EVALUATION OF PHOTOPERIOD SENSITIVITY AND ADAPTATION IN KENAF *(HIBISCUS CANNABINUS)* IN SOME NIGERIAN AGRO-ECOLOGIES

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ABSTRACT
Seven genotypes of Kenaf were grown in pots at controlled and natural photoperiod (PP) regimes in Ibadan, South-western Nigeria, to determine their PP sensitivities. Numbers of days to flowering and fibre yield were recorded. The same genotypes were grown on the field at Jos, Ibadan and Badeggi of high altitude, southern guinea savannah and forest agro-ecologies of Nigeria, respectively. Days to flowering, fibre and seed yields were recorded. Potted plants grown at natural PP flowered earliest, 54 days after planting (DAP) while they flowered at 118 DAP at 12 hours PP. IFEKEN DI400 flowered 20 days later than other genotypes at both PP regimes, and was grouped as being relatively photo-insensitive. Fibre yield was significantly higher at natural than at 12 hours PP only in IFEKEN DI400, with highest mean yield of 24.08g / plant. In the genotype × environment studies, IFEKEN DI400 was consistently latest to flower across locations with an average of 107 days. Mean fibre yield of 11,314.5kg/ha in Ibadan tripled that obtained in Badeggi and Jos. Genotype Tainung had the highest seed yield of 473.75g and 179.35g at Badeggi and Ibadan, respectively while the lowest seed yield 201.08g for Jos was recorded in genotype 8B. Badeggi is recommended for seed production while Ibadan is recommended for fibre production pending the availability of specifically adapted genotypes. The genotypes IFEKEN DI400, Tainung and 8B are candidate genotypes in breeding for high yield and adaptation to Nigerian agro-ecologies.

Key words: Kenaf, Nigerian *Hibiscus cannabinus*, photoperiod sensitivity, fibre yield, adaptation

INTRODUCTION
Kenaf is a low-risk, environment-friendly crop used as alternate raw material in paper production (Rymsza, 1999) and in the production of acoustic tiles, oil absorbents and butanol, among others (Stricker *et al.*, 2001). It also helps to alleviate global warming by absorbing carbon dioxide gases due to its rapid growth rate. However, in spite of its being native to Central Africa, supply and use of kenaf raw materials in this region are scarce, with Africa producing only 2.91% of the global production of kenaf (FAO, 2003). This is due in part to lack of easily-identified, locally adapted varieties which can be cultivated in specific locations all year round due to sensitivity of most cultivars to photoperiod, temperature and their interaction. Thus, there are specific times for planting and harvesting of these cultivars, causing surplus supply of raw materials at a time and shortage during the rest of the year (Webber and Bledsoe, 1993).

It is the latitude (North or South of the equator) of a place that determines its daily photoperiod yearly. Photosensitive varieties initiate flowering when photoperiod reduces to below 12.5 h, and are suited for countries above the tropics specifically at latitudes 10^0 to 27^0 North or South of the equator (Scott, 1982; Webber *et al.*, 2002; Carberry *et al.*, 1192; Shilin, (1996). In contrast, when planted at latitude 0^0 to 10^0 N or S where photoperiod is more uniform from June to September, these cultivars flower very early, causing a reduction in vegetative growth and fibre yields. Photo-insensitive cultivars have therefore been recommended for the tropics, in that, in this geographical region, they flower late, or when they flower early, their vegetative growth is not significantly reduced (Balogun *et al.,* 2007). The photoperiod sensitivity of seven kenaf accessions in controlled environment was investigated and genotype by environment interaction studies were conducted in selected agro-ecologies in Nigeria. This will aid in the identification of genotypes that can be incorporated into kenaf improvement programmes for optimum yields.

MATERIALS AND METHODS

The controlled-environment study was done in Ibadan, South-western Nigeria. Determination of photoperiodic response was done in a 12ft × 20ft plywood-insulated metal growth room provided with 1 air conditioner set at 26°C and 120 white fluorescent tubes. Seven kenaf genotypes obtained from the kenaf genebank of the Institute of Agricultural Research and Training, Ibadan were planted in pots. These were: Tainung, 20C, 8B, Local35, IFEKEN DI400, S72 and Cuba108. The photoperiod levels used were:

1. Control: Natural photoperiod (mean = 11.8 h from December, 2008 to May, 2009).
2. 14-h photoperiod for 50 days followed by 12 h until harvest.

