Economic Evaluation of the Planting Period and Retting Techniques in the Production of Quality Kenaf Fibre

Abstract

The quality and quantity of fibre produced in terms of fibre length, tensile strength and fineness could be determined by the planting period and good retting techniques in kenaf. This study was carried out to determine the appropriate time of planting and examined the different retting techniques for enhanced quality fibre for value addition. Five varieties of Kenaf (Cuba108, Ifeken-DI-400, Ifeken100, Ifeken-400 and Tianung-2) were planted at 50cm x 20cm monthly from June to August (June 10, July 10 and August 10) in 5 locations with their coordinates; Ibadan (Transitional-Rain forest, Lat.7.23′N;Long.3.55′); Ilora (Derived savannah, Lat.8.54′N;Long4.54′E); Ikenne (High Rain forest, Lat.6.92′N;Long.9.46′N); Orin Ekiti (Rain forest, Lat.7.49′N;Long.5.14′E) and Kishi (Southern Guinea Savannah, Lat.9.46′N; Long.3.52′E). Gross Margin (GM) analysis was used to determine the profitability and suitability of the different planting periods. The results show that total variable cost (TVC) in Orin Ekiti for each planting time was the highest (₦705,650:00). The least TVC (₦250,000) was from August plantings in Ikenne. The GM value for a sum of ₦701,650 and ₦1,736,400 were obtained from Kishi and Ilora respectively while ₦1,441.750, ₦184,750, ₦1,224,950 were obtained for the months of June plantings in Orin-Ekiti, Ikenne and Ibadan respectively. July and August plantings recorded low GM. The GM value of June planting was significantly higher in all the locations. The results of the retting techniques revealed that chemical retting had a greater efficiency in the processing of fibre while tank retting is technically supported due to its potability and availability.

Keywords: Economic evaluation, Planting period, Retting techniques, Kenaf fibre, Fibre strength

Background

Kenaf (*Hibiscus canabinus* L.) is an annual fibre crop and is the third largest fibre crop of economic importance after cotton and jute [5]. Kenaf crop has several economic potentials that can increase the economy of developing countries such as Nigeria through diverse uses of its fibre into various value addition [1]. It is commercially cultivated in some Asian countries like India, China, Thailand and Vietnam [9]. Kenaf cultivation is becoming more popular in the developing country like Nigeria. To meet the quality of fibre production for value addition, the Institute of Agricultural Research and training, Ibadan (IAR&T) has the mandate of producing, processing, creating awareness and diversification of production of various kenaf varieties for value addition. There is a renewed interest of government in the production of kenaf for fibre in Nigeria. Therefore, farmers are increasingly becoming aware of its economic potentials, making it gradually become a major crop in the country [8]. These factors have increased the demand for kenaf seeds across the country.

Due to the light weight, high tensile strength to weight ratio and other advantages, natural fibre based composites are becoming important composite materials in building and civil engineering fields, coupled with the global consciousness on health and environment which is compelling us to carry out research in the area of green engineering, commercialization of process and products that are feasible, economical and improve natural ecosystems while protecting human health and the environment [3]. We have much greater concern in selecting materials based on attributes like eco-friendliness, sustainability, biodegradability and recyclability. The arrangement and orientation of fibres also influences the mechanical properties of composite materials. Bast fibres could be arranged continuous or chopped randomly aligned in woven or non- woven formation [14]. Bast fibres are the most widely used non-wood lignocellulose fibres due to their superior technical characteristics and ease of extraction from raw resources [13].

The time of planting of kenaf and different procedures involved in kenaf retting techniques determine the quality and quantity of fibre produced in terms of fibre length, tensile strength and fineness for value added products to be able to compete favourably with the imported fibres in terms of its chemical and mechanical properties [2]. The cost involved timing of operation, labour on various activities and the availability of the different retting materials varies across different locations. Kenaf has a high adaptability to various growing environments and its cultivation is easy but the efforts to produce kenaf seed in different agro-ecologies in South West Nigeria resulted in low seed yield which might be attributed to several reasons, among which is the effect of climate change on the crop. However, the flowering pattern was irregular and delayed, while the capsule formation was poor. Kenaf can be photosensitive, thus it will respond to the time of planting which can be influenced by climate change [2]. Consequently, it becomes pertinent to validate information on the response of the crop to prevailing weather conditions and determine the most appropriate planting time for the crop to produce optimum seed yield of acceptable quality. It follows that the post-harvest operation like the best method of the processing into fibre such as retting method also determine its quality in terms of fibre strength and other mechanical properties that could enhance its utilization.

