THE EFFECT OF TIME AND LEVEL OF DEFOLIATION ON THE GROWTH AND YIELD OF KENAF (Hibiscus cannabinus L.)

BY

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree

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The above declaration is confirmed.

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Date 20/12/2001

CERTIFICATION

This thesis entitled **"THE EFFECT OF TIME AND LEVEL OF DEFOLIATION ON THE GROWTH AND YIELD OF KENAF (<u>Hibiscus</u> <u>cannabinus</u> L.)"** by **WISDOM SOHUNAGO JAPHET** meets the regulations governing the award of degree of Masters of Sciences of Ahmadu Bello University, Zaria, and is approved for its contribution to Scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to God almighty for his Love and mercy throughout the period of this study.

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ABSTRACT

Field experiments were conducted at the research farm of the institute of agricultural research, Samaru, Nigeria during the 1999 and 2000 wet seasons. The aim was to study the effect of time and level of defoliation on the growth and yield of kenaf (Hibiscus cannabinus L.).

The treatments were time of defoliation (4,6,8, and 10 weeks after sowing (WAS)) and level of defoliation (Control, leaves of the lower half removed, leaves of the upper half removed and complete defoliation). The experiment was laid in a split-plot design with time of defoliation allotted to the main plot while level of defoliation was allotted to the sub-plot.

The result indicated that defoliation at 4 weeks afler sowing reduced plant height, stem girth, ribbon and stem dry weight while defoliation at 8 and 10 weeks afler sowing reduced the number of pods per plant, pod diameter, number of seed per pod, and 100-seed weight. Defoliation at 6 weeks after sowing did not adversely affect kenaf in this study but led to an increase in plant height and number of seeds per pod.

The result also indicated that yield of kenaf was affected more by removing the upper leaves than by removing the lower leaves showing that the upper leaves are more important to growth and yield of kenaf than the lower leaves.

Time X level of defoliation interaction was significant for all the parameters studied except number of days to 50% flowering. In both planting years and the combine analysis, removing the upper or all the leaves of kenaf at 4 weeks after sowing adversely affected the growth and development of kenaf. Similarly removing the upper or all the leaves of kenaf at 8 and 10 weeks after sowing adversely affected the pod and seed characteristics. Removing the lower leaves at 6 weeks after sowing led to substantial increase in plant height, pod diameter, and number of seeds per pod.

There was significant positive correlation between ribbon yield, plant height and stem girth in this study. Seed yield also was positively correlated with number of pod per plant and number of seed per pod.

Based on the above findings, it was concluded that defoliation at 4 weeks after sowing will affect fibre yield of kenaf while defoliation at 8 and 10 weeks after sowing will affect seed yield of kenaf. Defoliation at 6 weeks after sowing might be beneficial to kenaf. Removing all the leaves or the upper leaf of kenaf will affect fibre and seed yield of kenaf.

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CHAPTER 1 INTRODUCTION

Kenaf (Hibiscus cannabinus L.) is an important annual fibre crop in the tropical and sub-tropical regions of the world. It yields a soft fibre from the stem that is very similar to jute. Thus, it is an important source of a retted fibre, which is a raw material of the jute manufacturing industry. Kenaf is an agro-industrial crop that is assuming increasing economic importance in Nigeria in recent times, the status of kenaf has greatly increased and there is therefore urgent need to increase its local production in the country in order to locally source the retted fibre requirements of jute manufacturing factories, which hitherto had relied heavily on imported retted fibre.

The crop is particularly important because of the multiplicity of the products that can be obtained from it. Kenaf has long been recognised as a possible source of cellulosic fibre for pulp production (Ahlgren et al; 1950; Lagoke et al; 1981). The economical potential of this crop is related to the gradual diminishing supply of hardwoods and softwoods in the world, and the increasing per capita consumption of paper and paperboard materials. In 1987, newspaper publishers in the USA alone used 12 million tone of newsprint, with two-third of it imported at a cost of nearly four hundred dollars. By 1996, the demand was expected to reach 14.5 million tone a year (Bosisio, 1988). Paper produced from kenaf pulp has excellent ink-retention characteristics and its high tensile strength is ideal for high speed presses (Robinson , 1988).

Since it is currently impossible for forests to produce an annual quantity of fibers to meet our domestic demands, the greatest potential rests with the production of annual species such as kenaf to meet the need. Kenaf has been reported to be three to five times more productive per unit area than pulpwood trees and produces a pulp that is equal or superior to many wood pulps. (Theisen, et al; 1978).

White et al; (1970) summarized the numerous studies that had been conducted to determine the agronomic potential for kenaf in the USA. Since then, additional studies have been conducted on plant population density (Campbell and White, 1982; Bhangoo et al; 1986), Nitrogen fertilization (Massey, 1974; Adamson et al; 1979), and fiber and pulping properties (Adamson and Bagby, 1975; Watson et al; 1976).

The cordage fibre is used in sacks, mats, carpets, ropes, roofing and canvass. Kirby (1963) reported that about 40 – 60% of retted fibre could be mixed with jute for making hessian sacks. It has also been demonstrated that jute sacks can be produced using 60% ribbons and 40% retted fibre (Adeoti and Idem, 1986). The bast bag is important in the Nigerian economy for the packaging and transportation of farm produce.

The kenaf seed contain about 20% by volume of edible oil (Dempsey, 1972; Lagoke et al; 1981). This oil compares favourably with cottonseed oil and can be used for industrial purposes. The cake obtained after oil extraction can also be used for compounding livestock feeds. The leaf has been found to be high in protein (Lagoke et al; 1981) and is harvested green and eaten as vegetable in parts of the savanna zone of Nigeria.

The only part of kenaf that is produced in commercial quantity is the fibre. Baker (1970) reported fibre yield averages of 1.0 – 1.5t/ha. Kenaf along with roselle account for about one third of the world production of soft fibres used for packaging (Kumar et al; 1985). The world wide jute and jute like fibre (kenaf inclusive) average production from 1991 – 1993 was put at 4.44 million metric tonnes (FAO, 1994). In Nigeria, the annual production was put at 367 tons in 1970 (Anonymous, 1971). At that time both the Badagary and Jos factories in Nigeria which were the main users of kenaf fibre were operational. But now, it is only the Jos factory that is still operational and it depends completely on imported kenaf. This therefore, has resulted in lack of recently documented production figures as the crop is now grown mainly for domestic consumption.

1.1 Statement of Research Problem and Objective of the Study

A major constraint for optimum kenaf production in Nigeria is that the crop is highly susceptible to diseases and insect pest. Adeoti (1991) reported that the most severe fungal disease of kenaf that is prevalent in the Nigerian savanna is Coniella leaf spot, induced by Coniella musacaensis. In a similar manner, Donnelly (1966) listed a number of insects pest of kenaf, among which is the flea beetles (Podagrica sp). These insects and diseases attack mostly the leaves of kenaf and in most cases cause complete defoliation. It is also a common practice of local kenaf growers in the Nigerian savannas to remove leaves in some region s of the stem during growth of the crop which is eaten as a vegetable or for feeding of livestock and these might adversely affect the fibre and seed yield of the crop.

Many workers have reported the valuable effect of defoliation on the growth and yield of different species of crops. For instance Schneiter et al. (1987) in a defoliation study on sunflower reported that 50, 75 and

100% defoliation averaged across all developmental stages decreased seed yield significantly compared to the control and that 75 and 100% defoliation decreased seed yield significantly when treatments were applied at the reproductive stages. Their results also indicate that plant death often resulted when treatments of 100% defoliation were applied at advanced reproductive stages.

Remison (1978) reported that in maize, defoliation reduces the number of ears, size of cobs, weight of kernel and total yield. He further stated that total leaf removal had the most severe effect. Enyi (1964) showed that in rice complete defoliation at the time of panicle emergence reduces the grain yield/spikelet percentage. Sato (1966) however reported that defoliation of rice might even have a rejuvenating effect and results in faster growth and seeds if there was enough time for recovering before flowers were initiated.

Fehr and Hintz (1990) reported that in soybean, complete defoliation of plants resulted in a significant yield reduction compared with the undefoliated plants. Weber (1955) reported that in soybeans protein percentage was not altered by either defoliation or topping treatments but oil content was however decreased by increased defoliation percentage but it was not appreciably altered by topping treatments.

This present study was initiated to determine the amount of leaves that could be remove from kenaf without necessary affecting its yield. The study have the following aims;

1. To determine the effect of time of defoliation on the growth and yield of kenaf.

2. To determine the effect of level of defoliation on the growth and yield of kenaf.
3. To study the interaction, if any, between time and level of defoliation on the growth and yield of kenaf.

1.2 Justification of the Study

Understanding the mechanisms underlying yield loss in plants due to insect and disease attack is essential for better explanations of plant/insect interactions and for developing economic injury levels (Eils) for practical use in pest and disease management. Insufficient understanding of yield loss relationship imposes a continuing impediment to pest management. To establish injury–yield loss relationship, it is essential to accurately quantify injury imposed over time and space.

Results from this study will therefore be useful in the careful timing in the application of fungicide and insecticides in the control of diseases and insect pest.

While it would be desirable to measure the response of crop to natural causes of defoliation such as insect and diseases, experimental control of timing and magnitude of damage level to whole canopies was not practical due to limited information in factors initiating pest and disease outbreaks. Thus we employed artificial defoliation to simulate damages cause by pest and diseases to establish treatments in which timing and magnitude of foliage damage can be controlled.

