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Growth Performance of Kenaf (*Hibiscus cannabinus* var. Tainung) in relation to sowing depths and soil types

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Abstract
Kenaf is a non-woody plant that has become one of the important alternative sources of soft fibre material used for packaging materials, paper making and textile. Higher fibre production depends largely on suitable agronomical conditions or practices the plant is subjected to during cultivation. Hence, the need to investigate how different seeding depths and soil types influence the growth performance of the plant. Three soil types (loam, sand and clay) and five sowing depths (0, 1, 2, 3, 4 and 5 cm) were studied. The parameters assessed were germination and growth attributes. The results showed that percentage germination, speed of germination and ability of seeds to germinate were significantly increased when the seeding depth was at 2 cm over other seeding depths. Seeding depth at soil surface and those of 1 cm limited all the germination attributes. All the germination attributes were significantly increased in kenaf seeds sown in loamy soil when compared to the other soil types. The results of growth attributes such as plant height, number of leaves, stem girth, leaf area and above-ground dry weight and yield attributes such as number of capsules per plant, number of seed per capsule and number of seeds per plant followed similar trend as recorded for those of germination parameters. Kenaf seeds planted on sandy soil showed reduction in time of seedling emergence, better growth and yield compared to clay soil. The study concluded that 2 cm seeding depth and well-drained soil such as sandy-loam soil are suitable agronomical practice and condition respectively needed for higher productivity that will hitherto translate to greater fibre production. Therefore, the reliance on fibre producing trees could be reduced if these optimum seeding depth and suitable soil type are used by the farmer in the cultivation of this non-woody plant which has the bulk of its stem filled with soft fibre tissue.

Keywords: Kenaf, soil type, soil depth, fibre and yield.

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Introduction

Hibiscus cannabinus L. popularly known as Kenaf belongs to family Malvaceae. It is a fibre plant native to east central Africa where it has been grown for several years for food and fibre (Le-mahieu *et al*., 2003).

It is a fast growing crop which has high potential to be used as an industrial crop globally since it contains higher fibre material or lignocelluloses material (Manzanares *et al*., 1996). The plant is composed of multiple useful components such as stalk, leaves and seeds. Each of the plant components has various usable portion which include fibres, fibre straw, protein, oil and allelopathy. The combined attributes of these components provide ample potential product diversity (Webber and Bledsoe, 2002).

Kenaf yield soft fibre from the stem which is used for packaging. In addition, the plant is being explored as a useful raw material for paper making and its new application includes board making, absorbent, textile and livestock feed (Atchison, 1996). The commercial success of Kenaf has important economic and environmental benefits in the areas of soil remediation, removal of oil spills on water, reduced soil erosion due to wind and water (Webber and Bledsoe, 2002). The seeds yield edible oil that is used for first class cooking, margarine products, making of soap, paint vanish and lubricant (Le-mahieu *et al*., 2003).

Literature abounds have shown that the yield of the various part of the plants can be influenced by many factors such as planting date, photosensitivity, plant population, length of growing season, carbon level, soil fertility, herbicide application, rainfall, temperature and soil type (Webber and Bledsoe, 2002; Agbaje *et al*.. 2008; Hussein *et al*., 2011). Given the demand for fibre materials worldwide, shortage of tree in many areas and environmental awareness with respect to deforestation, non-wood plants have become one of the important alternative sources of fibre materials (Atchison, 1996).

Arising from the foregoing discourse, this study focused on revealing those agronomic practice or condition that may influence Kenaf growth and development.

Materials and Methods

Collection of Samples

Seeds of *Hibiscus cannabinus* var. Tainung were collected from the Institute of Agricultural Research and Training (IART), Ibadan, Oyo State. The seeds were stored in a paper envelope for ten days until they were used for the study. The soil types (loam, sand and clay) were collected from different sites at the University of Ilorin Campus while soil used for the sowing depth was collected from the farm site within the Botanical Garden of the University of Ilorin.

Study site

The potted experiments were carried out in the screen house at the Botanical Garden of University of Ilorin, from November, 2017 to March, 2018.

