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Growth, Development and Yield of Kenaf as Affected by Planting Dates and N Fertilization

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Abstract

Kenaf (*Hibiscus cannabinus* L) consists of various beneficial components like stalks, seeds, leaves, fibers, oils, proteins, allelopathic chemicals, and fiber strands, among other things. Despite the numerous uses of the crop, there is little or no information on optimum agronomic practices such as planting date and N fertilization of the crop in the Upper East Region (UER) of Ghana where the crop is widely cultivated by smallholder farmers. Field experiments were therefore carried out in 2020 and repeated during the 2021 cropping season in the study area. The objective of the study was to determine appropriate planting date and N fertilization for increased kenaf productivity. In each year, the treatments consisted of 3 × 5 factorial combinations of three planting dates (1st July, 7th July and 14th July) and five levels of N (0, 20, 40, 60 and 80 kg/ha) replicated three times. The design of the experiment was a split-plot with the N fertilizer as the main plot and the planting date assigned to sub plot. The results showed that, planting kenaf in early (1st) July or N fertilization at the rate of 60 kg/ha increased plant density, stem height, stem diameter, dry bast and core yields in both cropping seasons.

Keywords

Growth, Fibres, Bast Yield, Core Yield

1. Background

Kenaf is a fast-growing, annual crop that belongs to the Malvaceae family, along with cotton (*Gossypium hirsutum* L.) and okra (*Hibiscus esculentum* L.). It belongs to the genus *Hibiscus* that comprises about 400 annual and perennial species. Kenaf is originally from Africa, more specifically Tanzania and Kenya [1] (Xu *et al.*, 2013), probably since 4000 BC. Kenaf stalks can reach a height of 4 to 6 m and can yield up to 24 $Mg \cdot ha^{-1}$ in 5 - 7 months [2] (Brown and Brown, 2014). Studies show a strong correlation between the first flower node and effective plant height; the higher the first flower node, the more fiber is produced in kenaf [3] (Li *et al.*, 2016). Kenaf is outstanding due to its quick growth cycle, tall, durable plants, high-stress resistance, soft bast fiber, strong tensile force of fiber, high fiber yield, and rapid water dispersal [4] (An *et al.*, 2017). Maximizing yield and productivity in kenaf requires an understanding and selection of late-flowering or less sensitive kenaf varieties [5] (Al-Mamun *et al.*, 2021). The kenaf plant continues to be in its vegetative phase and is characterized as a photoperiod-sensitive crop when the length of the day is shorter than 12 hours or 12 hours and 45 minutes, according to [6] Alexopoulou *et al.* (2013), respectively. The flowering of kenaf can be influenced by environmental conditions that exist during the cropping season. Taller plants usually bloom earlier and from an agronomic perspective, the negative association between plant height and flowering time is a valuable criterion since taller plants produce better fiber yields and allow for an earlier harvest. In most kenaf, fiber growth quickly declines after flowering [7] (Li and Zhao, 2019).

Sowing dates set the vegetative phase for kenaf. Early sowing prolongs the vegetative phase, allowing the crop to succeed in critical photoperiodic levels. Delayed flowering and photoperiodism have been recognized as the most important traits for growing kenaf plants in tropical countries such as Malaysia [8] (Hossain *et al.*, 2011). As reported by [9] Bukenya-Ziraba (2004), planting season influences flowering; vegetative growth is slowed by long days and warm temperatures.