CHAPTER 2 **LITERATURE REVIEW**

2.1 Botany, Physiology, Soil And Climatic Requirement Of Kenaf

Kenaf belongs to the malvaceae family. It is an erect annual shrub with height ranging between 1 and 4 meters, with well developed tap roots, straight and slender stems (Purseglove, 1974; Dempsey, 1975). Kenaf produces cream coloured, large flowers characterised by a reddish – purple throat (Dempsey, 1975). Kenaf seeds are cylindrical or kidney -shaped, pubescent, grey and ranged between 35,000 to 40,000 per kg.

Most kenaf varieties are very sensitive to photoperiod, flowering on a shortening day of twelve and half-hours or less (Purseglove, 1974; Dempsey, 1975). This enables the plant to obtain as much rapid vegetative growth as possible before flowering begins. The longer the vegetative phase the greater will be the fibre yield.

Pereverzev and Kapralova (1972) however, reported that the duration of vegetative growth in six forms of kenaf was genetically controlled and dependent mainly on the duration of the period between emergence and bud formation. The duration of phases subsequent to bud formation as reported by Pereverzev and Kapralova (1972) to be slightly shorter in early maturing than in late maturing forms. The early maturing forms were characterised by long internodes. Kenaf crop is harvested when about ten flowers are in bloom, at which time the fibre is at its best quality and more easily separable (Baker, 1970; Purseglove 1974; Dempsey, 1975). If harvesting is delayed while seed has set the fibre is coarse and lacks lustre (Purseglove, 1974). This is due to the translocation of the assimilates from the leaves (source) to the seed (sink) at the seed formation stage.

Cereti et al. (1972) reported dry matter partitioning during the growing season of kenaf crop between flowering and the start of seed growth of 65% of biomass to be partitioned to bolls increased linearly to 80%. Hu and Li (1986) reported slow growth in kenaf stems and leaves at seedling stage with a leaf area index of 0.39. At seedling stage, root growth was reported to be very fast and leaf area and plant height increased by 4.44cm^2 and 3.43cm daily on average. The daily-accumulated biological yield was 13.4kg at the fast growing stage. Amaducci et al. (1990), harvesting kenaf crop at 10 days interval starting at 8 to 18 weeks after sowing reported that the proportion of stem increased while that of leaves decreased.

Kenaf is adapted to a wide range of soils. It thrives best on well drained, neutral sandy loams, rich in humus. It will not tolerate water logging but could tolerate flooding at its early stages of growth, requires ample moisture and a rainfall of about 100mm or more per month.

2.2 Effect Of Sowing Date

Planting date is an important yield factor in kenaf since it highly influences both total fibre and seed yields of the crop partly due to response to day length (White et al; 1970, Baker 1970).

Baker (1970) Abdullahi (1973) and Katung (1997) emphasized the importance of early planting as early planting after sufficient soil moisture ensures good establishment of the crop. The time of planting also varies depending on the purpose for which the crop is to be grown (Negash, 1967). Late planting has been reported to be more suited for seed production than to fibre production (Muchow et al., 1990). Kirby (1963) believed that late planting is beneficial to seed production since stem length is not important. Hari–Izook (1965), Amanguah (1968) and Bukhtiar et al. (1990), have all reported decreases in fibre yield and quantity with late planted kenaf. Thakuria et al. (1989) reported fibre yields of 2.90, 2.11 and 1.77t/ha from kenaf sown on 25 April 10 May and 25 May respectively.

Fibre yield does not proportionally relate to time of planting alone but also to the stage of development of the crop. White et al. (1970) reported that for fibre production best yields are obtained when kenaf is harvested just prior to or at the beginning of flowering. plant height which is an important consideration in terms of fibre was also affected by delayed planting.

2.3 Diseases Of Kenaf

One of the major constraints to kenaf production is its susceptibility to many diseases. Dempsey (1975) reported that practically all kenaf diseases are caused by various seed and soil borne fungi. He considered Anthracnose induced by Colletotrichum sp to be a major kenaf disease because it is widespread and very destructive.

Another major disease of kenaf is Rhizoctonia root rot induced by Rhizoctenia solani kaln. The imperfect stage of Thanatephonsus cucumeris (franale) punk. Another stem disease is the eye rot induced by Myrothecium noridum tone ex fr. This was first reported in India (Das and Dikshift, 1975) and could result in the breaking of the stems in severe cases.

Some leaf spot diseases have also been reported on kenaf. Kundu (1964) reported that Cercospora leaf spot diseases was the major leaf spot disease of kenaf in India, Japan and Taiwan, while Protesenko (1967) in USSR, reported a damping off disease of kenaf induced by Alternaria sp.

Some work has been carried out on the biology and control of kenaf diseases in different parts of the world. In Nigeria, not much work has been done on kenaf diseases. However, Abdullahi (1970) first reported that pests and diseases were potentially important in the development of bast fibre industry in Nigeria. He observed that a few diseases attack kenaf and roselle in Nigeria. Among these were leaf spot diseases common at Jema'a and Zonkwa in Kaduna state which included anthracnose induced by Collectotrichum hibisci and "leaf barn" induced by Corticium solani. Others are stem diseases such as Phytophthora blight induced by Phythophthora nicotinanae, which usually results in rotting of stems and roots.

The first major record of kenaf diseases in Nigeria was by Emechebe (1980) who listed eight different organisms responsible for causing kenaf diseases in the savanna and semi arid zones of Nigeria. These include Phytophthora parasitica and the stem rot disease of kenaf, Corticium solani (Drill and Delaer) inducing the web blight and leaf spot. Also included were leaf spot diseases induced by Coniella hibisci. Morgan jones, Coniella musaiensis sutton, and Ascochyta blight induced by Aseochyta abelmoschi. Hertes. Others listed were the collar rot (Sclerotium rolfsii sac.) vascular with, Fusarium oxiysporum schlecht, and stem rot induced by Rhizoctonia solani kuctu and Macrophomina phaseolina (Tassi) gold.

Of all the diseases listed above, Coniella leaf spot is the most destructive (Annon 1983). Its attack always starts with a water soaked spot; this expands extensively covering a large part of the leaf. At the same time, a dark brown area appears in the centre of the lession. The brown area is usually covered by a large number of pycnidia that give the spot a dark brown appearance. The attack could lead to premature, complete defoliation of the kenaf plant. On the average, between 75 and 80 percent of the plants were attacked when sampling was carried out in September (Annon, 1983). Loss of seed viability of up to 66 percent has also been attributed to leaf spot disease (Idem, 1982 personal communication).

The causal organism has been found to be Coniella musaiensis B. sutton var. hibisci B. sutton (Khatua and Maita, 1977). It is not certain whether the two causal agents of leaf spot disease listed by Emechebe (1980) as C hibisci Morgan Jones and C. musciaensis sutton were synonymous with C. musaiaensis var hibisci. *Apart from above identifications*, it appears, from available literature that no work has been carried out on the causal agent of the coniella leaf spot.

Coniella species have also been recorded on other crops in Nigeria. For instance, Bailay (1966) reported Coniella diplodiella (speg) peter and sup as inducing the leaf blotch disease of grape vine – Vitis vinifera L.– while Emechebe (1980) listed Coniella sp as inducing the leaf and stem blight of roselle, Hibiscus sabdariffa L.

2.4 Effect Of Date Of Planting On The Development Of Coniella Leaf Spot Of Kenaf

Field observations (report in Anon, 1983) showed that 85 percent of kenaf farmers usually plant their crops at the onset of rains in April or May, fifteen percent of them, however, delayed their planting until later in the season when they would have completed planting other crop, such as maize, sorghum and millet. Some farmers even plant kenaf under irrigation as vegetables during the dry season. It was observed that the disease incidence and severity varied considerably between the kenaf plants grown at the onset of rains and those planted at various times in the rainy season. On the other hand, kenaf grown during the dry season was found to be free of the leaf spots.

Results obtained from other studies consistently showed that the later the planting date, the greater the severity of the disease on the subsequent crop (Adeoti, 1991). Thus, June sown crop showed significantly greater disease attack than May sown crop. In the two years of the study the disease appeared significantly later on kenaf sown in May or June when compared with planting done as from July. Since kenaf is photo period sensitive, flowering when the day length falls below twelve and half-hours (Dempsey, 1975) the May and June sown crop enjoyed longer period of growth before flowering set in August hence they were significantly taller and produced significantly more grain and fibre yields than the plantings carried out as from July.

2.6 Effect Of Defoliation On Growth And Yield Of Crops

Although there are no documented literature on the effect of defoliation on kenaf, results from defoliation studies done on other crops provides a useful theoretical framework for this present study.

Several studies have shown a direct relationship between leaf as the major photosynthetic area and growth/yield of crops. Pauli and Laude (1959) reported winter wheat grain losses of 32% when plants were completely defoliated during five days preceding heading and smaller losses when defoliated at later stages. Also working with winter wheat, Kiesselbach (1925) found grain yield reduction of 22, 11 and 3% when leaves were removed 3, 10 and 17 days after heading. Straw yields were decreased by 16, 11 and 5%. Roebuck and Brown (1923) however observed that yield losses in wheat due to leaf removal were greatest when the leaves were removed seven weeks before harvest. Similar results were obtained by Suneson and Paltier (1936), who reported that defoliation of field grown winter wheat plants in the early tillering stages reduced the cold resistance of the plants. The decrease in survival was approximately in proportion to the degree of defoliation. David and Thurman (1962), investigated the effect of leaf removal on the grain yield of wheat and oats. They found that significantly grain yield reduction due to leaf area removed were probably due to a reduction of seed size.