Experimental design and treatment details

Six levels of sowing depth (0, 1, 2, 3, 4 and 5 cm) constituted the treatments. The depth was achieved using a graduated stick. A total of 30 pots were used and ten seeds were planted in each pot. In the soil type experiment, 15 pots were used and separated into three groups tagged as A, B and C. Group A, B and C were filled with sandy, clayey and loamy soils respectively. Ten seeds were equally planted in each of the pots. In both experiments, the pots were arranged following Complete Randomized Design (CRD) with five replications. Each pot measured 17 cm in height and 15 cm in diameter. The pots were perforated at the base to facilitate drainage.

Germination studies

Daily germination counts were made for 10 days and the index of germination was protrusion of the cotyledon from the soil surface. Using this germination count, parameters such as percentage germination, speed of germination and ability of seed to germinate were calculated. After 10 days, the seedlings were thinned to one per hole in both sowing depth and soil type pots to monitor the growth and yield of Kenaf.

Crop management

The planted seeds were managed by watering at two-day interval to field capacity with aid of watering can containing 2 liters of water to maintain normal crop growth. Weeds were removed manually on weekly basis to nullify their competitive effect on the crop productivity.

Data collection

Growth parameters such as plant height, number of leaves, stem girth were taken at the interval of 4 months. Leaf area was estimated by measuring the length and breadth and multiplying the value by total number of leaves (Length x Breadth x Number of leaves). At harvest which corresponded to 16 weeks after planting, plants were carefully removed from the each of the pots and separated into leaves and stems. These plant parts were then oven-dried at 80°C to a constant weight so as to determine the above-ground tissues dry weight at final harvest. Yield parameters such as number of capsule per plant, number of seed per capsule, number of seeds per plant were determined from an average of three plants in each of the levels of sowing depths and soil types.

Data Analysis

Data were analyzed using the One Way Analysis of Variance (ANOVA) to test for variation. Means were separated by Least Significant Difference (LSD) at p ≤ 0.05.

Results

Germination response

Germination attributes of *Hibiscus cannabinus* seeds were significantly influenced (p≤ 0.05) by sowing depth and soil type (Table 1). Depth of sowing of 2 cm showed significantly higher percentage germination (100%) and speed (27.2%) and ability of seeds to germinate (28.6) when compared to other depths. Seeds sown at the surface gave the lowest percentage germination (20%), speed (7.7%) and ability of seeds to germinate (16.7). Depth of sowing at 3, 4 and 5 cm had germination parameters that were respectively higher compared to those of 1 cm sowing depth (Table 1). Loamy soil had significantly higher percentage of germination, speed and ability of seeds to germinate with respective values of 100%, 24% and 28.57 compared to other soil types. However, significant differences in all germination parameters were not recorded between seeds sown in sand and clay soils (Table 1).

Table 1: **Germination ability of *Hibiscus cannabinnus* as influenced by sowing depth and soil type.**

		Germination (%)	Speed of germination (%)	Ability of seed to germinate
Sowing depth (cm)	0	20±0.00^{f}	7.7^{d} ± 0.33^{d}	16.7^{d}±1.66^{d}
	1	30±0.00^{e}	24.3±0.33^{b}	23.2±0.33^{c}
	2	100±0.00^{a}	27.2±0.67^{a}	28.6±0.23^{a}
	3	80±0.00^{b}	22.2±0.67^{c}	25.0±0.00^{b}
	4	60±0.00^{c}	22.2±0.67^{c}	22.2±0.67^{c}
	5	40±0.00^{d}	20±0.00^{c}	22.2±0.67^{c}
	P-value	< 0.001	0.02	0.03
Soil type	Clay	20±0.00^{b}	22.0±0.67^{b}	25·0±0.00^{b}
	Loam	100±0.00^{a}	24.4±0.33^{a}	28.6±1.66^{a}
	Sand	20±0.00^{b}	20.0±0.00^{b}	25 .0 ±1.67^{b}
	p-value	0.03	0.03	0.04

Within column mean values followed by the same superscript (s) are not significant at p ≤ 0.05.