Kenaf consists of various beneficial components like stalks, seeds, leaves, fibers, oils, proteins, allelopathic chemicals, and fiber strands, among other things [10] (Akinrotimi and Okocha 2018). Traditionally, its fiber is useful in the making of rope, twine, and sackcloth, currently which is used in paper products, building materials, and also in automotive industries. In addition, non-toxic to the healthy (NIH3T3) cells was found from extracts of kenaf leaves and seeds, except *n*-hexane extracts, which were stated to be toxic slightly which was *in vitro* cytotoxic activity [11] (Adnan *et al.*, 2020). Kenaf leaves are rich sources of the bioactive compound such as chlorogenic acid, caffeic aid, kaempferol, and catechin hydrate as proven [12] (Kho *et al.*, 2019). High antioxidant activities were found in the kenaf leaves when the age of the plants was at the fourth month after planting, which was suggested for tea preparation [12] (Kho *et al.*, 2019). Moreover, a high amount of protein exists in the kenaf leaf which is factitious of amino acids necessary for animal growth and milks production [13] (Noori *et al.*, 2016). Kenaf can also be used for a variety of purposes including paper, pulp, animal bedding, construction materials, and carpet backing [3] (Li *et al.*, 2016). It is presently cultivated for multiple uses such as thermal insulation boards, pulp, energy sources and building materials [3] (Li *et al.*, 2016). Kenaf is used as raw material and as an alternative to wood in pulp and paper industries to avoid deforestation [14] (Khalil *et al.*, 2010). Chemically modified kenaf fiber can also be used as a sorbent material for wastewater purification, smart textiles, electrostatic discharge protection, and composite reinforcement [15] (Mohammed *et al.* 2017). Although the plant is cultivated for its fiber, its leaves and seeds are used to treat various illnesses in India and Africa [16] (Ayadi *et al.*, 2017). Improved α-cellulose gratification, especially in kenaf bast, has been proven to strengthen kenaf-based products [17] (Edeerozey *et al.*, 2007). According to [18] Ryu *et al.* (2017), kenaf leaves are used as vegetables due to their high antioxidant and phenolic content. Hence, the leaves are a delicacy and are used as ingredients for sausages in the southern part of India and Africa. Kenaf is used for pulp and paper. Kenaf, a jute substitute, can produce large amounts of biomass, thus, it is currently used as a renewable source of raw materials for paper pulp production [19] (Al-Mamun *et al.* 2020).

Despite the numerous uses of the crop, there has not been much research effort made on the crop especially in the study area where it is predominantly planted as a dividing hedge between farms without application of fertilizers resulting in low productivity. There is little or no information on optimum agronomic practices such as planting date and N fertilization of the crop in the study area. Generally, farmers adopt mid-July (14^{th} July) for planting and no fertilization as their practice. The purpose of the present study was therefore to determine appropriate planting date and N fertilization for increased kenaf productivity. Specifically, the objective was to assess the effect of planting date and N fertilization on the growth, development and yield of kenaf.

2. Material and Methods

2.1. Experimental Site

Field experiments on Kenaf were carried out in 2020 and repeated during the 2021 cropping season at the Manga Station (11˚01'N, 0˚16'W)) of the Savannah Agricultural Research Institute of the Council for Scientific and Industrial Research (CSIR-SARI), Bawku of the Upper East Region (UER) of Ghana. The region lies in the Sudan savanna agro-ecological zone, which forms the semiarid part of Ghana. The area is part of what is sometimes referred to as the interior savanna and is characterized by level to gently undulating topography. Important crops cultivated here include millet, sorghum, maize, rice, sweet potato, groundnut, cowpea, soybean, cotton onion and tomato. The shea nut tree grows wild and it is an important cash crop. It has alternating wet and dry seasons with the wet season occurring between May and October during which about 95% of rainfall occurs. Maximum rainfall occurs in August, and severe dry conditions exist between November and April each year. Annual rainfall ranges from 800 - 1200 mm. There is wide fluctuation in relative humidity with values as low as

30% in dry season and above 75% in the wet season.

2.2. Land Preparation, Experimental Treatment and Design

In each year, the experimental area was first ploughed, harrowed and ridged using bullock-drawn implements. Lining and pegging were done to establish the plots for the treatments. The treatments consisted of 3 × 5 factorial combinations of three planting dates (1st July, 7th July and 14th July) and five levels of N (0, 20, 40, 60 and 80 kg/ha) replicated three times. Plot size of 22.5 m^2 (5 m × 4.5 m) was used for each treatment. The design of the experiment was a split-plot with the N fertilizer as the main plot and the planting date assigned to sub plot. The ridges were separated by a distance of 1 m. Planting in the experimental field was done manually based on the proposed treatments on the same day. The seeds were planted manually at a depth of 3 - 5 cm. Three seeds per hill were sown at an intra-row spacing of 50 cm inter-row spacing of 75 cm. The three seeds per hill were later thinned to one plant per stand at the first weeding two weeks after sowing. Forty-five (45) kg P_2O_5/ha as single super-phosphate was applied as basal dose at the time of plot layout. Weeding was done manually at 2 & 6 weeks after sowing (WAS) using hand hoe. The plot with zero level of nitrogen was used as a control treatment.