Kalton et al. (1949), found only slight reduction in soybean grain yield when 10 to 75% of the leaves were removed prior to bloom. Complete defoliation resulted in 22% decreased in yield. In every case, the greatest yield reduction occurred when leaves were removed at the time beans were beginning to developed in the lower pods. McAlister and Krober (1958) found soybean seed yield decreased approximately by 40 and 21% respectively for 80 and 40% defoliation. Moderate depodding increased seed weight enough to maintain growth and yield.

Weber (1955) experimented with defoliation and topping to simulate hail injury in soybean. He found out that the effects from topping alone were additive as well as when combined with defoliation. With 100% topping, yield was reduced less than 100% topping, whereas 100% defoliation alone gave 20% yield reduction. He also observed that maturity date, plant height, and seed weight were affected considerably more by high defoliation percentages than high topping percentages. But degree of lodging and seed quality as measured by appearance, were not affected by either defoliation or topping injuries.

Fehr and Hintz (1990) reported that in soybean, complete defoliation of plants injured by stem cut off resulted in a significantly greater yield reduction than stem cut off alone. Their results also indicate that plant density had no significant effect on yield reduction or any of the traits evaluated.

Stickler and Pauli (1961) in defoliation test on sorghum showed that all leaves contribute something to grain yield and their result also showed that the top two leaves are the most efficient in producing grain yield. Hamingway (1954) indicated that grain yield reduction due to leaf removal at anytime is directly proportional to the percentage of the leaf area removed and that the yield reduction is greatest attaining a maximum of 100% yield reduction for complete leaf removal at the time when 40% of the plant are detasseled. Stickler and Pauli (1961) showed results of sorghum defoliated at 100%. This was done at boot stage and at each succeeding day until the grain was ripe. Clipping before midfruiting gave significant decrease in grain yield. There was reduction in grain yield when all leaves were removed 30 to 40 days before anthesis. Removal of leaves three weeks before heading reduced grain yield in relation to the proportion of leaf removed. Stickler and Pauli (1961) reported that Sorghum bicolor (L) Moenah yield were reduced more from removing approximately one half of the upper portion of leaf area of sorghum plants than the removal of an equal amount of leaf area from the lower portions of the plants. They also observed that there was no significant difference in grain yield defoliated at booting stage or at anthesis. This was however, contradicted by Selassie and Gebrekidan (1975) who found that the weight of seed of the late maturing Ethiopian variety was severely reduced by early defoliation and severe increase in lodging. Rajewski and Francis (1991) reported that yield response to defoliation in sorghum grain can be influenced by time and intensity of leaf removal.

Eldredge (1936) found greatest reduction in corn yields when plants were completely defoliated during the tasseling periods. Yields were reduced by 30, 73 and 100% when ½, 2/3 and all leaves were removed at the 40% tassel stage. Removing half of each leaf at pre-tassel, full tassel and the milk stage reduced yields by 27, 33, and 13% respectively. Kiesselbach and Lyness (1945) Dungan (1942) reported that in maize remaining leaves functioned more efficiently after defoliation. Allison and Watson (1966) were able to establish that there was a decrease in the photosynthetic activities from top to the base of the stem of maize plant when some of the leaves were defoliated. But there came an increase in photosynthetic activity at a later time when some new leaves were developed. Defoliation leads to an increase in photosynthetic activity of the remaining leaves (Sanchiez and Oliviera 1973; Kiesselbach and Lyness, 1945; Dungan, 1942).

Egharevba et al. (1974) agrees with Sanchez and Oliviera (1973) that defoliation within 30 days after silking reduces accumulated dry matter and grain production and that the relative contribution of the upper, middle and lower leaves amounts to 38, 36 and 28 percent of dry matter respectively. This shows that there is significant difference in defoliating upper and lower leaves which was disputed by Egharevba et al. (1974) who was supported by Remison (1978) that there is no significant difference. Egharevba et al. (1974) however found that Kernel weight was most affected by the different treatment while the number was only greatly reduced with complete defoliation 10 days after silking. Along (1983) found that defoliation up to 40 percent had no adverse effect on maize hence he recommended that some leaves could be removed for the feeding of livestock. Chianson (1983), however, found that total defoliation reduced grian yield by 90 percent while 75 percent defoliation reduced grian yield by 80 percent and that when half of the leaves were removed grain yield reduction was by 63 percent. Allison et al. (1975) stated that more kernel aborted in defoliated plants.

Enyi (1964), showed that in rice, complete defoliation at the time of panicle emergence reduced the grain yield/spikelet percentage. This was, however, contradicted by Sato (1966), who reported that defoliation of rice might even have a rejuvenating effect and results in faster growth and more seeds if there was enough time for recovering before flowers were initiated.

Brisley et al. (1959) found a linear relationship between cotton yield and leaf area destroyed by fumigation with sulphur dioxide. Yield loss was a function of loss in number of bolls rather than weight of cotton per boll.

Sackston (1959) reported that total defoliation severely reduced sunflower yield in Canada. Yield were reduced 22 to 30 percent when 50 percent of each leaf was removed at flowering. In contrast, artificial excision of 10 to 75 percent of the leaves on soybean plants prior to flowering in Iowa and removal of 50 percent at flowering in Alabama resulted in little or no yield reduction. Johnson (1972), observed that sunflower seed yields were significantly reduced as a result of partial or complete leaf excision when compared with the control. He reported that yields were affected least when leaves 5 through 12 from the top or the top 12 were left on the sunflowers plants. His result indicate that the lower leaves on the plant were more important to seed yield than when only top 4 were left. De Beer (1980), studied the effect of 25, 50, 75 and 100 percent defoliation at seven stages of sunflower plant growth from the nine leaf to 50 percent adhere maturity at three South African locations. His result indicate that yield decreased significantly with 100 percent defoliation at all stages of plant development. He also reported that, at two locations, 50 and 75 percent defoliation significantly decreased yield at the 15 leaf to flowering stages, 25 percent defoliation resulting in no significant yield reduction and 100 percent defoliation decreased oil percentage at all stages of plant development. Schneiter et al. (1987), in a defoliation study on sunflower found that 50, 75 and 100 percent defoliation averaged across all developmental stages decreased seed yield significantly compared to the control and that 75 and 100 percent defoliation decreased seed significantly when treatments were applied at the reproductive stages. Their results also indicate that plant death often resulted when treatments of 100 percent defoliation were applied at advanced reproductive stages. During reproductive development, defoliation has been shown to significantly decrease seed yield when imposed on plants injured by stem cut off (Camery and Weber, 1953; Weber 1955). The effect of defoliation on plants injured by stem cut off during vegetative development is not well understood. During vegetative development, removing a portion of the main stem decreases seed yield, but defoliation at the same stage of development has no significant effect on seed yield (Fehr et al; 1983). The adjustment procedures currently in use assume that yield reductions caused by stem cut off with and without defoliation are not significant.

Iremiren (1987), reported the result of artificial defoliation on the growth and yield of okra. He found out that artificial defoliation of okra generally delayed flowering, reduced pod length, pod diameter, mean pod weight and number of pods per plant. He further observed that the removal of leaves from the upper half of the stem had a similar effect with complete defoliation whereas the removal of leaves from the lower half had no significant effect, indicating that the leaves on the upper stem contributed more to growth and yield than those lower down.

George and Obermann (1989) observed that a short period of moderate defoliation of switch grass in early to mid June could break grazing programmes by providing

i. Some very high quality switch grass herbage during early to mid June.

ii. A brief rest and re-growth period for the cool season pasture and

iii. Relatively high summer yields of quality switch grass when it is most needed.

Burns et al. (1984) observed no negative effect on switch grass production when available forage was removed to below 15cm in the second and third year of their grazing study, compared to a 20 to 28 cm canopy height the first year.

Kang and Brink (1995) observed that permitting white clover seedling to attain advanced leaf stages before initial defoliation and increasing the time interval before subsequent defoliation will enhance seedling growth and potential survival.

According to Julio Muro et al. (1998) the most critical growth stage for the effect of defoliation on the yield of sugar beet (Beta vulgaris. L) was between 1700 and 1800 degree days when 100 percent defoliation produced a 42 percent yield loss. They also observed that the higher the level of defoliation the higher the yield loss.

CHAPTER 3 MATERIALS AND METHOD

3.1 Description of the Experimental Site

The field trials were conducted during the wet seasons of 1999 and 2000 on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (Lat 11° 11'N; Long 7° 38'; 686m above mean sea level) in the Northern Guinea Savanna ecological zone of Nigeria. The soil of the area is characterised by ferrugenous tropical group of soils. (Keay,1959)

3.2 Agronomic practices

3.2.1 Land Preparation

At the onset of each rainy season, the site for the planting trials was ploughed and a week after, disc-harrowed, to get a fine tilth. Ridges measuring 0.75m x 6m were then raised.

3.2.2 Seed Sowing

Several seeds of kenaf (Cu. (Cuba) 108) were sown on ridges immediately after land preparation on August 9th and June 17th in 1999 and 2000 respectively. Seeds were sown at a spacing of 20 x 20 cm and later thinned to one plant per stand 10 days after sowing.

