adverse growth conditions. Samanta *et al*. (2009) reported production of shorter inflorescences (39.54cm) during winter month in some coconut varieties in West Bengal.

Girth of inflorescence stalk

Girth of inflorescence stalk among the genotypes varied from 6.93cm to 9.55cm. Genotype KKHC 4 recorded the highest girth of inflorescence stalk (9.55cm), whereas KKHC 13 (6.93 cm) genotype produced inflorescence with least stalk girth. A relatively wider range of variation for inflorescence stalk girth (8.00-12.75cm) has been observed in coconut germplasm at ICAR-CPCRI Kasaragod (Niral *et al.,* 2008). The relatively smaller inflorescence stalk girth in the present study, is indicative of the relatively smaller size of the inflorescences produced.

Inflorescence stalk length

Pooled data (Table 1) showed that highest inflorescence stalk length was observed in genotype KKHC 5 (18.41cm) which was statistically at par with genotype KKHC 4 (17.32cm). Lesser inflorescence stalk length was observed in genotype KKHC 3 (12.23cm). Variation of floral traits in coconut has been reported by many workers (Panda, 1982; Patil *et al*., 1993; Kumaran *et al*., 2004; Niral *et al*., 2008), with much larger variation for stalk length. Samanta *et al*. (2009) observed seasonal variation in inflorescence stalk length with higher stalk length recorded during the month of January.

Length of spikelet bearing portion

Length of spikelet bearing portion among the genotypes varied from 28.24cm to 47.52cm. Genotype KKHC 4 (47.52cm) showed higher length of spikelet bearing portion, whereas, relatively lesser length of spikelet bearing portion was recorded in the

Table 1. Inflorescence characters of coconut genotypes

Accession	Inflore-scence length (cm)	Girth of inflore-scence stalk (cm)	Length of inflore-scence stalk (cm)	Length of spikelet bearing portion (cm)	Length of spikelet (cm)	No. of spikelets per inflore-scence	No. of male flowers per spikelet	No. of female flowers per inflore-scence	Duration of male phase (days)	Duration of female phase (days)	Flower sex-ratio (%)	Intra spadix over-lapping of male & female phases (days)	No. of inflore-scences produced/ palm
KKHC 1	57.33	8.43	16.57	38.28	30.30	33.10	142.77	23.52	31.48	5.45	0.53	1.61	0.69
KKHC 2	59.03	8.62	16.66	39.59	30.71	31.72	135.47	20.90	28.32	5.33	0.46	1.74	0.68
KKHC 3	49.85	7.78	12.23	35.20	26.77	28.70	125.72	29.26	28.86	4.76	0.60	2.21	0.81
KKHC 4	67.55	9.55	17.32	47.52	35.39	37.85	155.88	27.69	36.78	6.56	0.52	3.60	0.90
KKHC 5	65.54	7.40	18.41	44.22	33.03	37.19	149.60	20.61	35.67	5.39	0.38	2.03	0.70
KKHC 6	54.70	7.88	14.38	37.90	26.25	30.31	125.67	14.81	26.60	3.56	0.30	1.71	0.63
KKHC 7	47.83	7.62	12.67	32.59	23.78	27.13	119.27	17.22	24.47	3.90	0.40	0.85	0.57
KKHC 8	51.62	8.21	15.00	33.30	26.40	28.91	124.77	15.92	27.14	4.17	0.41	1.24	0.67
KKHC 9	53.40	8.33	14.91	35.87	27.52	31.28	132.03	18.31	30.02	4.45	0.40	1.82	0.68
KKHC 10	54.05	8.19	15.09	35.98	26.09	30.81	124.19	18.07	28.58	4.22	0.38	1.32	0.57
KKHC 11	49.17	8.06	13.08	33.77	24.80	27.19	111.96	14.89	26.74	3.69	0.37	1.21	0.63
KKHC 12	46.97	7.67	14.07	29.56	23.39	25.22	118.96	12.25	25.35	3.37	0.35	1.00	0.60
KKHC 13	43.56	6.93	13.40	28.24	19.27	22.03	94.80	6.85	21.59	2.35	0.27	0.18	0.55
SEm (+/-)	2.51	0.49	1.37	2.08	2.06	1.87	7.05	1.93	2.15	0.58	0.08	0.56	0.13
NS (0.05%)	7.35*	1.32**	4.00**	6.08**	6.01**	5.45*	20.53**	5.65*	6.27**	1.71**	0.24**	1.61*	0.37

*Significant at 5%, ** Significant at 1%

genotype KKHC 13 (28.24cm). Similar variations have been reported in coconut germplasm (Niral *et al*., 2008).