Retting is one of the important steps in fibre production and the length of retting time will determine the efficiency rate of fibre production in kenaf and texile industries [12]. Retting is a biological process by which the bast fibres are extracted by decomposing the plants by the combined action of water and aquatic micro-organisms, mostly bacteria and fungi. Retting is also a biological process involving moisture to remove the bark material (bast) from the kenaf plant after harvesting. Retting techniques affect the fibre quality in terms of its fineness, elongation, grade, length uniformity, colour, lustre, tensile strength and breaking tenacity. The traditional retting practice has a number of limitations such as time and labour consumption, non-eco friendliness, water pollution and lack of precise control on the quality of fibre produced [12]. Some Nigerian institutes have been saddled with the task of awareness creation and diversification of production of kenaf varieties in Nigeria. Contrary to this objective, getting the quality fibres is the major challenge facing the kenaf and jute growers. This is occasioned by retting techniques which is one of the important steps in fibre production [7, 12]

This study therefore examined the cost associated with the planting periods from different locations with varied months to determine the most appropriate time of planting, determined the most efficient method of retting techniques, the availability of the most efficient retting materials at minimum cost for policy implications and recommendation.

Material and Methods

Study area

The study was conducted at five research stations of the Institute of Agricultural Research and Training (I.A.R.&T) Ibadan Nigeria in 2021 and 2022 planting seasons. The stations with their coordinates are located in Ibadan (Transitional-Rain forest, Lat.7.23′N;Long.3.55′), Ilora (Derived savannah, Lat.8.54′N;Long4.54′E), Ikenne (High Rain forest, Lat.6.92′N;Long.9.46′N), Orin Ekiti (Rain forest, Lat.7.49′N;Long.5.14′E) and Kishi (Southern Guinea Savannah, Lat.9.46′N; Long.3.52′E).

Five varieties of Kenaf (Cuba108, Ifeken DI 400, Ifeken100, Ifeken400 and Tianung-2) were planted at 50cm x 20cm in monthly interval from June to August (June 10, July 10 and August 10) of each year. All agronomic activities, economic performance evaluation and data collection were carried out from the planting to maturity period. The costs associated with the planting of kenaf from land preparation to harvesting were also determined in all the locations.

Sampling Techniques

Market valuation of fibre yield components using adjusted yield per hectare at prevailing market prices of kenaf fibre, associated cost of production comprising of labour cost, input purchases and other expenses were noted and used to conduct a gross margin analysis. The associated cost of the production differs from location to locations. Therefore, the cumulative gross margin and net benefit associated with production costs were calculated and compared among treatments and locations. The profitability analysis was conducted to estimate the cost and returns to production in different locations.

The Gross Margin analysis is expressed as follows:

Gross margin (GM) = TR – TVC,
where
GM is the gross margin,
TR = Total Revenue and
TVC = Total Variable Cost.
On the retting of fibre: Different methods were tested with plants already established on the field and cost analyses of different retting techniques (concrete block, plastics, streams, reservoir) were determined. The quality and quantity of fibre produced through the different retting techniques were economically evaluated. Samples of the newly released varieties was planted and processed in order to ascertain the prevailing cost of labour and materials used as well as the constraints encountered in different retting methods. Also, costs and returns associated with the production of kenaf fibre under varied time of planting in different agro ecologies were empirically determined.

Retting Techniques

Four (4) retting techniques were evaluated.

1. Tank / Plastics retting

2. Stream retting

3. Concrete block or Reservoir retting

4. Chemical retting.

Sample preparation: All kenaf samples used in this experiment were harvested at 10 weeks after planting (WAP). Freshly harvested kenaf plants were manually defoliated and then were tied in a replicate consisting of six kenaf stems. Each treatment was carried in three replicates of kenaf samples.

Retting procedures:

Tank retting: Triplicate of kenaf stems were soaked in an improvised plastic tank containing 1000 litres of water. The texture of kenaf stems were checked daily by touching with fingers as to determine when the retting is completed. Retting was adjudged to have been retted completely when the kenaf bast were very soft and can easily be loosened from the core stems. Tank retting with decorticated fibre: The same quantity (in triplicate) of kenaf stems were decorticated into ribbons (using a decorticator) and the ribbons were steeped in an improvised plastic tank containing 100 litres of water. The ribbon texture was also assessed daily until it became soft.