3.2.3 Fertilizer Application

Nitrogen in form of calcium ammonium nitrate (26 percent N) was applied in two equal doses at planting by side placement and at six week after planting by side placement at the rate of 95kg per/ha. Compound fertilizer at the rate of 135kg per hectare was also applied as a single dose, 3 weeks after planting by side placement.

3.2.4 Weed Control

Weed was controlled by hoe-weeding beginning from four weeks after planting and then at an interval of two weeks until the crop established.

3.2.5 Pest and Disease Control

The following recommended chemicals were used to control diseases; Delsene – m at the rate of 1.2kg/ha; Bavistin, at 3.5kg/ha and Benlate at 0.6kg/ha; while the following chemicals were used to control insect pests; Cypermethrin (cymbush 10EC) + dimethioate (Roger) at the rate of 175mls in every 10 litres of water. Malathion was also applied at the rate of 0.25 – 0.5kg/ha.

The chemicals were applied beginning from two weeks after planting and then weekly until the crop flowered.

3.3 Physico – Chemical Properties of the Soil

In each year and prior to the establishment of each planting trial, a composite soil sample was taken from depth of 0 – 15 cm. The samples were air-dried, thoroughly mixed, ground and then passed through a 2mm sieve for the physical and chemical laboratory analysis. Particle size distribution after grinding was determined by the hydrometer method as described by Day (1965). Soil PH was determined using PH meter (Black, 1965). Organic carbon was estimated by the Walky – Black method (Jackson, 1958). Total N was estimated by the micro kjeldehil method (Bremmer, 1965). Cation exchange capacity (CEC) and exchangeable bases (K, Na, Ca and Mg) were estimated by ammunium acetate extraction and distillation as described by Chapman (1965): Na and K in the extracts were determined by an EEC flame photometer, while Ca and Mg were determined by a Perkin Elmer, model 290B atomic absorption spectrophotometer. Available P was estimated according to Brayl sulphuric acid reduction method as described by Through (1930).

3.4 Meteorological Data

Data on temperature, rainfall, relative humidity and sunshine hours during the periods of the investigation were obtained from the IAR meteorological unit, Samaru.

3.5 Treatment and Experimental Design

The treatments consisted of defoliation at4, 6, 8 and 10 weeks after sowing, T1, T2, T3 and T4 respectively for the main treatments while the subplot treatments are control with no artificial defoliation (Do), lower half of the leaves only removed (D1). Upper half of the leaves only removed (D2) and complete defoliation in which the whole leaves on the stem were removed (D3). The apex of the plant was left intact to ensure the survival of the plant..The experiment was laid in a split plot design with three replications each year.

3.6 Observations and Data Collection

3.6.1 Plant Height

This was recorded at 50 percent flowering and at seed harvest. Ten plants were taken at random and their individual heights measured using a meter rule. The measurement was done from the ground level to the tip of the terminal bud of the plant. The average height was then computed.

3.6.2 Stem Girth

This was recorded at 50 percent flowering and at seed harvest. Ten plants were taken at random from each plot and the butt diameter of individual plant taken and the average for each plot was computed.

3.6.3 Wood and Ribbon Dry Weight

Ten plants from each plots were used at 12WAS for the stem and ribbon dry weight. The plants were cut and left in the field for several days to ease removal of leaves and reproductive structures. The sticks were packed to separate the ribbon from the stalks. They were later dried to constant weight at 65°c and then weighed. The average weights of wood and ribbon per plant were later determined and the average for plots were computed.

3.6.4 Number Of Days to 50 Percent Flowering

Daily inspection of plants on each plot to determine the number of days to floral initiation and attainment of 50 percent flowering was carried out appropriately.

3.6.5 Number Of Pods Per Plant

Ten plants, taken at random from each plot, were used at seed harvest. The pods on them were counted and the average number of pods per plant appropriately determined.

3.6.6 Number Of Seeds/Pod

The pods indicated above were sun dried, threshed and the number of seeds per individual pod counted.

3.6.7 100 – Seed Weight

One hundred seeds were taken from the seed harvest of the respective plots and weighed to determine their weight.

3.7 Statistical Analysis

The data collected were subjected to analysis of variance using the 'F' test to determine significant differences in the treatment means as described by Snedecor and Cochron (1967) and when test indicated significant difference multiple comparism of treatments means was carried out using the Duncan's multiple range test (Duncan, 1955); and the magnitude of association and relationship between some growth and yields parameters were assessed through simple correlation (Little and Hills, 1978).

CHAPTER 4 RESULTS

4.1 Effect Of Time And Level Of Defoliation On Growth And Development Of Kenaf

4.1.1 Plant Height

The effect of defoliation on kenaf height at 50 percent flowering is presented in table 1. Time of defoliation and level of defoliation significantly influenced plant height at 50 percent flowering in both years. In both years and the combined analysis plant height increased significantly with time of defoliation from 4WAS to 6WAS. Thereafter, decreased significantly when time of defoliation was further delayed from 6WAS to 8WAS. However, plant height recorded when the crop was defoliated at 8WAS and 10Was was significantly higher than the plant height recorded when the crop was defoliated at 4WAS. Similar trends were observed for plant height at seed harvest (Table 2).

In 1999 and the combined analysis, no defoliation and half the lower leaves removed produced significantly taller plants than half the upper leaves removed. In 2000, half the lowest leaves removed produced the tallest plants. In all cases the shortest plants were recorded with complete defoliation of the crop.

Time X level of defoliation significantly affected plant heights at both 50 percent flowering and at seed harvest (Table 3 and 4). In both years, the tallest plants were recorded when half the lower leaves were defoliated at 6WAS. In all cases, the shortest plants were recorded when the crop was completely defoliated at 4 WAS.

Table 1: Effect of Time and Level of defoliation on plant height of kenaf at 50 percent flowering.

Treatments	Plant Height (m) 1999	2000	Combined
Time of Defoliation			
4WAS	1.86981c	1.86883c	1.87088c
6 WAS	2.10139a	2.13083a	2.10903a
8 WAS	2.036026	2.05642b	2.04528b
10 WAS	2.06111b	2.07050b	2.06884b
SE±	0.02	0.02	0.01
Level of Defoliation			
No defoliation	2.34722a	2.35725b	2.34722a
Half lower leaves removed	2.37870a	2.39758a	2.37870a
Half upper leaves removed	1.70389b	1.72042c	1.70389b
Complete defoliation	1.63852c	1.65133d	1.63852c
SE±	0.02	0.02	0.01
Interaction			
Time and level of defoliation	*	*	*

Means followed by the same letter(s) within the same column and treatment are not significantly same column and treatment are not significantly different at 5 percent level of probability using DMRT

WAS - Weeks after sowing
SE - Standard error
* - Significant at 0.05 probability level.

Table 2: Effect of Time and Level of defoliation on plant height at seed harvest.

Treatments	Plant Height (m) 1999	2000	Combined
Time of Defoliation			
4WAS	1.91981[c]	1.91883[c]	1.92088[c]
6 WAS	2.1513[a]	2.18083[a]	2.15903[a]
8 WAS	2.08602[b]	2.10642[b]	2.09528[b]
10 WAS	2.11111[b]	2.12050[b]	2.11884[b]
SE±	0.02	0.02	0.01
Level of Defoliation			
No defoliation	2.39722[a]	2.40725b	2.39722[a]
Half lower leaves removed	2.42870[a]	2.44758a	2.42870[a]
Half upper leaves removed	1.75009[b]	1.77042c	1.75389[b]
Complete defoliation	1.68852[c]	1.60133d	1.68852[c]
SE±	0.02	0.02	0.01
Interaction			
Time and level of defoliation	*	*	*

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability.

WAS - Weeks after sowing

SE - Standard error

Table 3: Time and level of defoliation interaction on plant height in 1999

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	2.17^{f}	2.30^{e}	2.46^{c}	2.48^{ab}
Lower leaves removed	2.19^{f}	2.53^{a}	2.49^{bc}	2.38^{d}
Upper leaves removed	1.64^{kl}	1.89^{g}	1.60^{h}	1.74^{c}
Complete defoliation	1.46^{n}	1.80^{h}	1.66^{jk}	1.67^{jk}
	SE $\pm$ 0.01			

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing

Table 4: Time and level of defoliation interaction on plant height in 2000

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	2.17^{f}	2.30^{e}	2.46^{c}	2.48^{ab}
Lower leaves removed	2.19^{f}	2.53^{a}	2.49^{bc}	2.38^{d}
Upper leaves removed	1.64^{kl}	1.89^{g}	1.60^{h}	1.74^{c}
Complete defoliation	1.46^{n}	1.80^{h}	1.66^{jk}	1.67^{jk}
	SE $\pm$ 0.01			

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing

4.1.2 Stem Girth

Time and level of defoliation significantly influenced stem girth at 50 percent flowering (table 5) and at seed harvest (Table 6).

In all cases, the values for stem girth were significantly lower when the crop was defoliated at 4WAS than crop defoliated at 6WAS and beyond. Subsequently leaf defoliation beyond 4WAS did not result in significant differences in stem girth.

The crop that was not defoliated and half the lower leaves removed produced plants that were significantly thicker than those that where half the upper leaves were removed and complete removal.