Planting was done in pots in a completely randomized design with four replicates. The controlled-photoperiod regime was achieved by varying the numbers of light hours in the first 50 days. The plants were taken outside the growth room to receive 11 h of sunlight from 7a.m to 6p.m and returned to the growth room with the lights switched on from 6p.m to 9p.m for the balance of 3 h of light. This gave a total of 14 h of light per day for the first 50 days. Thereafter, the light received in the growth room was reduced to 1 h to give total of 12 h until harvest. The control plants were planted outside the growth room to receive natural photoperiod. Fertilizer application was done four weeks after planting. Data were collected on days to flowering and fibre yield (g) per plant. Analysis of variance was done using the generalized linear model procedure of SAS (SAS, 2000) and means were separated using Duncan multiple range test.

In the multi-locational field trials the seven genotypes were planted at three locations with different latitudes and longitudes: Jos (9.9 N, 8.9 E), Badeggi (9.1 N, 6.1 E) and Ibadan (7.4 N, 3.9 E), corresponding to high altitude, southern guinea savannah and forest agro-ecologies of Nigeria. The experimental design was randomized complete blocks with four replicates. Plot size was 2m × 2m for each genotype with 50cm between and 20cm within rows. Five randomly selected plants per plot were used for data collection on number of days to 50% flowering, fibre yield (g) per selected plant, fibre yield (g) per half of each plot (later converted to kg /ha). Seed yield was determined (g) using the remaining plants on the second half of each plot. The GGE Biplot software was used for statistical analysis to determine the significance of the performance of each genotype at each location.

RESULTS

Controlled environment studies

The main effects of photoperiod and genotype were significant for number of days to flowering, but their interaction was not significant (Table 1). Table 2 shows that all genotypes flowered earlier (53 days) when grown at natural photoperiod (mean=11.7 h during the experimentation period) than at 12 h photoperiod (118 days) in the controlled environment. Among the genotypes, IFEKEN DI400 matured at least

20 days later than the other genotypes at all photoperiod regimes.

Fibre yield varied significantly with photoperiod regime among genotypes (Table 1). Higher yield was recorded at 12 h than at natural photoperiod in all genotypes except IFEKEN DI400 in which significantly lower fibre yield was recorded at 12 h than at natural photoperiod (Table 2). Differences in fibre yield between the photoperiods were not significant in genotypes 20C and Tainung 1. Among the genotypes, the highest mean fibre yield of 17.32g per plant was recorded in IFEKEN DI400.

Multi-locational trial

The main effects of location, genotype and their interaction were highly significant for number of days to flowering and seed yield, but only location effect was significant for fibre yield (Table 3). The highest mean number of days to flowering was recorded in Ibadan (97.6days) and shortest in Jos (85days) while Badeggi had an intermediate mean value of 93 DAP. This trend was true for all genotypes except IFEKEN DI400 and Ifeken400, which matured latest at Badeggi, 121 and 98 DAP, respectively. Also, in genotypes 8B, S72, Cuba108 and Tainung 1 there was no significant difference between Jos and Badeggi for this trait. Among the genotypes, IFEKEN DI400 was the latest to mature (mean=107 days) followed by 20C (mean=96.9 days) and Tainung 1 (mean=90 days) while there were no significant differences among the other genotypes.

Figure 1 shows a biplot of the genotypes' number of days to flowering at each location. The rays divide the biplot into sectors. The vertex genotype for each sector is the winner (i.e., has the largest value) in all environments falling within that sector. On this biplot, all the three environments fall into the same sector with IFEKEN DI400 being the vertex genotype. It also has the highest mean (longest maturity period) in all environments followed by genotype 20C.

Figure 2 shows a biplot of seed yield for each genotype at the locations. The rays divide the biplot into four sectors. Ibadan and Jos fall into one sector while Badeggi fell to another sector. 8B is the vertex genotype for the Badeggi sector while Tainung is the vertex genotype in the second sector and has the highest seed yield at the two locations.

The highest mean seed yield (g/plot) was recorded in Badeggi (383.75g) and this is true for all genotypes (Figures 2 and 4). Mean seed yield was lowest in Ibadan (108.14g) while Jos had an intermediate mean value of 124.94g. In genotypes S72 and 20C however, seed yield was significantly higher in Jos than Ibadan. There was no significant difference between Ibadan and Jos for seed yield in Ifeken400, Cuba 108 and Tainung 1.