Growth response

The results of the plant height of Kenaf as affected by sowing depth and soil type are shown in Fig. 1. The plant height increased as the crop aged. Depth of sowing at 2 cm had the highest plant height at all sampling stages except at 4 weeks after planting (WAP). Kenaf seeds sown at the soil surface (control) showed significant reduction of plant height when compared to other sowing depths (Fig.1). At all sampling periods, significantly highest plant height was recorded in Kenaf plant grown in loamy soil and followed in decreasing order of magnitude in those Kenaf grown in sandy and clayey soils. At 8 WAP, significant difference in plant height was not recorded between Kenaf plant grown in clayey and sandy soils (Fig.1).

Number of leaves followed the same pattern of results as recorded for plant height for sowing depths (Fig. 2). Number of leaves attained maximum peak at 8 WAP at all levels of sowing depths and declined till final sampling date (16 WAP). The effect of soil types was also pronounced on number of leaves. Loamy soil had significantly higher number of leaves compared to other soil types. Lowest number of leaves was recorded in the clay soil (Fig.2).

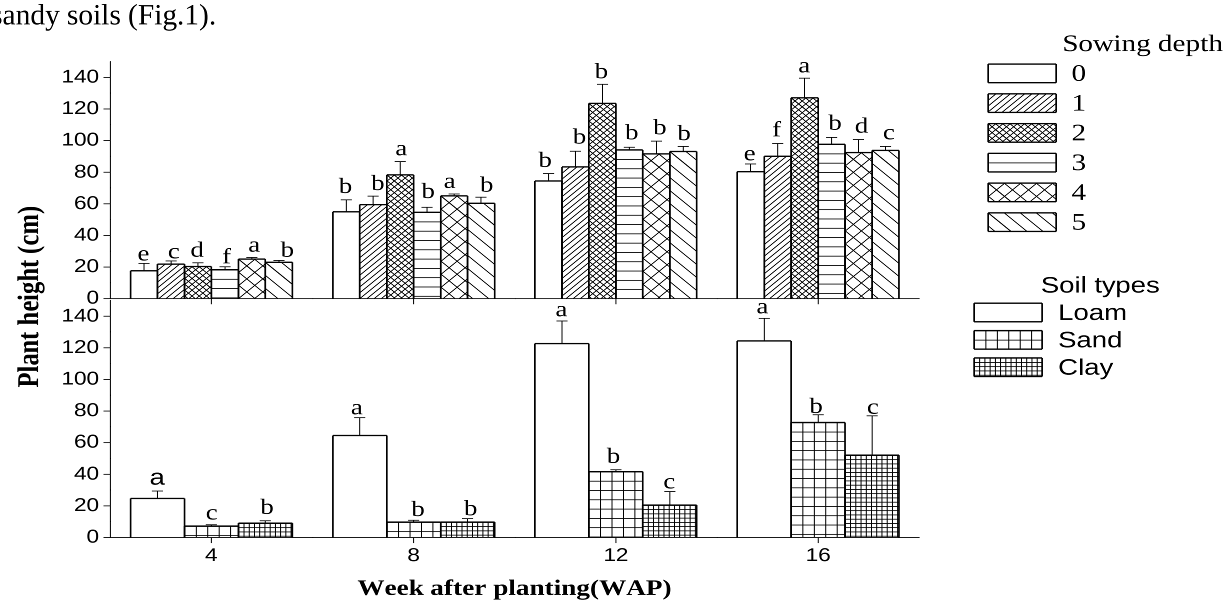

Fig.1: Plant height of Kenaf as influenced by sowing depth and soil type at different weeks after planting.