Time X level of defoliation had significant effect on stem girth only in the combined analysis (Table 7 and 8). The lowest value was recorded when half the upper leaves and all the leaves on the plant were removed at 4WAS while the thickest kenaf plants were obtained when half the lower leaves were removed at 6WAS.

Table 5: Effect of time and Level of defoliation on stem girth of kenaf at 50 percent flowering.

Treatments	Stem Girth (cm)		
	1999	2000	Combined
Time of Defoliation			
4WAS	5.4861[b]	5.63006[b]	5.57222[c]
6 WAS	6.0825[a]	6.6825[a]	629819[a]
8 WAS	6.1648[a]	6.3250[a]	6.23056[a]
10 WAS	6.1833[a]	6.4133[a]	6.25120[a]
SE$\pm$	0.06	0.06	0.04
Level of Defoliation			
No defoliation	6.7944[a]	6.9350[a]	6.87870[a]
Half lower leaves removed	6.6713[a]	6.8758[a]	6.75045[a]
Half upper leaves removed	5.1324[b]	5.3508[b]	6.22454[b]
Complete defoliation	5.1130[b]	5.2892[c]	5.22222[b]
SE$\pm$	0.06	0.06	0.04
Interaction			
Time and level of defoliation	Ns	Ns	*

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent. Probability level.

Table 6: Effect of time and Level of defoliation on stem girth at seed harvest.

Treatments	Stem Girth (cm)		
	1999	2000	Combined
Time of Defoliation			
4WAS	5.4961[b]	5.63006[b]	5.57222[c]
6 WAS	6.0925[a]	6.6825[a]	629819[a]
8 WAS	6.1748[a]	6.3250[a]	6.23056[a]
10 WAS	6.1933[a]	6.4133[a]	6.25120[a]
SE±	0.06	0.06	0.04
Level of Defoliation			
No defoliation	6.8044[a]	6.9450[a]	6.8887[a]
Half lower leaves removed	6.6813[a]	6.8858[a]	6.7604[a]
Half upper leaves removed	5.1424[b]	5.3608[b]	6.23454[b]
Complete defoliation	5.1230[b]	5.2992[c]	5.23222[b]
SE±	0.06	0.06	0.02
Interaction			
Time and level of defoliation	Ns	Ns	*

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level
* - Significant at 5 percent level

Table 7: Time and level of defoliation interaction on stem girth at 50 percent flowering

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	6.88^{a}	6.66^{ab}	6.81^{a}	7.16^{a}
Lower leaves removed	5.96^{bc}	6.88^{a}	7.06^{a}	7.10^{a}
Upper leaves removed	4.49^{e}	5.12^{de}	5.76^{cd}	5.53^{cd}
Complete defoliation	4.95^{de}	5.27^{d}	5.30^{cd}	5.37^{cd}
	SE $\pm$ 0.51			

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing

Table 8: Time and level of defoliation interaction on stem girth at seed harvest

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	6.87^{a}	6.66^{ab}	6.91^{a}	7.18^{a}
Lower leaves removed	5.96^{bc}	6.97^{a}	7.17^{a}	7.11^{a}
Upper leaves removed	4.48^{e}	5.12^{de}	5.76^{cd}	5.52^{cd}
Complete defoliation	4.94^{de}	5.28^{d}	5.30^{cd}	5.38^{cd}
	SE $\pm$ 0.51			

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing

4.1.3 Number Of Days to 50 Percent Flowering

Time and level of defoliation did not significantly influence the number of days to 50 percent flowering in both years and the combined analysis. Similarly time and level of defoliation interaction did not significantly influence the number of days to 50 percent flowering in both years of the study and the combined analysis (Table 5).

Table 9: Effect of time and Level of defoliation on days to 50 percent flowering.

Treatments	Days to 50 percent flowering (months)		
	1999	2000	Combined
Time of Defoliation			
4WAS	2.83	**2.77**	2.90
6 WAS	2.90	**2.90**	2.97
8 WAS	2.80	**2.83**	2.87
10 WAS	2.77	**2.83**	2.83
SE±	0.02	**0.02**	0.02
Level of Defoliation			
No defoliation	2.80	**2.80**	2.90
Half lower leaves removed	2.80	**2.80**	2.83
Half upper leaves removed	2.87	**2.87**	2.80
Complete defoliation	2.80	**2.80**	2.80
SE±	0.02	**0.02**	0.02
Interaction			
Time and level of defoliation	Ns	**Ns**	Ns

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level
***** - Significant at 5 percent level

4.2 Effect Of Time and Level Of Defoliation On Pod Characteristics Of Kenaf

4.2.1 Number of Pods Per Plants

The effect of defoliation on number of pods plant of kenaf are presented in table 10. In 2000 and the combined analysis, the number of pods/plant was significantly higher when the plants were defoliated at 4WAS, 6WAS, and 8WAS than when it was defoliated at 10WAS. However, in 1999 the number of pods/plant of 8WAS was significantly lower than the number of pods/plant at 4 and 6 WAS.

In both years and the combined analysis the least number of pods were recorded when all the leaves on kenaf were removed. The treatments in which no leaves were removed and half the lower leaves removed produced similar number of pods/plants but significantly higher than the number of pods/plant recorded for defoliating half the upper leaves.

Time X level of defoliation interaction did not significantly affect the number of pods/plant in both years and the combined analysis.

Table 10: Effect of time and Level of defoliation on number of pods per plant.

Treatments	Number of pods/plant 1999	2000	Combined
<u>Time of Defoliation</u>			
4WAS	30.759^{a}	32.258^{a}	31.787^{a}
6 WAS	32.944^{a}	34.650^{a}	33.963^{a}
8 WAS	33.481^{b}	35.650^{a}	34.120^{a}
10 WAS	28.778^{b}	30.358^{b}	29.648^{b}
SE$\pm$	0.89	0.84	0.63
<u>Level of Defoliation</u>			
No defoliation	40.620^{a}	41.492^{a}	41.528^{a}
Half lower leaves removed	42.569^{a}	44.925^{a}	43.347^{a}
Half upper leaves removed	24.435^{b}	25.583^{b}	25.389^{b}
Complete defoliation	18.343^{c}	26.317^{c}	19.255^{c}
SE$\pm$	0.82	0.74	0.56
<u>Interaction</u>			
Time and level of defoliation	Ns	Ns	Ns

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

4.2.2 Pod Diameter

The effects of time and level of defoliation on pod diameter are presented in table 11. Time of defoliation significantly influenced the pod diameter of kenaf in both years of the study and the combined analysis. In both years defoliation at 4 and 6 WAS produced pods that were significantly bigger than those produced when the crop was defoliated at both 8 and 10 WAS. However, in 1999, pods produced when the crop was defoliated at 10 WAS were significantly smaller than those produced with defoliation at 8 WAS.

Pod diameter was significantly affected by level of defoliation. In both years and the combine analysis pod diameter increased significantly when the level of defoliation was increased from no defoliation to half the lower leaves removed. Thereafter, there was a significant reduction in pod diameter when the level of defoliation changed to half the upper leaves removed. Pod diameter was significantly affected by time X level of defoliation interaction (Table 12 and 13).

In both years, the biggest pods were obtained when half the lower leaves of the crop were removed at 6 WAS and the smallest pods were obtained when no leaves were removed. Complete defoliation and removing half the upper leaves of kenaf produced similar values for pod diameter.

Table 11: Effect of time and Level of defoliation on pod diameter

Treatments	Stem Girth (cm) 1999	2000	Combined
Time of Defoliation			
4WAS	4.87500a	5.07917a	4.97824a
6 WAS	4.91111a	5.15167a	5.02917a
8 WAS	4.79630b	4.97750c	4.84537c
10 WAS	4.74907c	4.94417c	4.87731c
SE±	0.02	0.02	0.01
Level of Defoliation			
No defoliation	4.83611b	5.04333b	4.93796b
Half lower leaves removed	4.97500a	5.16167c	5.06528a
Half upper leaves removed	4.77130c	4.98667c	6.86574c
Complete defoliation	4.74907c	4.96083c	4.86111c
SE±	0.02	0.02	0.01
Interaction			
Time and level of defoliation	*	*	*

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

* - Significant at 5 percent level

Table 12: Time and level of defoliation interaction on pod diameter in 1999

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	4.44^{d}	4.40^{d}	4.42^{d}	4.41^{a}
Lower leaves removed	4.94^{bc}	5.97^{a}	4.85^{bc}	4.84^{bc}
Upper leaves removed	4.96^{bc}	4.97^{bc}	4.91^{bc}	4.89^{bc}
Complete defoliation	4.82^{bc}	4.91^{bc}	4.81^{bc}	4.80^{c}
	SE $\pm$ 0.05			

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing

Table 13: Time and level of defoliation interaction on pod diameter in 2000

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	4.48^{d}	4.52^{d}	4.49^{d}	4.51^{a}
Lower leaves removed	4.93^{bc}	5.95^{a}	4.82^{bc}	4.83^{bc}
Upper leaves removed	4.95^{bc}	4.97^{bc}	4.90^{bc}	4.90^{bc}
Complete defoliation	4.81^{bc}	4.91^{bc}	4.82^{bc}	4.81^{c}
		SE ± 0.05		

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing

4.3.3 Pod Length

Time of defoliation significantly influenced the pod length of kenaf in both years of the study and the combined analysis (Table 14). In 1999 and the combined analysis defoliation at 8 WAS and 10 WAS recorded significantly longer pods ($p > 0.05$) than defoliation at 6 WAS and 4 WAS. However, defoliation at 4 WAS produced significantly longer pods than defoliation at 6 WAS. In 2000, there was a significant increase in pod length when the defoliation was shifted from 6 WAS to 8 WAS. However, defoliation at 10 weeks after sowing resulted in a significant reduction in pod length.