Spikelet length

Spikelet length differed significantly among the genotypes studied. KKHC 4 genotype recorded the highest spikelet length (35.39cm) as compared to other genotypes. Smaller spikelet length was recorded in genotype KKHC 13 (19.27cm). Among the conserved coconut germplasm at ICAR-CPCRI Kasaragod, spikelet length ranging from 27-55cm has been reported (Ratnambal *et al.*, 1995, 2000; Niral *et al.,* 2008). Spikelet length variation among coconut varieties and seasonal changes were also observed by Samanta *et al*. (2009).

Spikelets per inflorescence

Significant differences were observed for the number of spikelet produced per inflorescence. Genotype KKHC 4 (37.85) produced the highest number of spikelets per inflorescence, while lesser number of spikelets per inflorescence was recorded in genotype KKHC 13 (22.03). The findings are in agreement with those reported in coconut varieties by (Balakrishnan *et al*., 1988), wherein similar variation in number of spikelets (20-65) was observed.

Male flowers per spikelet

Number of male flowers per spikelet among the genotypes varied from 94.80 to 155.88. Genotype KKHC 4 (155.88) produced more number of male flowers per spikelet and was found to be statistically on par with genotypes KKHC 5 (149.60), KKHC 1 (142.77) and KKHC 2 (135.47). Lesser number of male flowers per spikelet was observed in genotype KKHC 13 (94.80). Ohler (1999) reported two to three hundred male flowers per spikelet.

Female flowers per inflorescence

Significant difference was observed for the number of female flowers produced per inflorescence. Average female flower produced among the genotypes varied from 6.85 to 29.26. Genotype

KKHC 3 produced higher number of female flowers per inflorescence. Variation with respect to female flower production among coconut varieties and environment condition has been reported by many workers (Marechal, 1928; Vanaja and Amma, 2002; Samanta *et al*., 2009; Niral *et al.,* 2017). Rao (1988) also observed seasonal variation among coconut varieties for number of female flowers produced.

Duration of male phase

Average length of male phase among the genotypes studied varied from 21.59 days to 36.78 days. Genotype KKHC 4 recorded the longest duration of male phase followed by genotype KKHC 5 (35.67). Shortest male phase duration was observed in genotype KKHC 13 (21.59 days). Sangare *et al*. (1978) and Peter (2002) reported duration of male phase varying from 19.5 to 22.7 days and 18-20 days, respectively. However, in the present study (Table 1), the relatively longer duration of male phase among the genotypes studied was observed during winter and might be related to the low temperature during the period of observation. The findings are in agreement with those reported by Rognon (1976) and Sangare *et al*. (1978) wherein they observed longer duration of male phase during cooler season than hot season.

Duration of female phase

Length of female phase in the coconut genotypes (Table 1) differed significantly among the genotypes. Genotype KKHC 4 recorded the longest duration of female phase (6.56). Ratnambal *et al*. (2003) reported longer duration of female phase in the accession Standard Kudat Tall (6.4) among the tall coconut types studied. They also reported seasonal variation changes in various coconut accessions studied.

Flower sex ratio

Percentage of female to male flowers among the genotypes varied from 0.60% (KKHC 3) to 0.27% (KKHC 13), with KKHC 3, KKHC 1 and KKHC 4 showing significantly higher sex ratio as compared to the rest of the accessions.

Intra spadix overlapping of phases

Intra-spadix overlapping of male and female phases was observed in all the genotypes studied. KKHC 4 recorded significantly higher period of intra-spadix overlapping of male and female phases (3.60) among the genotypes studied. While inter-spadix overlapping of male and female phases among tall coconut cultivars has been reported by various workers (Rognon, 1976; Samanta, 2009; Thomas and Josephrajkumar, 2013), in the present study, intra-spadix overlapping was recorded in all the genotypes. Ratnambal *et al*. (2003) observed a little influence of intra-spadix overlapping with seasonal changes in tall coconut types.