Only the main effect of location was significant for fibre yield. The highest mean fibre yield of 11,156kg/ha was recorded in Ibadan, while 4,550 and 4,794kg/ha were recorded in Badeggi and Jos respectively. Although genotype by environment interaction was not statistically significant, some genotypes performed better than others at certain locations (Figures 3 and 4). IFEKEN DI400 had the highest mean fibre yield of 6,593kg/ha at Badeggi, 20C had 14,495kg/ha at Ibadan while S72 was highest at Jos with a mean value of 9,313kg/ha.

DISCUSSION

Early flowering at natural photoperiod may be due to short photoperiod between January and March which ranged from 11.6 to 11.9 h since kenaf is a short day plant. Late flower initiation in IFEKEN DI400 (137days) at 12 h photoperiod confirms this genotype to be photo-insensitive. Relativity in response of genotypes to photoperiod has been reported (Dempsey, 1975; Muchow and Wood, 1983;, Balogun *et al.*, 2007). Also, earlier flowering recorded In Jos and Badeggi (nearer in latitudinal locations of 9.9^{0}N and 9.1^{0}N respectively) is due to the photoperiod reducing sooner after planting (earlier in the year) relative to Ibadan (latitude 7.1^{0}N) where the genotypes had more time for vegetative growth due to photoperiod reducing much later after planting. Kenaf has been reported to initiate flowering when the photoperiod reduces to 12.5 h (Dempsey, 1975). Consequently, genotypes 8B, Cuba 108, Ifeken 400, Local 35, S72, and Tainung 1 that flowered early at Badeggi and Jos are photosensitive while IFEKEN DI400 and 20C which flowered late are relatively photo-insensitive.

Significant variations of fibre yield with genotypes and photoperiod suggest possible genotypic response to other factors like temperature which may be interacting with photoperiod in the environment (Webber and Bledsoe, 1993; Balogun *et al.*, 2007). Since late flowering is desirable for high fibre yield, then early planting is recommended to allow sufficient time for maximum vegetative growth. Delayed sewing in Greece reduced biomass production by 38%.

The implication of the significant effect of location on fibre yield is that certain locations (Ibadan) are better for fibre production than others (Badeggi and Jos) in Nigeria. However, if Kenaf must be grown for fibre at other locations, specifically adapted genotypes must be used. Other environmental factors like soil, rainfall and interaction of temperature with photoperiod hours could affect the yield at different locations. In the multi-locational field trial, fibre yield in Jos which did not significantly differ from that in Badeggi for genotypes 8B, S72, Cuba108 and Tainung 1 suggests temperature insensitivity in these genotypes relative to the other genotypes. Maximum daily temperature ranges from 23.33^{0}C in Jos through 27 to 34°C in Ibadan and Badeggi, respectively.

Conditions that give high seed yield were reported to yield poorly for fibre and vice versa (Dempsey, 1975). This explains why Ibadan is good for fibre production but relatively poor for seed production, while Badeggi is excellent for seed production but had the lowest fibre yield. However, it will be worthwhile to test the effect of planting date on fibre and seed yields at each location to optimize yields. In IFEKEN DI400 planted in Jos, no seed was produced as the capsules were empty. This is probably due to low temperature which affects seed setting in late maturing, photo-insensitive genotypes (Zhang and Zhang, 1990). Soil factors in Jos should also be specifically investigated for IFEKEN DI400 as they may be limiting.

The rays of the biplot which showed the three environments to belong to the same sector indicated that more environments be included in subsequent multi-locational trials for adequate spread. This will show more genotype by environment interactions.

CONCLUSION

This study identified photoperiodic response of seven genotypes of kenaf. It has also shown that other factors in the environment like temperature have significant effect on vegetative growth, fibre and seed yields in kenaf. Conducting wider multi-locational trials for new candidate varieties will be necessary for the selection of specifically adapted genotypes that will yield optimally at specific locations. This is more so as high temperature is associated with equatorial climates, Nigeria alone having six agro-ecological zones whose maximum daily temperature range from 23.33^{0}C in Jos plateau to 41.11^{0}C in Sokoto and Maiduguri. It will also increase the impact of kenaf research on the society when specifically adapted genotypes are introduced to appropriate environments in farmer-participatory variety selection.

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