2.3. Soil Sampling and Analysis

The soil characteristics were determined in order to know nutrients status of the experimental site before application of the fertilizers. At the beginning of the experiment (in 2020), 15 samples were randomly collected by using an auger and composited. Then, soil samples were also taken from each treatment at harvesting (in 2021). The samples were air dried, crushed with mortar and sieved to pass through 2 mm mesh. The characteristics analyzed for included; Soil pH, Organic matter, Total Nitrogen, Exchangeable Calcium, Magnesium, Potassium, Sodium and Effective Cation Exchange Capacity, and Bray NO.2 Extractable Phosphorus and Potassium. The air-dried soil samples were ground at the laboratory and sieved through a 2 mm sieve. Soil pH was determined using a glass electrode (pH meter) in a soil ratio of 1:2.5 as reported by [20] IITA (1979) and [21] Mclean (1982). Soil organic matter was determined by the wet combustion method [22] (Walkey and Black, 1934). Percentage total nitrogen was determined by the micro Kjeldahl-technique [20] (IITA, 1979). The available phosphorus was extracted by the Bray method and determined colorimetrically [23] (Bray and Kurtz 1945). Potassium was determined by flame emission photometry [20] (IITA, 1979). The exchangeable cations calcium, magnesium, potassium and sodium were determined as recommended by [20] IITA (1979) using EDTA Titration after extraction with 0.1 N Ammonium Acetate at pH 7. Effective Cation Exchange Capacity (ECEC) was calculated as the sum of the exchangeable bases and exchangeable acidity [20] (IITA, 1979).

2.4. Management Practices

The mineral fertilizer was applied two weeks after planting and by side placement using Urea (46% N) and Triple Super Phosphate (45% P_2O_5) as mineral sources. Half of the N and the whole P fertilizer rate was applied 2 weeks after planting; and the remaining half of the N dose was applied during the first earthing up as side dressing. Lime (CaO: 0.5 t/ha), Muriate of Potash (60% K_2O) and 20 kg/ha $MgSO_4$ were broadcast and worked into the soil two weeks before planting. This was necessary for timely mineralization for adequate uptake of the nutrients by the plants. Weeds were managed by hoeing and hand picking.

2.5. Data Collection

At harvest, two 3-meter rows were harvested by hand in each plot. The number of plants (stand density) and the wet weight were determined on those two rows for each harvest. Ten random individual stems from each plot were selected and subjected to morphological, and physical analyses. Plant density, Stem height at maturity and diameter at half height were measured. The mean over these 10 plants per plot was then recorded. The 10 stems were then combined into one sample to represent the plot, stripped by hand, and separated into bast and core yields. To obtain dry bast and dry core yields, the wet bast and core yields were weighed, oven-dried at 60˚C until constant weights were attained.

2.6. Statistical Analysis

Data collected were analyzed statistically using GenStat 12th Edition. Mean separation for significant effects was performed using least significant difference at 5% probability level.

3. Results and Discussion

Results of analysis of soil in the study site showed that the soil was sandy loam and low to very low available P and exchangeable cations (Ca, Mg) (Table 1). The pH was acidic for the soil at the experimental site (0 - 20 cm depth). Organic matter content was low while the total N level was high. Exchangeable Ca and K levels as well as available P and K values were also low at the site.

3.1. Effect of Planting Date and Nitrogen Fertilizer Application on the Growth and Yield of Kenaf

In both years, the effects of planting date (D) and nitrogen application (N) were significant ($P < 0.01$) while D × N interaction effects were not significant ($P > 0.05$) for plant density, stem height, stem diameter, dry bast yield and dry core yield.

3.2. Plant Density

Planting date and Nitrogen application significantly ($P < 0.05$) affected plant density in both cropping seasons (Table 2). In 2020, plant density ranged from

Table 1. Selected initial soil chemical properties of the study site in Manga in 2019 cropping season.