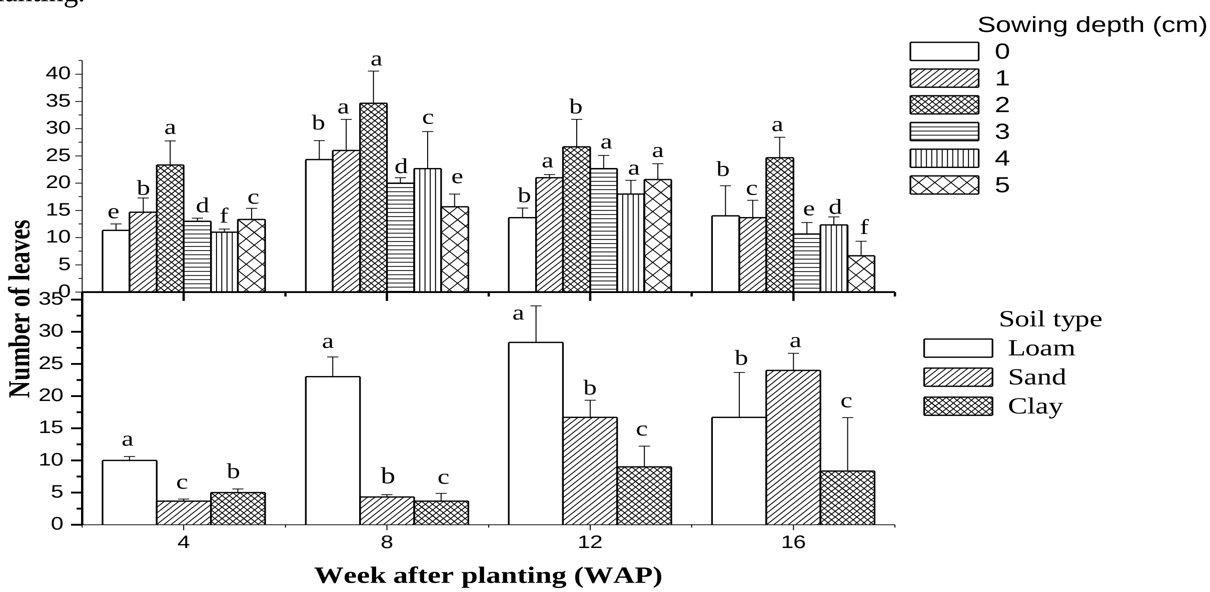

Fig.2: Number of leaves of Kenaf as influenced by sowing depth and soil types at different weeks after planting.

Stem girth increased with the age of the crop and was significantly affected by different sowing depths and soil types (Fig. 3). Sowing depth at 2 cm still maintained the significantly highest stem girth. Lowest stem girth was recorded in Kenaf plant sown on soil surface in all the crop growth stages except at 16 WAP where highest sowing depth (5 cm) showed significantly lower stem girth over all other sowing depths (Fig. 3).

Leaf area development was significantly influenced by t sowing depths and soil types (Fig. 4). Generally, leaf area increased with increase in age of the crop till 12 WAP before showing declination (Fig. 4). Significantly higher leaf area was recorded for Kenaf sown at 2 cm when compared to other sowing depths. Sowing depths at 0-1 cm showed lower leaf area development at 4 and 8 WAP compared to those between 3cm and 5cm depths (Fig.4). Total leaf area per plant was significantly higher in Kenaf grown in loamy soil than in sandy soil and lowest in clayey soil at all crop growth stages (Fig 4). The increment in leaf area with age of the crop followed similar pattern as recorded for sowing depths (Fig. 4).

