Induced Plant Mutations in the Genomics Era

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Development of High Yielding, Late Maturing Kenaf (*Hibiscus cannabinus*) Using Gamma Irradiation

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Abstract

Two mutants of Kenaf (*Hibiscus cannabinus*) derived from gamma irradiation of Cuba 108 (Mutant 1) and Tainung-1 (Mutant 2), their parents and two landraces were evaluated for maturity period and fiber yield traits in the forest, derived and southern Guinea savannah agro-ecologies of southwest Nigeria. Mutant 2 was consistently late maturing across locations with an average of 80 days compared to 71 in the parent. Fiber yield and maturity period were highest in forest and lowest in Southern Guinea savannah agro-ecologies due to photoperiod and rainfall differences. Mutant 2 was most stable, and had the highest mean value of 26,158kg/ha for fiber yield followed by 17,611kg/ha in Mutant 1. Mutant 2 is suspected to be photo-insensitive and recommended for equatorial climates.

Introduction

Kenaf is an important fiber plant that alleviates global warming by absorbing carbon dioxide gases due to its rapid growth rate. However, Africa produces only 2.91% of the global production [1]. This is due in part, to photosensitivity of most of the varieties.

Photosensitive varieties of Kenaf initiate flowering when day length reduces to 12.5 hours, and are suited for countries above the tropics. In contrast, these cultivars flower very early at latitude 0^0 to 10^0 N or S, where day length is more uniform from June to September, causing a reduction in vegetative growth and low fiber yields. Photo-insensitive cultivars are therefore preferred since they flower late, or when they flower early their vegetative growth is not significantly reduced [2]. To develop varieties that are adapted to Nigerian agro-ecologies, induced mutagenesis was used to create genetic variability for maturity period and fiber yield in Kenaf.

Methods

Dry seeds of two varieties of Kenaf were exposed to Cobalt^{60} source of Gamma-ray at doses of 200 and 400Gy and the M_2 population was screened for mutants in terms of maturity period and fiber yield. Cuba 108 was irradiated with 200Gy (Mutant 1) and Tainung-1 irradiated with 400Gy (Mutant 2) were mostly high yielding and late maturing, respectively, and therefore selected. The selections were planted up to the M_5 generation when they became stable. To formulate recommendations for areas of optimal cultivar adaptation [3, 4], the selections were planted in multi-locational trials alongside the parents and two local varieties at Ikenne, Ilora and Ballah corresponding to forest, derived and southern Guinea savannah agro-ecologies respectively in southwest Nigeria.

Results and Discussion

Mutant 2 was consistently late maturing in the three locations (**Fig. 1**) compared to other genotypes, except for Mutant 1 at Ikenne, which matured two days later. Maturity periods varied with location in other genotypes. The average maturity period for Mutant 1 was 80 days, compared to 71 in the parent.

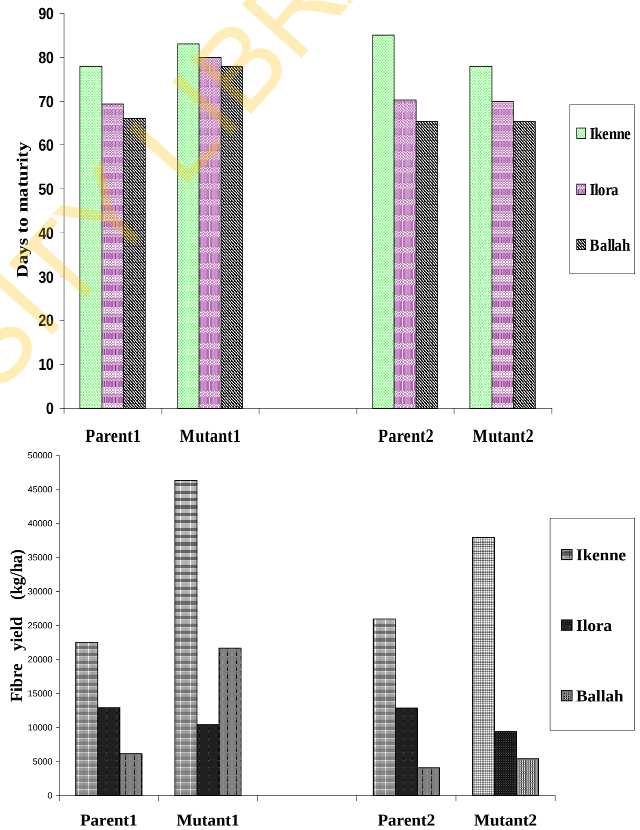

Figure 1 Maturity period and fiber yield in two mutants of Kenaf and their parents in three Nigerian agro-ecologies.

Although at flowering, Mutant 2 plants were taller than other genotypes in Ikenne (**Table 1**), they were shorter than other genotypes in Ilora and Ballah despite longer days to maturity at these locations. Mutant 2 had the highest percentage gain in height after flowering, 293.08% compared to 90.13% in the parent line (**Table 1**).

The highest fiber yield was recorded in Ikenne across genotypes (**Table 1**). At Ikenne, both mutants had higher fiber yields than other genotypes. Mutant 2 had the highest value of 46,321kg/ha (Figure 1), followed by Mutant 1 with 37,966.5kg/ha. These were in comparison with 22,498.7kg/ha in Tainiung-1 (Mutant 2 parent) and 25,978.3kg/ha in Cuba 108 (Mutant 1 parent). One of the landraces (Local 35) had the lowest fiber yield of 17,427.67kg/ha.