Parameter	Measured Value	Required value@ (SRI 2007 guide)
pH (H_2O)	5.1	Acidic: 5.1 - 5.5
Organic Matter (%)	1.0	Low: <1.5
TN ($g \cdot kg^{-1}$)	0.4	High: >0.2
Ex. Ca {Cmol (+) kg^{-1}}	2.02	Low: <5.0
Ex. Mg {Cmol (+) kg^{-1}}	0.32	Not available
Ex. K {Cmol (+) kg^{-1}}	0.16	Low: <0.2
Ex Na {Cmol (+) kg^{-1}}	0.09	Not available
CEC	6.8	Low: <10
Av. P ($mg \cdot kg^{-1}$)	3.8	Low: <10
Av. K ($mg \cdot kg^{-1}$)		Low: <0.2
Depth (cm)	0 - 20	-
Texture	Sandy loam	-

@SRI: Soil Research Institute of Ghana.

Table 2. Effect of planting date, nitrogen application and their interaction on plant density in the 2020 and 2021 cropping seasons.

Treatment	**2020**	**2021**
Planting Date	Plant density	Plant density
1st July	30^a	28^a
7th July	25^b	26^b
14th July	15^c	16^c
CV (5%)		
Nitrogen (Kg/ha)		
0	12^d	10^d
20	16^c	17^c
40	22^b	20^b
60	28^a	27^a
80	27^a	28^a
CV (5%)		
Interaction		
M × N	Ns	Ns

** = significant at 1%, Ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

15 (at 14th July) to 30 (at 1st July) and also ranged from 12 (at 0 Nkg/ha) to 26 (at 60 Nkg/ha) beyond which there was no further increase. In 2021, it ranged from 16 (at 14th July) to 28 (at 1st July). Thus, plant density was greater when kenaf was planted in early July. As plant density represents the number of plants that were recorded at harvest, the plant density can be linked to the plants that have fully emerged and survived. Therefore, according to these results, most of the seeds germinated and survived better when kenaf was planted in early July. The dependence of stand density on planting date in this study did not confirm what was observed previously by [24] (Webber and Bledsoe, 2002) who reported that kenaf plants fully emerged and survived at the middle of the season rather than the early stages of the season.

The N application effects showed that the plant density generally increased with increased application rates. Increased application rates of Nitrogen from zero to 60 kg/ha increased plant density by 57% in (2020) and 63% (in 2021) over the control. The reason for this trend could be the availability of nutrients to the crop resulting in increased photosynthetic and metabolic activities. In addition, the trend could be due to stimulation of root growth and development resulting from adequate N supply as well as the uptake of other nutrients [25] (Ansa (2015). This could be due to the function of N in promoting plant growth and survival which appears to be more enhanced with the N fertilizer application. This observation is consistent with reports by [26] (Sharma *et al.*, 2014) who reported that plant growth increased with increasing fertilizer levels of nitrogen. In their study, [27] Banerjee *et al.* (2016) found that adequate nitrogen had significant effect on plant growth and yield.

3.3. Stem Height

Planting date and Nitrogen application significantly ($P < 0.05$) affected stem height in both cropping seasons (**Table 3**). In 2020, stem height ranged from 2.23 m (at 14th July) to 3.23 m (at 1st July) and also ranged from 2.22 m (at 20 Nkg/ha) to 3.67 m (at 60 Nkg/ha) beyond which there was no further increase. In 2021 it ranged from 2.20 m (at 14th July) to 3.15 m (at 1st July) and also ranged from 2.32 m (at 20 Nkg/ha) to 3.57 m (at 60 Nkg/ha) beyond which there was decline in stem height. Thus, stem height which is an indicator for fibre yield declined as planting date advanced from 1st to 14th July. The results show that in both cropping seasons, kenaf planted in early July were taller than those sown later in the month. Thus, planting kenaf in early July or N fertilization at the rate of 60 kg/ha increased stem height. This could be due to the fact that the growing season became shorter as the planting date advanced which would give less time to the plants to reach high heights. This result is at variance with the views of [28] Berger (1969) who reported that stalk height was not significantly affected by planting date.

As with plant density, the N application effects showed that the plant height generally increased with increased application rates in both seasons. Increased application rates of Nitrogen from zero to 60 kg/ha increased plant height by

Table 3. Effect of planting date, nitrogen application and their interaction on stem height in the 2020 and 2021 cropping seasons.