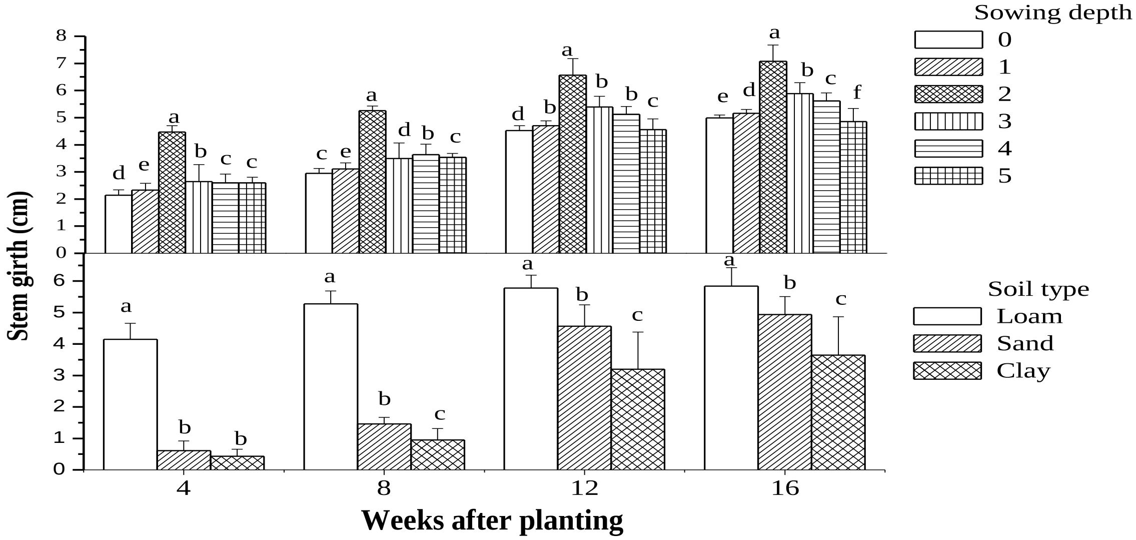

Fig.3: Stem girth of Kenaf as influenced by sowing depth and soil type at different weeks after planting.

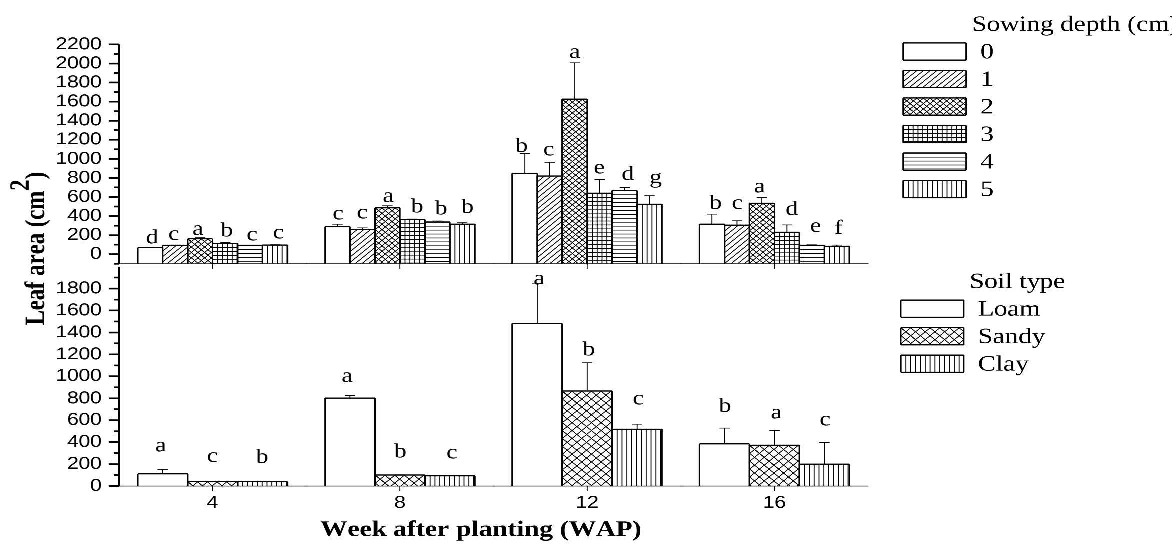

Fig.4: Leaf area of Kenaf as influenced by sowing depth and soil type at different weeks after planting.

The above- ground dry weight as affected by soil depth and soil type is shown in Table 2. The highest above-ground dry weight was recorded at soil depth of 2 cm, this was followed in decreasing order of magnitude by those of 3, 0, 4, 5 and 1cm soil depths respectively. The effect of soil type was significant on above-ground dry weight of Kenaf. Above-ground dry weight was highest in those Kenaf grown on loamy soil followed by sand, while the lowest above-ground dry weight was recorded in Kenaf grown in clayey soil.