Interaction between time and level of defoliation had no significant effect on pod length (Table 14).

Table 14: Effect of time and Level of defoliation on pod length

Treatments	Pod length (cm)		
	1999	2000	Combined
Time of Defoliation			
4WAS	2.18981[b]	2.38917[c]	2.28889[b]
6 WAS	2.13241[c]	2.37500[c]	2.25324[c]
8 WAS	2.29815[a]	2.48083[a]	2.39676[a]
10 WAS	2.31389[a]	2.43167[b]	2.38009[a]
SE±	0.10	0.01	0.07
Level of Defoliation			
No defoliation	2.18241[b]	2.34417[b]	2.27037[b]
Half lower leaves removed	2.27315[a]	2.44417[a]	2.36759[a]
Half upper leaves removed	2.23796[a]	2.44250[a]	2.33935[a]
Complete defoliation	2.24074[a]	2.44883[a]	2.34167[a]
SE±	0.09	0.03	0.04
Interaction			
Time and level of defoliation	Ns	Ns	Ns

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

4.2.4 Number Of Seeds/Pod

Both time of defoliation and level of defoliation significantly affected number of seeds per pod. Number of seeds per pod in both years and the combine analysis increase significantly when time of defoliation was changed from 4 to 6 WAS. Thereafter increases with time of defoliation from 6 to 10 WAS. 10 WAS decreased number of seeds per pod significantly. In 1999 and 2000 no defoliation and half the lower leaves removed resulted in a significantly higher number of seeds per pod than half the upper leaves removed and complete defoliation. However, complete defoliation gave a significantly fewer number of seeds per pod than half the upper leaves removed.

In the combine analysis no defoliation produced the highest number of seeds/pod while complete defoliation gave the least number of seed per pod (Table 15).

Number of seeds per pod was significantly affected by time X level of defoliation interaction. (Table 16 and 17). The highest number of seeds were produced when the lower leaves were removed at 6 WAS while the least number of seed were obtained when the upper leaves and all the leaves were removed at 8 WAS and 10 WAS.

Table 15: Effect of time and Level of defoliation on number of seeds per pod

Treatments	Number of seeds 1999	2000	Combined
<u>Time of Defoliation</u>			
4WAS	18.2222[b]	21.8000[b]	20.0093[b]
6 WAS	20.3011[a]	23.6917[a]	21.773[a]
8 WAS	17.0185[c]	20.1000[c]	18.9741[c]
10 WAS	14.6204[d]	17.1750[d]	16.1111[d]
SE±	0.22	0.21	0.16
<u>Level of Defoliation</u>			
No defoliation	18.7722[a]	21.7667[a]	20.2824[a]
Half lower leaves removed	18.6667[a]	20.9417[a]	19.5370[b]
Half upper leaves removed	17.30566[b]	20.4667[b]	18.9491[b]
Complete defoliation	16.2778[c]	18.9917[c]	17.6991[c]
SE±	0.21	0.18	0.19
<u>Interaction</u>			
Time and level of defoliation	*	*	*

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

* - Significant at 5 percent level

Table 16: Time and level of defoliation interaction on number of seeds/pod in 1999

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	17.59^{abc}	16.33^{bc}	21.89^{abc}	15.51^{c}
Lower leaves removed	18.00^{abc}	22.44^{a}	16.44^{bc}	14.33^{bc}
Upper leaves removed	19.67^{abc}	20.44^{ab}	15.78^{bc}	14.00^{bc}
Complete defoliation	19.11^{abc}	20.44^{ab}	13.00^{c}	12.50^{c}

SE $\pm$ 7.1

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing.

Table 17: Time and level of defoliation interaction on number of seeds/pod in 2000

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	17.54^{abc}	16.32^{bc}	21.87^{abc}	18.54^{a}
Lower leaves removed	18.02^{abc}	22.47^{a}	16.42^{bc}	14.30^{bc}
Upper leaves removed	19.62^{abc}	20.42^{ab}	15.71^{bc}	14.03^{bc}
Complete defoliation	19.31^{abc}	20.07^{ab}	13.33^{c}	13.09^{c}

SE $\pm$ 7.1

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing.

4.2.5 100 Seed Weight

Defoliation significantly influenced 100 – seed weight of kenaf (Table 18). In both years of the study the 100 – seed weight were significantly heavier when the kenaf crop was defoliated at 4 and 6 WAS than when defoliation was either done at 8 or 10 WAS.

A similar trend was observed in the combined analysis except that the seeds were much heavier in the crop defoliated at 10 WAS than at 8 WAS.

Table 10 shows that 100 seed weight decreased significantly from no defoliation to the removal of the lower leaves. Thereafter, the difference in the 100 seed weight did not differ significantly.

Time and level of defoliation interaction had no significant effect on 100 seed weight (Table 18).

Table 18: Effect of time and Level of defoliation on 100 – seed weight.

Treatments	Number of seeds		
	1999	2000	Combined
Time of Defoliation			
4WAS	2.23031^{a}	2.251188^{a}	2.24109^{a}
6 WAS	2.25729^{a}	2.28582^{a}	2.27156^{a}
8 WAS	2.05833^{b}	2.09073^{b}	2.17453^{c}
10 WAS	2.22115^{b}	2.09273^{b}	2.23656^{b}
SE±	0.02	0.02	0.01
Level of Defoliation			
No defoliation	2.24656^{a}	2.26094^{a}	2.2465^{a}
Lower leaves removed	2.212246^{b}	2.23104^{ab}	2.21224^{b}
Upper leaves removed	2.19224^{bc}	2.20063^{bc}	2.19229^{bc}
Complete defoliation	2.17255^{c}	2.18781^{c}	2.17266^{c}
SE±	0.03	0.02	0.02
Interaction			
Time and level of defoliation	Ns	Ns	Ns

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

4.3 The Effect of Defoliation on Stem and Ribbon Dry Weight

4.3.1 Stem Dry Weight

The effect of defoliation on stem dry weight of kenaf is presented in table 19. Time of defoliation significantly influenced the stem dry weight of kenaf. In both years and the combined analysis, the stem dry weight increased significantly with time of defoliation from 4 WAS to 6 WAS, thereafter decreased significantly as time of defoliation was delayed from 6 WAS to 8 WAS.

In both years and the combined analysis, stem dry weight decreased significantly as the level of defoliation was changed from no defoliation to complete defoliation.

Time and level of defoliation interaction significantly influenced stem dry weight of kenaf in both years and the combined analysis (Table 20 and 21). Removing half the lower leaves of kenaf at 8 WAS produced significantly heavier stem than all other levels of defoliation at other times. In all cases complete defoliation of the crop at 4 WAS produced significantly lighter stem. (Table 20 and 21)

Table 19: Effect of time and Level of defoliation on stem dry weight

Treatments	Stem dry weight (gramme)		
	1999	2000	Combined
Time of Defoliation			
4WAS	115.3049[d]	116.5251[d]	115.4961[d]
6 WAS	170.2761[a]	172.3764[a]	172.1143[a]
8 WAS	157.3171[b]	157.6069[b]	154.7122[b]
10 WAS	119.3015[c]	119.6118[c]	119.3181[c]
SE$\pm$	3.71	2.45	2.39
Level of Defoliation			
No defoliation	201.1661[a]	206.0861[a]	204.0171[a]
Lower leaves removed	172.1418[b]	174.2318[b]	174.1317[b]
Upper leaves removed	107.5634[c]	107.2630[c]	107.3461[c]
Complete defoliation	78.4565[d]	78.5385[d]	78.5019[d]
SE$\pm$	5.41	5.53	4.39
Interaction			
Time and level of defoliation	*	*	*

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

* - Significant at 5 percent level

Table 20: Time and level of defoliation interaction on stem dry weightin1999

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	230.72[a]	242.07[a]	231.91[a]	229.42[a]
Lower leaves removed	125.70[c]	179.12[b]	237.64[a]	181.92[b]
Upper leaves removed	92.37[d]	96.52[d]	134.51[c]	105.46[d]
Complete defoliation	17.81[f]	67.75[e]	131.81[c]	94.72[d]

SE ± 5.28

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing.

Table 21: Time and level of defoliation interaction on stem dry weight in 2000

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	230.89^{a}	243.07^{a}	230.94^{a}	229.45^{a}
Lower leaves removed	125.72^{c}	179.01^{b}	237.26^{a}	181.95^{b}
Upper leaves removed	92.48^{d}	96.51^{d}	134.61^{c}	105.47^{d}
Complete defoliation	17.82^{f}	67.79^{e}	131.82^{c}	95.72^{d}

SE + 5.28

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing.

4.3.2 Ribbon Dry Weight

Defoliation significantly influenced the ribbon dry weight of kenaf (Table 22). In both years and the combined analysis ribbon dry weight increased significantly with time of defoliation from 6 to 10 WAS.