Fig 1. Tank Retting without water

Fig 2. Tank retting soaked with water

Stream retting: This method involved the use of flow sream as shown in Fig. 3. samples of kenaf stems (Core fibre) were immersed in a slow-running stream and the kenaf stem bundle was supported with heavy stones or any heavy load with the aim of holding and suppressing the fibre inside water. The soaked kenaf stems were assessed daily until it became soft to remove from the core stems (Fig.3).

Fig 3. Steam retting

Concrete blocks / Reservoir retting: this involved the use of constructed reservoir with blocks and the platform that is well supported with binding agent such as cement. After completion of the retting, kenaf fibres were manually removed from the core stems, washed properly, sundried and stored at room temperature for further analysis.

Chemical Retting: This is the retting method that involved the use of chemical such as Sodium hydroxide (NaOH) or the application of Urea into the retted fibres. Application of chemical enhances more of the microbial organisms to hasten the softening of the fibre. However, it is more preferable in the retting tanks or concrete blocks where the water will be stable for the efficient microbial action of the chemical.

Results and Discussion

The significant impact of production environment and time of planting on the quality of kenaf fibre is an indication of sensitivity of kenaf to weather situation. This may be connected to the constituent of both kenaf seed and fibre. The most seeds with high oil content have been reported to have physiological changes caused by enzymatic reactions within the seeds in reaction to the environmental situation [6]. The oil content in kenaf seed ranges from 21.4% to 26.4% [10], thus the reaction of the oil within the seed with the environmental situation can trigger deterioration in face of little unfavourable weather situation.

The varied cost of production across the locations can be connected to the price fluctuations of inputs as well as accessibility and negotiation for labour input. High TVC recorded in June across the locations was due to the scarcity of farm hands, being the peak period for agricultural activities that majority of the available labours were not easily accessible due to their engagement in personal farm operations and the few available farm hands increase their charges in cost of farming activities. This corroborates the findings of [4] that farm input use depends on the time and type of operational activities. The high cost of production in Orin-Ekiti was as a result of purchases and non–availability of inputs in the area. The transportation cost of inputs from head office of these agencies to some parts of Ekiti especially, Orin--Ekiti often leads to the increased cost and unavailability of the inputs.

Table 1. Gross Margin Analysis on kenaf fibre across locations

Planting date (Month)	Locations	Total fibre dry weight (g)	Fibre /ha (Kg)	Price / Kg (#)	Revenue /Ha	TVC	MRR	GM
June	Kishi	178.4	718.1	1,500	1,077,150.00	375,500	2.87	701,650
‘	Ilora	332.3	1611.3	1,500	2,416,950	680,550	3.55	1,736,400
‘	Orin-Ekiti	292.2	1431.6	1,500	2,147,400	705,650	3.04	1,441,750
‘	Ikenne	169.1	296.5	1,500	444,750	260,000	1.71	184,750
‘	Ibadan	591.7	1176.9	1,500	1,765,350	540,400	3.27	1,224,950
July	Kishi	6.9	22.3	1,500	33,450	360,000	0.09	-326,550
‘	Ilora	250.3	729.6	1,500	1,094,400	658,000	1.66	436,400
‘	Orin-Ekiti	73	627.4	1,500	941,100	660,350	1.43	340,750
‘	Ikenne	130.9	255.1	1,500	382,650	265,500	1.44	117,150
‘	Ibadan	147.1	459.5	1,500	689,250	520,650	1.32	168,600
August	Kishi	0	0		0	255,000	0.00	-255,000
‘	Ilora	181.1	132.9	1,500	199,350	550,000	0.36	-350,650
‘	Orin-Ekiti	13.1	129.2	1,500	193,800	650,000	0.30	-456,200
‘	Ikenne	10.5	69.1	1,500	103,650	250,000	0.41	-146,350
‘	Ibadan	36.1	230.8	1,500	346,200	480,500	0.72	-134

TVC = Total Variable Cost; GM = Gross Margin; MRR= Marginal Rate of Return

The gross margin analysis of kenaf fibre across the locations revealed that total variable cost (TVC) recorded in Orin Ekiti for each planting time was the highest when compared to other locations. Also, the TVC recorded in the plantings done in June in all the locations except Ikenne was the highest with Orin Ekiti recording the highest (₦705,650:00) TVC as well as the Marginal Rate of Return (MRR) (Table 1). The least TVC (₦250,000) came from August plantings in Ikenne. The gross margin value of June planting was significantly higher in all the locations. The gross margin value for a sum of ₦701,650 and ₦1,736,400 were obtained from Kishi and Ilora respectively while ₦1,441.750, ₦184,750, ₦1,224,950 were obtained as gross margin value for the months of June plantings in Orin-

Ekiti, Ikenne and Ibadan respectively. July plantings in some locations recorded low gross margin while all plantings done in August returned negative gross margin regardless of production station.