Inflorescence production

No significant difference was observed for the number of inflorescence produced during the four month period of observation among the genotypes studied. However, relatively higher number of inflorescence per palm was recorded in genotype KKHC 4 (0.90) as compared to other genotype. From the data (Table 1), it is evident that an average of one inflorescence is produced during this period and inflorescence production in the winter is low in most of the genotypes. Marar and Pandalai (1957) reported production of larger number of spadices during hot weather season as compared to other seasons. This might be attributed to low temperature (below 20˚C) and day length during the period affecting the photosynthetic efficiency (Wickremasurya, 1968; Siju Thomas *et al*., 2008). Louis (1981) also observed phenotypic variations for number of inflorescence produced in coconut varieties.

Correlation study among floral traits in coconut

Correlation coefficients among floral traits were calculated using the mean values (Table 2). Significant correlations were observed among the floral traits studied. The inflorescence length, girth of inflorescence stalk, length of spikelet bearing portion, spikelet length, spikelets per inflorescence and male flowers per spikelet showed significant correlation with the numbers of female flowers produced per inflorescence. Niral *et al*. (2008) also reported significant correlations among the floral traits, with number of female flowers in an inflorescence showing high significant positive correlation with the length of spikelet bearing position, but with

Table 2. Correlation among floral traits in coconut genotypes

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
X_1	1	0.63*	0.89**	0.98**	0.96**	0.97**	0.93**	0.63*	0.92**	0.88**	0.39	0.82**
X_2		1	0.46	0.64*	0.71**	0.65*	0.67*	0.61*	0.62*	0.75**	0.56*	0.75**
X_3			1	0.79**	0.82**	0.83**	0.80**	0.34	0.78**	0.71**	0.16	0.53
X_4				1	0.96**	0.97**	0.91**	0.70**	0.92**	0.89**	0.44	0.88**
X_5					1	0.97**	0.97**	0.77**	0.94**	0.96**	0.58*	0.87**
X_6						1	0.96**	0.71**	0.96**	0.91**	0.47	0.84**
X_7							1	0.76**	0.94**	0.94**	0.59*	0.85**
X_8								1	0.75**	0.87**	0.92**	0.83**
X_9									1	0.90**	0.54	0.87**
X_{10}										1	0.75**	0.86**
X_{11}											1	0.64*
X_{12}												1

X_1- Inflorescence length (cm)
X_2- Girth of inflorescence stalk (cm)
X_3- Length of inflorescence stalk (cm)
X_4- Length of spikelet bearing portion (cm)
X_5- Length of spikelet (cm)
X_6- Spikelets per inflorescence
X_7- Male flowers per spikelet
X_8- Female flowers per inflorescence
X_9- Duration of male phase (days)
X_{10}- Duration of female phase (days)
X_{11}- Flower sex-ratio (%)
X_{12}- Intra spadix overlapping of male and female phases (days)

*Significant at 0.05 level (2 tailed), **Significant at 0.01 level (2-tailed)

non significant but negative correlation with length of spikelet. Intra spadix overlapping of phases (days) showed significant positive correlation with the length of spikelet bearing portion, duration of male phase (days), duration of female phase (days) and flower sex ratio except for the inflorescence stalk length where no significant correlation was seen. The number of spikelets per inflorescence showed significant and positive correlation with the inflorescence length, girth of inflorescence stalk, inflorescence stalk length, length of spikelet bearing portion and spikelet length.

Conclusion

Seasonal changes affect the flowering and floral behavior of coconut palms. Under optimum condition, an adult, healthy coconut palm produces about 12 inflorescences per year. However, under Assam condition, winter stress has a detrimental effect on growth and development of the coconut palm and also the inflorescence production. Hence, understanding the floral biology of coconut genotypes will help the breeder in undertaking selection of desirable lines for crop improvement research and also planning crop management. In the present study, the genotype KKHC 4 recorded higher values for most of the floral traits studied *viz*., inflorescence length, girth of inflorescence stalk, length of spikelet bearing portion, length of spikelet, number of spikelets per inflorescence, number of male flowers per spikelet, duration of male phase, duration of female phase, intra spadix overlapping of male and female phase and number of inflorescences produced. However, higher number of female flowers per inflorescence and higher flower sex ratio was observed in KKHC 3. Therefore, considering the most important floral traits namely, number of inflorescences produced, number of female flowers and the sex ratio, the lines KKHC 4 and KKHC 3 appear to be promising for higher nut yield potential and are to be taken up for comparative yield evaluation trial, along with standard check varieties, in order to develop improved varieties suitable for commercial cultivation in Assam.

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