In the case of degree of defoliation, ribbon dry weight decreased significantly from no defoliation through half the lower leaves removed, half the upper leaves removed to complete defoliation. Dry ribbon yield was significantly affected by time and level of defoliation interaction. In every case, the highest ribbon dry weight was obtained when the lower leaves of the crop were removed at 8 WAS while the lowest ribbon dry weight was obtained when all the leaves on the crop were removed at 4 WAS (Table 23 and 24).

Table 22: Effect of time and Level of defoliation on ribbon dry weight

Treatments	Ribbon dry weight (g)		
	1999	2000	Combined
<u>Time of Defoliation</u>			
4WAS	81.67537^{d}	80.78667^{d}	80.73661^{d}
6 WAS	112.6177^{a}	112.62875^{a}	112.7045^{a}
8 WAS	108.62906^{b}	108.62917^{b}	108.5391^{b}
10 WAS	80.8911^{c}	80.98500^{c}	82.6634^{c}
SE±	2.57	2.17	2.36
<u>Level of Defoliation</u>			
No defoliation	143.41731^{a}	143.43722^{a}	143.43631^{a}
Lower leaves removed	116.21851^{b}	115.22750^{b}	116.21341^{b}
Upper leaves removed	70.14367^{c}	71.14583^{c}	71.143281^{c}
Complete defoliation	53.10612^{d}	53.21903^{d}	50.1172^{d}
SE±	3.45	3.11	2.31
<u>Interaction</u>			
Time and level of defoliation	*	*	*

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

NS - Not significant at 5 percent level

* - Significant at 5 percent level

Table 23: Time and level of defoliation interaction on ribbon dry weight in 1999

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	164.30[a]	168.42[a]	165.31[a]	164.40[a]
Lower leaves removed	80.88[d]	82.63[c]	165.40[a]	141.39[b]
Upper leaves removed	61.29[e]	65.73[e]	93.43[c]	65.31[e]
Complete defoliation	18.64[f]	64.13[e]	84.12[d]	44.12[f]
		SE ± 0.15		

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing.

Table 24: Time and level of defoliation interaction on stem dry weight in 2000

Level of Defoliation	Time of defoliation			
	4 WAS	6 WAS	8 WAS	10 WAS
No defoliation	165.29[a]	169.49[a]	164.49[a]	167.48[a]
Lower leaves removed	82.47[d]	82.60[c]	165.43[a]	140.41[b]
Upper leaves removed	62.24[e]	65.49[e]	91.52[c]	65.32[e]
Complete defoliation	18.94[f]	64.12[e]	84.67[d]	46.14[f]

SE ± 0.15

Means followed by the same letter(s) within the same column and treatments are not significantly different at 5 percent level of probability using DMRT.

WAS - Weeks after sowing.

4.4 Correlation Analysis

In the study, plant height was positively correlated with stem girth, number of pods per plant, pod diameter, number of seeds per pod, seed weight and ribbon dry weight. Plant height was however negatively correlated with pod length but the correlation was not significant ($P<0.05$). stem girth was positively correlated with number of pods per plant, pod diameter, number of seeds per pod, 100 – seed weight and ribbon dry weight. Stem girth was however negatively correlated with pod length although the correlation was not significant.

Seed weight and number of seeds per pod was positively correlated with the pod diameter but negatively correlated with pod length. The ribbon dry weight was positively correlated with the stem girth and also the plant height. (Table 25).

Table 25: Correlation analysis between some growth and yield characters

		1	2	3	4	5	6	7
Plant height1r	r	1.00000						
	P	0.0						
Stem girth 2		0.61876	1.00000					
		0.01	0.0					
No of pods/plant 3		0.49925	6.40312	1.00000				
		0.0001	0.0001	0.0				
Pod diameter 4		0.4912	0.41513	0.2015	1.00000			
		0.0001	0.0001	0.0001	0.0			
Pod length 5		-0.02241	0.05261	-0.4664	0.26271	1.0000		
		0.5106	0.1223	0.1708	0.0001	6.0		
No of seeds/pod 6		6.19373	0.19319	0.10373	0.13456	0.12348	1.00000	
		0.0001	0.0001	0.0023	0.0029	0.0026	0.0	
Seed weight 7		0.20139	0.21184	0.19314	0.04042	-10527	0.04188	6.1
		0.0001	0.0001	0.0001	0.3769	0.0118	0.0001	
Ribbon 8		0.59351	0.04531	-6.04152	0.040766	0.2814	0.29034	1.00000
		0.0001	0.0001	0.1604		0.0001	0.0001	0.0

R = correlation coefficient

P = probability.

CHAPTER 5 DISCUSSION

Significant differences in kenaf growth and yield were observed as a result of time and level of defoliation.

Though the amount of rainfall was more in 1999 than in 2000, the crop produced taller plants with thicker stems, more pods/plant and number of seeds/pod in 2000 compared to the 1999 season. This could be due to the delay in planting in 1999 as the crop were sown in August while in 2000 crop were sown in June. Planting date is an important yield factor in kenaf since it highly influences both total fibre and seed yields of the crop partly due to response to day length (White et al; 1970, Baker, 1970). Baker (1970), Abdullahi (1973) and Katung (1997) emphasized the importance of early planting for kenaf as soon as sufficient soil moisture supply is available to ensure a good establishment of the crop. The shorter period of growth available to the August sown crop in 1999 might have reduced the photosynthetic efficiency of the crop in 1999 crop thus, affecting the development of the plant which was reflected in the formation of pods and seeds.

Dempsey (1975), reported that most kenaf plants show a progressive decline in plant height, stem diameter and retted fibre yield when planted late indicating the lack of adequate growth period for proper crop development. The longer the vegetative phase the greater kenaf yield is likely to be (Purse glove, 1974).

5.1 Effect Of Time of Defoliation on Growth and Development of Kenaf

Early defoliation (4 WAS) reduced plant height, stem girth, stem dry weight and ribbon dry weight in this study. Defoliation at 6, 8 and 10 WAS did not show such an adverse effect on kenaf growth and development. This was probably because at 4 WAS the leaves are relatively young and more photosynthetically active and as the major source of assimilate for the growing plant (Enyi, 1972), their removal at this stage might have interfared with the process of assimilate production and partitioning to the growing plant thus led to a reduction in plant height, stem girth and ribbon dry weight. Dempsey (1975), Lagoke (1981), Katung (1997), have all reported a positive correlation between plant height, stem girth and ribbon dry weight. Therefore the reduction in plant height and stem girth must have accounted for the reduction in ribbon yield.

At 8 and 10 WAS defoliation did not adversely affect kenaf's growth and development probably because at those stages, adequate dry matter accumulation must have taken place. Therefore any insect pest or disease attack or any activity on kenaf leaves that will cause defoliation at 4 WAS is therefore detrimental if the target of the kenaf grower is for fibre production. Sarma (1967) and Berger (1969) reported that the best quality fibre is obtained when kenaf is harvested at the bud stage and/or when the first flower is noticed which coincides with these stages of development. This finding therefore highlights the need for the careful timing of applications of insecticides intended to control leaf eating insect or application of fungicides intended to control leaf destroying pathogens.

Defoliation did not significantly affect the number of days to 50 percent flowering in kenaf. This shows that kenaf is a photosensitive crop flowering when day length is shorter than 12 hours (Baker, 1970).

5.2 Effect Of Time Of Defoliation On Pod And Seed Characteristics

Defoliation at 8 and 10 WAS significantly reduced the number of pods per plant, number of seeds per pod and seed weight. Defoliation at 4 and 6 WAS did not shows such adverse effect on these parameters. This is so because at 8 WAS most of the flower buds had already been initiated and at 10 WAS few flowers had already developed on the crop. Therefore the pattern of assimilate distribution will change with the buds and flowers becoming the principal sink (Enyi, 1972). Therefore, defoliation at 8 and 10 WAS will definitely reduce the amount of assimilate which will normally be channelled to the flowers and buds for pod development and subsequent seed filling with the result that fewer pods and fewer seeds were produced when the crop was defoliated at 8 and 10 WAS. Seed yield of kenaf has been reported by Idem (1982) to be positively correlated with number of pods per plant and number of seeds per pod. Therefore, the decrease in seed yield resulting from defoliation at 8 and 10 WAS must have been accounted for by the decrease in number of pods per plant and number of seed per pod. Camery and Weber (1953) have observed a significant decrease in seed yield when defoliation was imposed on plant at the reproductive phase. Selassie and Gebrekidan (1975), show that in sorghum, defoliation at two weeks after heading severely affected seed setting. Since photosynthate from the leaves are necessary for getting as many potential seeds as possible developed on a given panicle, it is obvious that the removal of leaves means a lower number of seeds on a panicle. In this study, the low values for number of pods and number of seeds per pod indicates the dependency of pod production and subsequent seed filling on an adequate photosynthetic area.

The work of Schneiter et al. (1987), also reveals the adverse effect of defoliation of plants at the reproductive stages. Scheneiter *et al.* (1987), observed that in soybean, removing the leaves of the plant during reproductive bud development and expansion killed the majority of the plants and this response was due to a reduction in the source of phtosynthate at this stage. Schneiter et al. (1987),, further observed that the negative effect of defoliation begin to lessen significantly when defoliation was done after anthesis, because kernel located on the outer circumference of the head were already filled.