Reproductive Attributes

The results of number of flower as affected by soil depth and soil type are shown in Table 2. There were significant differences between the number of flowers in soil depths of 0, 1 and 3 cm. Number of flowers in soil depths of 0, 2 and 4 cm were statistically the same. Also, there were no significant difference between the number of flowers between 3 cm and 5 cm sowing depths (Table 2). Number of capsule per plant was significantly highest in those Kenaf grown at depth of 2 cm and followed in decreasing order of magnitude by those in 3, 5, 4 and 1 cm respectively (Table 2). Lowest value of number of capsule per plant was recorded in those Kenaf grown on the soil surface (Table 2). Number of seed per capsule was significantly higher in those Kenaf grown at 2 cm depth when compared to other sowing depths. Significantly lowest number of seed per capsule was recorded in Kenaf grown on soil surface (Table 2). Sowing depths of 1 cm and 3 cm did not show statistical difference in their number of capsule per plant. However, they were statistically higher when compared to those of 4 cm and 5 cm sowing depths. The results of number of seed per plant followed similar trend as recorded for number of capsule per plant except that sowing depths at 3, 4 and 5 cm had higher number seed per plant than those of 1 cm sowing depth (Table 2). Lowest number of seed per plant was recorded in Kenaf grown on soil surface over all other soil depths (Table 2).

Kenaf sown in clayey soil recorded the highest number of flower, followed by those grown in loamy and sandy soil types (Table 2). Other reproductive attributes were significantly higher in Kenaf grown in loamy soil except for number of seed per capsule where no statistical significant difference was recorded between loamy soil and sand soil. Lowest values for the number of capsule per plant, number of seed per capsule and number of seed per plant were recorded in clayey soil (Table 2).

Discussion

This study has clearly shown that the germination potentials of the seeds of *Hibiscus cannabinus* (Kenaf) can be influenced by depth of sowing and soil type. Planting of the Kenaf seeds at 2 cm depth has been found to promote percentage germination, speed of germination and ability of the seeds to germinate when compared to other depths. Seeds planted at soil surface and 1 cm limited the aforementioned germination parameters when compared with those of 3, 4 and 5 cm. The low germination parameters values at lower soil depths could be due to the fact that the seeds receiving these treatments may not enjoy adequate soil cover that will ensure enough moisture for accelerated germination condition when compared to those of 2 cm and other depths. Beyond 2 cm depth the germination parameters decreased with increase in sowing depth. The results partly agreed to the findings of George *et al* (2017) where the authors recorded 2 - 4 cm depth as the optimum sowing depth for enhancing the performance of *Crotolaria brevidens* in Kenya. Deep sowing had also been reported to increase the time between seed germination and seedling emergence as reported by Etejere and Olayinka (2015) in their studies of germination and seedling growth of *Tithonia diversifolia*. According to Loughton *et al*. (1996) *Asparagus* showed delayed emergence, thinner stands and lower crop yield as depth increases. Finally, Nabi *et al*. (2001) had also recorded reduction in germination and emergence in cotton seeds in Pakistan with increase in soil depth when the optimum depth is exceeded. The enhanced percentage germination and other germination parameters in loamy soil w

Table 2: **Above-ground dry weight and reproductive attributes of *Hibiscus cannabinnus* as influenced by sowing depth and soil type.**