It was concluded that the fibre yield of kenaf planted in June was highest irrespective of the locations. Therefore, for enhanced high profit and high yield of fibre, the appropriate time of planting of kenaf is in the month of June. However, other months like July or August could still sustain the production but might not be profitable due to the cost of production. Also, on the variable cost of production across locations, the cost varied due to some factors such as cost of inputs which varies across locations with price fluctuations and scarcity of labour which might have been connected to the period when all other productions are highly competing with few farm hands and non-availability of labour. Increase in farm operations were recorded in the locations in all the months evaluated but the yield was highest in the month of June (Table 1).

Tank / plastics retting: Fig. 1 and 2 show the retting method using plastic tanks. Whole plant stocks were cut and soaked in water tank. The stocks were suppressed with heavy weight materials to allow water to cover all the parts. However, decorticated ribbons were found more easier due to reduction in size area and opportunity of soaking more quantities of fibre. However, the cost associated with the different sizes of tanks varied. The cost ranges between #4,500 to #8,000 depending on the size of the plastics / tanks. It was observed that tank retting is more convenient and affordable due to its accessibility and portability. The same quantity (in triplicate) of kenaf stems were decorticated into ribbons (using a decorticator) and the ribbons were steeped in an improvised plastic tank containing 100 litres of water. The ribbon texture was also assessed daily until it became soft to remove from the core stems. Ribbon retting reduces the volume of water required as well as the container that would incorporate more kenaf fibre.

Stream retting: The result of the stream retting shows that the cost of transportation to the streams depends on the location of the farms and the available streams in the environment. However, the stream retting has a lot of constraints such as water pollution, fibre materials being carried away by the flowing water due to heavy rainfall and problem of application of chemical which would be washed away (Fig. 3).

Concrete block or Reservoir retting, the cost also depends on the sizes of the construction of the reservoir. It was observed that a concrete block / reservoir of 6m in length, 5m width and 3m deep would cost #325,000 for its construction. But the constraints are the portability and accessibility to the production areas or locations. The cost associated to packing and transportation to the reservoir points might be highly expensive even if it is available in the previous production.

Chemical retting, The results of this study vehemently supported the publication data reported previously by [12] that there was a strong positive correlation bundle strength and fibre fineness in the use chemical. The efficiency of the fibres retted with chemical (urea) gave the best kenaf fibre. These results showed that the chemical for retting is accessible to farmers and affordable in terms of price. This corroborate the findings of [11]. The prevailing price of a 50kg bag of urea is #22,000. After retting the remnants from the tank with the chemical could also serve as manure for other agricultural crops. It also has no adverse effect to human health. Application of urea chemical for retting had been the best for retting of fibres has it would shorten the retting periods as compared to the stream or plastics or reservoir that would stay for 14 days. It could be shortened to 7 days and still produce the quality fibre as expected. Thus, the microbial isolates in the use of urea chemical were more efficient in degradation of kenaf pectin resulting in the reduction of the retting periods. Also, farmers are very much familiar with the use of urea to boost nitrogen level of the soil. The cost of urea that can be used for an hectare of arable crop is #22,000.00/50kg bag. Small quantity of urea is required for retting depending on the size of retting tank or plastics and the quantity of kenaf stalks. However, 0.25g of urea can be used for 40 – 50litres of water.

Table 2. Comparative studies of retting properties of fibers from the different treatments

Treatment	Retting days	Tensile strength (MPa)	Fibre colour	Grade	Qty of urea for 1ha	Cost incurred (Urea / ha)
Stream	14	40.65c	Dull white	D		
Pond	14	43.76c	Dull white	C		
Tank (no Urea)	14	65.45c	Cream white	B		
Tank / Urea	7	79.92a	Cream white	B	1kg	# 2,500.00
Tank / Urea	14	89.95a	Cream white	B	1kg	# 2,500.00

The results above show that there is no significant difference in the tensile strength of the fibre for the number of days in the use of chemical.

General observation on retting techniques: It was observed that decorticated kenaf fibre would increase the quantity per space since the fibre core has been shopped-off. Also, the cost of transporting the fibre and the cost of labour for washing would be reduced and easy to pack. However, a farmer friendly decorticating machine had been fabricated for easy access to farmers and at affordable price.