Results reported by de Beer (1980), Lotgren (1970) and Sackton (1959) indicate that sunflower is most sensitive to defoliation just prior to anthesis with decreasing effects due to defoliation at early vegetative and late seed filling stage. During reproductive stages plants systematically shifts allocation of photosynthate from vegetative to reproductive structures (Fehr et al; 1977). Therefore, reproductive stages are critical and defoliation can result in significant yield reductions because photosynthate is increasingly directed to reproductive structures during pod elongation and seed enlargement.

In kenaf, this study showed that defoliation at 4 WAS did not permit enough time for dry matter accumulation in the stem due to inadequate supply of assimilate hence a reduction in ribbon dry weight which has been found to be positively correlated with fibre yield (Lagoke et al; 1981; Kumar et al; 1985 and Katung, 1997). Similarly defoliation at 8 and 10 WAS adversely affected the pods/seed yield. It therefore means that kenaf is severely affected both ways; when defoliated at early vegetative and early reproductive stages and therefore the control of pests and diseases which may reduce considerably the leaf area of the plant at these stages should be timely.

5.3 Effect Of Level of Defoliation On Growth And Yield Of Kenaf

Level of defoliation significantly affected all the growth and yield parameters in both years of the study except days to 50 percent flowering. The study show that kenaf crop was severely affected more by removing the upper leaves than by removing the lower leaves, indicating that the upper leaves are more crucial or important for growth and yield of kenaf than the lower leaves. This is probably because the upper leaves are relatively younger and more exposed to light and therefore more photsynthetic efficient than the lower older leaves. Buerlain and Pendleton (1971), attributed the greater photosynthetic rate of the upper leaves of plant to their younger age and better adaptation to high light. It is thus entirely feasible that a given unit area of leaf surface on the upper part of the kenaf crop would have a considerably higher net photosynthetic rate and therefore contribute more assimilate to the crop than would a unit area of leaf surface on the lower part of the plant. It has been reported that the lower leaves of plants because of age, declined in ability to fix CO_2 and presumably contribute less to photsynthesis than the upper leaves (Ojima et al, 1965). Furthermore, since the lower leaves are most often shaded by the upper leaves, it is possible that their rate of respiration may exceed their photosynthesis and therefore becomes parasitic to the crop and contribute less assimilate. Moreover senescence mostly starts from the lower and older leaves (Iremiren, 1987).

Buerlain and Pendleton (1971), observed that the lower (and older) leaves in a soybean canopy tended to lose their adaptation to high light and had a lower photosynthetic response than did leaves continuously exposed to full sun. This probably accounted for the reason why removing the lower leaves of kenaf in this study did not severely affect growth and yield but even led to a significant increase in parameters like plant height in 2000, pod diameter and pod length probably due to an increase in the photosynthetic efficiency of the remaining upper leaves. Dungan (1942), Kieselbach and Lyness (1945) have all reported that in maize, the remaining upper leaves functioned more efficiently after defoliation due to increase in competition and photosynthetic efficiency.

The practical implication of this result is that since kenaf growers may want to remove leaves of kenaf either as vegetable or feeding of livestock, removing the upper leaves or complete defoliation should be avoided.

5.4 Interactions

Ribbon yield and stem dry weights were significantly reduced when all the leaves on the plant or when the leaves on the upper half of the plant only were removed at 4 WAS. This is because removing the upper leaves might have the same effect as removing all the leaves on the crop since the upper leaves seems to be more crucial for growth and development. And at 4 WAS, the crop was at its early vegetative stage and therefore upper leaves removal or complete defoliation will reduce the amount of photosynthate that would have been accumulated on the main stem and side branches which would have reflected in ribbon yield and stem dry weight.

Similarly number of seeds per pod and seed yield were significantly reduced when all the leaves on the crop or when the leaves on the upper half of the crop were removed at 8 and 10 WAS because these stages coincides with the reproductive stage of the crop and the process of assimilate partitioning from the upper leaves or all the leaves was greatly affected due to the defoliation.

The practical implication is that for fibre production, any activity, for example insect pest and disease attack leading to defoliation at 4 WAS will definitely reduce fibre production and at 8 and 10 WAS will definitely reduce seed production of kenaf.

Therefore for high fibre and seed yield, kenaf crop should be sprayed with appropriate insecticides and fungicides at about 4 and 8 WAS in order to preserve or protect the leaves. These findings are consistent with those of Iremiren (1987), who reported that in Okra, defoliating the upper half or complete defoliation during the first eight weeks adversely affected the growth and yield, but defoliation at later stages did not show such adverse effect probably because conspicuous vegetative growth and the initiation and development of most of the flower buds had already taken place before defoliation occurred.

One important observation in this study is that removing the lower leaves of kenaf at 6 WAS led to an increase in some parameters like plant height, which has been found to be positively correlated to fibre yield (Dempsey, 1972; Lagoke et al; 1981 and Katung, 1997) and the number of seeds per pod which has been found to be positively correlated with seed yield (Idem, 1982). Therefore 6 WAS could be a time when the crop enters a grand growth period coinciding with a rapid increase in photosynthetic surface and therefore, removing the lower leaves might have enhanced the photosynthetic efficiency of the remaining upper leaves. Singh and Nair (1975) observed that in maize, even 100 percent defoliation done at the 10^{th} fully expanded leaf stage produced fairly higher stover yield due to rapid regeneration of leaves compared to defoliation done at earlier and later stages.

This result show that a moderate removal of the lower leaves of kenaf at 6 WAS should be encouraged because this might even be beneficial for fibre and seed production

5.5 Correlation Analysis

There were significant positive phenotypic correlation between ribbon weight, plant height and stem girth. This suggest that the taller the plant and the bigger the stem the more the fibre yield.

The number of seeds per pod was positively correlated with pod diameter but negatively correlated with pod length indicating that with wider pod, more space is provided for seeds. Such wider pods also have larger seeds as indicated by the significant positive correlation between the two characters.

Positive correlation between ribbon yield and plant height, bud diameter and wood yield of kenaf have also been reported by Lagoke et al. (1981), Kumar et al. (1985) and Katung (1997). Similar relationship between yield and growth characters of Okra and Tomato were observed by Adejonwo (1988) and Adigun (1991) respectively.

In this study, the positive relationships indicate that vigorous growth and thick stem favours fibre and seed yields of kenaf. And that fibre production is also linked with seed yield. Breeding kenaf for seed and fibre production should therefore aim at producing plants that are tall and have thick stems.

CHAPTER 6 SUMMARY AND CONCLUSION

Two field experiments were conducted at the research farm of the Institute for Agricultural Research, Samaru, Nigeria during the 1999 and 2000 wet seasons. The aim was to study the effect of time and level of defoliation on the growth and yield of kenaf.

The experiment was laid out in a split plot design and replicated three times. The main plot treatments were time of defoliation (4, 6, 8 and 10 weeks after sowing); while the subplot treatments were level of defoliation (control without defoliation, half the lower leaves removed, half the upper leaves removed and complete defoliation).

The results obtained showed that growth and yield of kenaf were significantly affected by time and level of defoliation. Defoliation at 4 WAS reduced plant height, stem girth, stem and ribbon dry weight. Similarly defoliation at 8 and 10 WAS reduced the number of pods/plant, number of seeds per pod and seed weight. The result also indicated that growth and yield of kenaf were significantly reduced more by removing the upper leaves than by removing the lower leaves.

Significant interactions between time and level of defoliation occurred for all parameters measured in this study except number of days to 50 percent flowering. Stem and ribbon dry weight were reduced significantly when the upper leaves and all the leaves on the crop were removed at 4 WAS. Similarly, number of seeds per pod and seed weight were reduced significantly when all the leaves on the crop or when the upper leaves were removed at 8 and 10

WAS.

The results also showed that there were significant positive correlation between ribbon yield and plant height and butt diameter of kenaf. The number of seeds per pod was also positively correlated with pod diameter but negatively correlated with pod length.

From all the results obtained from this study, the following conclusions can be made:

1. Defoliation at 4 WAS will reduce fibre yield while defoliation at 8 and 10 WAS will reduce the seed yield of kenaf.
2. Defoliation at 6 WAS might be beneficial to kenaf.
3. Defoliation of the upper leaves or complete removal of the plant leaves will reduce both fibre and seed yield of kenaf.

Based on these, it is suggested that for high fibre and seed yields of kenaf the crop should be sprayed against insect pest attack on the leaves at 4 WAS.

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APPENDIX 1

RAINFALL AND TEMPRATURE DATA (1999 SEASON)

Month	Temperature Average	Temperature Total	Rainfall
January	32.3	1031	00mm
Feb.	35.6	996	00mm
March	38.4	1190	TR
April	37. 0	1128	7.9mm
May	35. 8	1111	23.4mm
June	32.2	966	238. 2mm
July	29.8	925	285.5mm
August	29.8	883	154.8mm
Sept	29.9	897	204.2mm
Oct.	31.9	989	38.4mm
Nov.	32. 8	984	00.mm
Dec	31.2	986	00.mm

TR= Trace.

Appendix II

RAINFALL AND TEMPRATURE DATA (2000)

	TEMP		RAINFALL
Months	Total	Average	
Jan	1009	32.6	00mm
Feb	1114	38.4	00mm
March	1145	36.9	00mm
April	1186	39.6	TR
May	1147	37	159.5
June	953	31.8	193.4
July	935	30.1	221.3
August	907	29.3	245.2
Sept	930	31	182.1
Oct	1011	32.6	78.0mm
Nov	994	33.1	00mm
Dec	968	31	00mm

TR = Trace