		Above-ground dry weight	Number of flower	Number of capsule per plant	Number of seed per capsule	Number of seed per plant
Sowing Depth (cm)	0	5.74 ± 1.30^{b}	1.67 ± 0.67^{a}	2.11 ± 0.79^{d}	5.25 ± 0.29^{e}	6.50 ± 0.15^{f}
	1	3.98 ± 1.13^{e}	0.67 ± 0.33^{c}	$4.22\pm1.29^{\mathbf{bc}}$	10.68 ± 0.30^{b}	33.00 ± 1.16^{e}
	2	13.36 ± 3.31^{a}	1.67 ± 0.33^{a}	9.66 ± 2.13^{a}	11.24 ± 0.27^{a}	117.66 ± 0.18^{a}
	3	6.66 ± 1.02^{b}	1.33 ± 0.33^{b}	5.66 ± 0.80^{b}	10.83 ± 0.03^{b}	47.66 ± 1.53^{b}
	4	$5.66\pm1.26^{bc-}$	1.67 ± 0.67^{a}	4.89 ± 0.59^{bc}	10.50 ± 0.29^{bc}	43.67 ± 0.32^{c}
	5	4.69 ± 0.54^{d}	1.33 ± 0.33^{b}	5.00 ± 0.41^{b}	8.96 ± 0.03^{d}	38.33 ± 0.97^{d}
	SEM	7.26	2.66	6.01	0.51	8.23
	p-value	0.03	0.04	0.03	<0.001	<0.001
Soil type	Clay	2.79 ± 2.32^{b}	2.67 ± 0.33^{a}	0.67 ± 0.67^{c}	7.00 ± 0.58^{b}	7.00 ± 0.58^{c}
	Loam	7.40 ± 1.41^{a}	1.00 ± 0.66^{b}	4.67 ± 0.88^{a}	10.22 ± 0.46^{a}	46.00 ± 0.58^{a}
	Sand	3.85 ± 0.95^{b}	0.33 ± 0.33^{b}	2.67 ± 0.33^{b}	9.50 ± 0.29^{a}	$24.66\pm0.21^{\mathbf{b}}$
	SEM	4.68	1.32	1.88	0.54	5.64
	p-value	0.01	0.01	<0.001	0.04	<0.001

Within column mean values followed by the same superscripts are statistically similar at p<0.05

compared to other soil type could be due to conducive environment provided by this soil type in terms of adequate moisture, moderate soil texture and rich mineral elements which loamy soil is known to have. The results agreed with the findings of Etejere and Olayinka (2015) in their study of soil type on performance of *Tithonia diversifolia.* George *et al*. (2017) had earlier reported that level of soil moisture had profound effect on process of germination He further reiterated that for ideal seed germination, ideal soil moisture should be closed to field capacity which is influenced by soil texture where fine textured soils, such as clay and loam soils, have larger moisture holding capacity than coarse-textured soils such as sand.

Growth attributes such as plant height, number of leaves, stem girth and leaf area were optimum when the Kenaf seeds were planted at 2 cm depth and grown in loamy soil. The enhanced growth attributes at 2 cm depth of sowing and loamy soil could be linked to early emergence and faster seedling growth when compared to other treatments. In the same vein, suitability of the soil depth which recorded the highest magnitude of growth responses could be as a result of abundance of water at that particular depth which was optimal for Kenaf growth. Availability of nutrient may also account for increased growth of Kenaf in loamy soil. The same reasons could be adduced for the robust stem enlargement for higher fibre content, increase in number of leaves and leaf area developments. Depth of sowing is an important factor in maximizing the potential of plant height (Hussen *et al*. 2013). According to Lee (2014), Kenaf is well adapted to wide range of soil types but performs better in well-drained fertile soils.

The above-ground dry weight was at its maximum when the seeds were planted at 2 cm depth and grown in loamy soil. The enhanced dry matter in these treatments could be attributed to increase in all the aforementioned growth attributes. Choice of seeding depth should reflect strategies for optimizing dry matter partitioning to storage organs (Proctor and Sullivan, 2013).

The enhanced reproductive attributes such as number of capsule per plant, number of seed per capsule and number of seed per plant at 2 cm depth of sowing and loamy soil is not unconnected to the reasons that had been adduced for increase in germination and growth attributes. Optimum seed depth had been closely linked to enhance crop productivity (Proctor and Sullivan, 2013). Similarly, conducive soil condition enhances root accessibility to water and nutrients for crop production and development. This enables the plant to absorb more moisture and nutrient for enhanced leaf area development and seed production. Well-developed root system with ability to explore greater soil volume has been recognized has an important adaptation of plants to ensure sufficient water and nutrient uptake (Horst *et al*., 2001).

Conclusion

This study has clearly shown that 2 cm sowing depth and well-drained fertile soil such as sandy-loam soil are considered appropriate and suitable for early emergence, growth and yield of Kenaf plant. The reliance on fibre producing trees will be reduced if these optimum seeding depth and soil type are adopted in its cultivation.

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