Treatment	**2020**	**2021**
Planting Date	Stem height (m)	Stem height (m)
1st July	3.23a	3.15a
7th July	2.40b	2.23b
14th July	2.23c	2.20b
CV (5%)		
Nitrogen (Kg/ha)		
0	3.12b	3.22b
20	2.22d	2.32d
40	2.34c	2.44c
60	3.67a	3.57a
80	3.15b	3.25b
CV (5%)		
Interaction		
M × N	Ns	Ns

** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

40% in (2020) and 35% (in 2021) over the control. The reason for this trend could be the availability of nutrients to the crop resulting in increased photosynthetic and metabolic activities. In addition, the trend could be due to stimulation of root growth and development resulting from adequate N supply as well as the uptake of other nutrients [25] (Ansa (2015). This could be due to the function of N in promoting vegetative growth which appears to be more enhanced with the N fertilizer application. This observation is in line with that of [29] Ullah *et al.* (2017) who reported that plant height increased with increasing levels of nitrogen.

3.4. Stem Diameter

Planting date and Nitrogen application significantly ($P < 0.05$) affected stem diameter in both cropping seasons (**Table 4**). In 2020, stem diameter ranged from 21.22 mm (at 14th July) to 25.20 mm (at 1st July) and also ranged from 21.20 mm (at 20 Nkg/ha) to 26.10 mm (at 60 Nkg/ha) beyond which it declined. In 2021 it ranged from 21.2 mm (at 7th July) to 24.20 mm (at 1st July) and also ranged from 21.30 mm (at 20 Nkg/ha) to 25.20 mm (at 60 Nkg/ha) beyond which it declined. Thus, planting kenaf in early July or N fertilization at 60 kg/ha increased stem diameter. These results confirm the positive effect of management

Table 4. Effect of planting date, nitrogen application and their interaction on stem diameter at half height in the 2020 and 2021 cropping seasons.

Treatment	2020	2021
Planting Date	Stem diameter at half height (mm)	Stem diameter at half height (mm)
1st July	25.20a	24.20a
7th July	22.27b	21.20b
14th July	21.22c	21.30b
CV (5%)		
Nitrogen (Kg/ha)		
0	22.20c	22.27c
20	21.20d	21.30d
40	22.21c	22.31c
60	26.10a	25.20a
80	23.20b	23.20b
CV (5%)		
Interaction		
M × N	Ns	Ns

** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

practices such as timely planting and adequate N application on yield of kenaf productivity [8] (Hossain *et al.*, 2011). In addition, all fiber morphological properties were also significantly improved when fertilizers were added, which was strongly supported by previous study by [30] (Salih *et al.*, 2014).

From the above observations, timely planting of kenaf (in early July) or N fertilization at the rate of 60 kg/ha increased plant density, stem height and stem diameter. These traits increased with increased N rates in both cropping seasons, indicating that either the crop was efficient in its capture and use of fertilizer N or the soils were low in plant available nutrients or both. In the environments where these studies were carried out, the soils were low in plant available nutrients with average pH of 5.50. [31] Adamtey *et al.* (2016) reported low maize yields for soils that received no fertilizer and attributed it to reduced plant growth as a consequence of low levels of nutrients, particularly N supply and uptake. This could be applicable to kenaf as well.

The results of growth parameters were not consistent with reports by other researchers, who reported significant ($P \leq 0.01$) interaction between the planting date and N rate in kenaf plant diameter and plant height (Al-Mamun *et al.*, 2022).

3.5. Dry Bast Yield

Planting date and Nitrogen application significantly ($P < 0.05$) affected dry bast yield in both cropping seasons (Table 5). In 2020, dry bast yield ranged from 12.80 t/ha (at 14th July) to 15.10 t/ha (at 1st July) and also ranged from 11.10 t/ha (at 0 Nkg/ha) to 16.10 t/ha (at 60 Nkg/ha) beyond which it declined. In 2021 it ranged from 13.10 t/ha (at 14th July) to 15.80 t/ha (at 1st July) and also ranged from 12.10 t/ha (at 20 Nkg/ha) to 15.90 t/ha (at 60 Nkg/ha) beyond which it declined. Thus, planting kenaf in early July or N fertilization at the rate of 60 kg/ha increased dry bast yield. The increased dry bast from early planting could be as a result of the fact that, as the season advanced, kenaf had shorter period to grow and develop thick stems than when kenaf was planted earlier. On the other hand, the increased dry bast from 60 Nkg/ha application rate suggests that this rate was adequate for improved kenaf bast and fibre yield. [27] Banerjee *et al.* (2016) reported that optimal level of nitrogen had significant effect on plant growth, yield, and fiber quality. [29] Abd Eldaiem & El-Borhamy (2015) reported that yield and quality properties were improved by applying the adequate level of N, which was one of the favorable factors for increasing kenaf productivity.