Conclusion

The study revealed that kenaf fibre yield and quality is highly influenced by the production environment across the locations. The most appropriate month to plant kenaf for optimum fibre yield of high quality and profitable gross margin on investment is June in south-western Nigeria. However, the prices of the inputs varied significantly across locations their unavailability of materials in some areas. It was observed that some of the farmers could not afford some of the inputs light the processing machines due to high prices of the machines. For the retting techniques, it was found that tank / plastic retting is most appropriate since it is potable and can retain the efficiency of the use of chemical unlike the stream retting which is highly unhygienic with the use of chemical and can cause environmental pollution. The use of urea in retting is considered safe, affordable and its liquor could serve as liquid fertilizer. Chemical retting is more efficient and has produced the cleanest, finenest, consistently long and smooth surface fibers with appreciable tensile strength and tensile modulus. The retting liquor can be used as liquid fertilizer for plant production. Therefore, kenaf fibre has enormous utilization which could also describe its economic strength as a business.

References:

[1] Adeniyan, ON. Response of Kenaf to Early and Late Cropping Seasons in Cassava-Maize Based Intercrops. *Journal of Experimental Agriculture International*. 2016;13(5):1-9. https://doi.org/10.9734/AJEA/2016/26347.

[2] Adetumbi JA, Ogunniyan DJ, Ajijola S, Oyegbami A and Adeniyan ON. The Appropriate Planting Time for the Profitable Production of the Quality Seed of Kenaf (Hibiscus Canabinus L.) in Southwestern Nigeria. *Journal of Agricultural Sciences (Belgrade)* 2022; 67, (3), 253-267

[3] Akubueze1 EU, Ezeanyanaso CS, Muniru SO, Igwe CC, Nwauzor GO, Ugoh U, Nwaze IO, Mafe O, Nwaeche FC. Reinforcement of Plaster of Paris (POP) for Suspended Ceilings Applications Using Kenaf Bast Fibre. *Current Journal of Applied Science and Technology*. 2019; 36(6): 1-6,

[4] Aminu FO, Mohammed HA, Iheagwan CI. Determinants of labour use among Ofada Rice Farmers in Ewekoro Local Government Area of Ogun State, Nigeria. *Agricultural Economics and Extension Research Studies(AGEERS)*. 2020; 8 (2): 11 - 20

[5] Amusat AS, Ademola AO. Information needs of Kenaf farmers in Ogbomosho zone of Oyo State, Nigeria. *American Journal of Experimental Agriculture*. 2014; 4 (12): 1625 – 1636.

[6] Catao HC, Gommes LAA, Guimaraes RM, Fonseca PHF, Caixeta F, Galvao G. Physiological and biochemical changes in lettuce seeds during storage at different temperatures. *Horticultura Brasileira* 2018; 36:118 -125

[7] Chen F, Liu LS, Cooke PH, Hicks KB, Zhang J. Performance enhancement of poly (lactic acid) and sugar beet pulp composites by improving interfacial adhesion and penetration. Industrial and Engineering Chemistry Research, 2008; 47, 8667–8675

[8] Ogunniyan DJ, Adeniyan ON, Aluko OA, Olanipekun SO, Anjorin FB. Seasonal performance and traits relationship of kenaf (*Hibiscus cannabinus* L.) cultivars grown in forest-savannah-transition agro-ecology. *Moor Journal of Agricultural Research* 2016; 17: 37-50.

[9] Olanipekun SO, Togun AO. Effect of planting date on the growth, fibre and seed yield of Kenaf (*Hibiscus cannabinus L*) in Ibadan, South Western Nigeria. *Journal of Applied Science and Environmental Management*. 2020 24 (10) 1711-1714

[10] Omenna EC. Effect of Alkali Treatment on Kenaf Fibre Quality *Specialty Journal of Agricultural Sciences.* 2017; 3 (1): 12-21

[11] Omenna EC, Oduwaye OF. Effect of variation in urea concentration used in retting ,on the chemical and mechanical properties of kenaf fibres. Journal of Experimental Agriculture International. 2017;16 (4):1-11

[12] Omenna EC, Adeniyan ON, Ejigbo EA, Oduwaye OF, Ezaka E. Comparative effect of chemical and stream retting on the kenaf fibre quality. Agr. Biol. J. North America 2016;7: 275-283.

[13] Paulo P, Hugo C, Hafiz S, Marco L. Natural Fibre Composites and Their Applications: *Journal of Composites Science*. 2018; 2:66.

[14] Verma D, Jain S. Green approaches to biocomposite materials science and engineering. In Advances in Chemical and Materials Engineering; 2016; IGI Global Publishing.