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Table 1. Mean vegetative growth traits and fiber yield of Kenaf genotypes grown at forest, derived from southern Guinea savannah agro-ecologies of Nigeria

Genotypes/Trait	Agro-ecologies			Mean (Genotypes)
	Ikenne	Ilora	Ballah	
Height at flowering (cm)				
Mutant 1	182.92b	152.67a	77.00a	137.53A
8B	168.17c	148.00a	69.17ab	128.44BC
Tainung-1 (Parent 2)	145.67d	154.67a	73.00a	124.44CD
Cuba 108 (Parent 1)	147.92d	142.00a	72.00ab	120.64DE
Local35	146.83d	143.67a	59.27b	116.59E
Mutant 2	239.92a	123.33b	40.33c	134.53AB
Mean (Agro-ecologies)	171.90A	144.06B	65.13C	
Error mean square	63.77			
Gain in Height after flowering (%)				
Mutant 1	9.55a	27.46a	74.54b	37.18B
8B	10.12a	24.29a	69.92b	34.77B
Tainung-1 (Parent 2)	13.63a	13.97a	90.13b	39.24B
Cuba 108 (Parent 1)	12.69a	37.51a	62.63b	37.61B
Local35	19.47a	14.92a	103.42b	45.94B
Mutant 2	4.82a	33.12a	293.08a	110.34A
Mean (Agro-ecologies)	11.71C	25.21B	115.62A	
Error mean square 779.56				

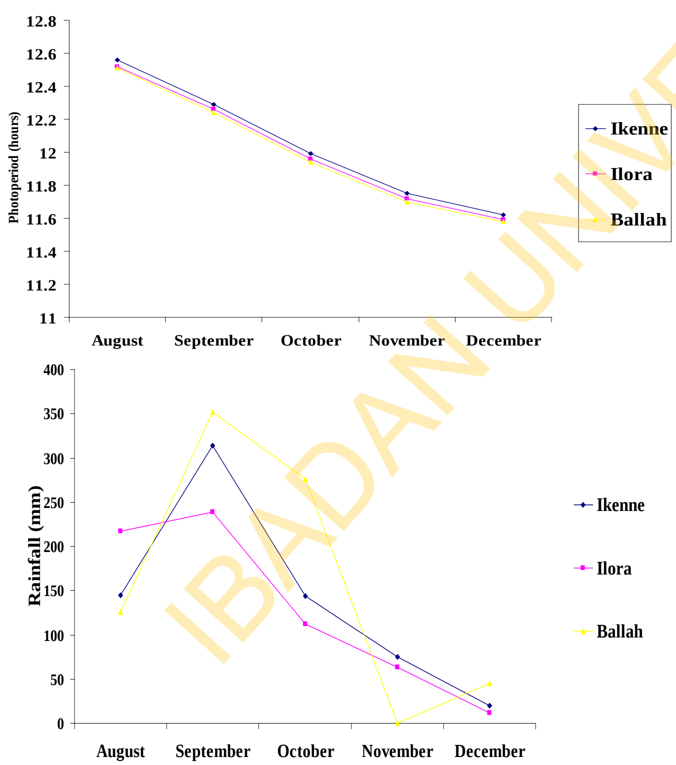

Figure 2 Rainfall distribution and rainfall patterns at the three agro-ecologies during the growing season.

Mean in each column followed by the same lower case letters are not significantly different at p=0.05. Genotype and location means followed by the same upper case letters are not significantly different at p=0.05.

Highest fiber yields were recorded in Ikenne for the Kenaf genotypes evaluated in this study. Kenaf fiber yields have been reported to be highest in regions with long growing seasons and abundant moisture [5], which are characteristic of Ikenne.

Also, Kenaf is a short-day annual that remains vegetative until the number of daylight hours fall below 12.5 hours, when flowering occurs [2, 6]. Ballah, Ilora and Ikenne are located on 13, 7 and 6 degrees latitude respectively, and this is associated with an increasingly wetter climate and later shortening of day length (**Fig. 2**). The growing season is longest at Ikenne and shortest at Ballah.

Low fiber yield was recorded in Mutant 2 at Ballah and Ilora as it was yet to reach its maximum vegetative growth when it flowered. This was as a result of water stress due to no rainfall in November at Ballah (**Fig. 2**). Vegetative growth was therefore retarded, but resumed with sparse rain in December, causing its high percentage gain in height after flowering at this location. Also, day length decreased soon after planting at Ballah and Ilora, making the plants (especially the relatively photosensitive genotypes) flower earlier to produce seeds before the dry season. The initiation of flowering is associated with reduced vegetative growth, and in turn, low fiber yield. Planting should therefore be done earliest in Ballah, followed by Ilora and Ikenne to allow for ample vegetative growth and high fiber yields before cessation of rains.

Conclusion

The consistently late maturing, high yielding Mutant 2 is recommended for the three locations, while Mutant 1 will also yield well at Ikenne. Fiber yield will be optimum when planted early in the growing season. Induced mutagenesis was successfully used to develop high-yielding genotypes of Kenaf adapted for specific climates (**Table 2**). This could be a very useful tool for creating genetic diversity that will cope with global climate change in a sustainable way.

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