Table 5. Effect of planting date, nitrogen application and their interaction on dry bast yield at half height in the 2020 and 2021 cropping seasons.

Treatment	2020	2021
Planting Date	Dry bast yield (t/ha)	Dry bast yield (t/ha)
1st July	15.10ᵃ	15.80ᵃ
7th July	13.20ᵇ	13.32ᵇ
14th July	12.80ᶜ	13.10ᵇ
CV (5%)		
Nitrogen (Kg/ha)		
0	11.10ᵉ	12.10ᵈ
20	12.80ᵈ	13.10ᶜ
40	13.30ᶜ	13.20ᶜ
60	16.10ᵃ	15.90ᵃ
80	14.80ᵇ	13.80ᵇ
CV (5%)		
Interaction		
M × N	Ns	Ns

** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

3.6. Dry Core Yield

Similar to the dry bast yield, planting date and Nitrogen application significantly ($P < 0.05$) affected dry core yield in both cropping seasons (**Table 6**). In 2020, dry core yield ranged from 34.40 t/ha (at 14th July) to 40.10 t/ha (at 1st July) and also ranged from 33.20 t/ha (at 0 Nkg/ha) to 39.90 t/ha (at 60 Nkg/ha) beyond which it declined. Similarly, in 2021 it ranged from 35.20 t/ha (at 14th July) to 39.70 t/ha (at 1st July) and also ranged from 32.20 t/ha (at 0 Nkg/ha) to 41.10 t/ha (at 60 Nkg/ha) beyond which it declined. Thus, timely planting of kenaf (1st July) or N fertilization at the rate of 60 kg/ha increased dry core yield. The increased dry core from early planting could be due to the fact that, kenaf had shorter period to grow and develop thick xylem than when kenaf was planted earlier

Planting could not be done earlier than 1st July as a result of delay in the onset of rain and the results indicated that kenaf sown in mid-July has lower dry bast and core yields. This may be connected to unfavourable climatic condition [32] (Fernado *et al.*, 2004) which could suppress kenaf development and yield. This study revealed that early July is most appropriate for kenaf planting for dry bast and core yields in the study area. This agrees with the report of [33] Alexopoulou *et al.* (2015), who reported that early sowing favoured growth and fibre yield

Table 6. Effect of planting date, nitrogen application and their interaction on dry core yield at half height in the 2020 and 2021 cropping seasons.

Treatment	**2020**	**2021**
Planting Date	Dry core yield (t/ha)	Dry core yield (t/ha)
1st July	40.10[a]	39.70[a]
7th July	36.40[b]	37.00[b]
14th July	34.40[c]	35.20[c]
CV (5%)		
Nitrogen (Kg/ha)		
0	33.20[c]	32.20[e]
20	34.20[b]	35.25[c]
40	33.40[c]	34.45[d]
60	39.90[a]	41.10[a]
80	37.40[b]	39.40[b]
CV (5%)		
Interaction		
M × N	Ns	Ns

** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

of kenaf than late planting except with irrigation. Thus, sowing date has a direct effect on the growth and yields of kenaf. The observation that dry core yield started declining after 60 Nkg/ha suggests that the 60 Nkg/ha was the adequate application rate for kenaf dry core yield. This is in line with reports by [30] Salih *et al.*, 2014 that all fiber morphological properties were significantly improved when adequate rates of fertilizers were added.

4. Conclusion

There is positive effect of planting date and N fertilizer on the growth and yield of kenaf which could be due respectively to their contribution to available moisture and fertility status of the soils. Planting date of 1st July and Nitrogen rate of 60 kg/ha recorded the highest kenaf growth and yield in both cropping seasons. Kenaf plants that received no N application (control) were significantly out-yielded by the other treatments, suggesting the need for N application in kenaf production and productivity. Thus, early July (1st July) was timely for planting kenaf and nitrogen fertilization at the rate of 60 kg N/ha was optimal for kenaf productivity. Overall, this study has shown that kenaf can grow very well in the study area and should receive more attention from smallholder farmers to improve the economy.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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