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RESPONSE OF SOME KENAF (*HIBISCUS CANNABINUS* L.) CULTIVARS TO PLANT DENSITY AND NITROGEN FERTILIZATION

Hussein, M.M.M.
Fiber Crops Res. Sec., Field Crops Research Institute, ARC, Giza, Egypt.

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ABSTRACT: Two field experiments were carried out as split split plot design with four replicates in the Experimental Farm of Kafr El-Hamam Agric. Res. Station, El-Sharkia governorate Egypt, during the two successive summer seasons of 2007 and 2008. Quantitative and qualitative crop characters of the three kenaf cultivars (Tianung, Hindi and Giza3) as responded to nitrogen levels (20, 40 and 60kg N/fed) under three plant densities (25,50 and 75 plants/m^2) were studied.

The combined analysis for the results showed significant differences among three kenaf cultivars under study. Tianung cultivar was superior in green yield characters followed by Hindi cultivar and the local cultivar Giza3 in descending order. On the other hand, the local cultivar Giza3 outyielded significantly the other two kenaf cultivars in seed yield characters. Hindi cultivar ranked intermediate position in all studied traits between Tianung and Giza 3 cultivars. The plant density (50 plants/m^2) caused remarkable increase in all studied characters. The greatest nitrogen level i.e., 60kg/fed achieved significant increase in green yield characters, however, 40 kg N/fed. was recommended to produce the best seed yield characters. Cultivar (C) × plant density (D) interaction had a significant effect on green yield/fed, and fiber fineness. Cultivar (C) × nitrogen (N) interaction had a significant effect on fiber fineness and oil yield/fed. D×N interaction had a significant effect on seed and oil yields/fed.

Correlation coefficient was highly significant and positive between green yield/fed and each of green yield/plant, plant height, technical length, fiber length and fiber yield/fed. However, seed yield/fed was highly significant and positive correlated with seed yield/ plant, oil yield/ fed., No. of capsules/plant, No. of seeds/capsule and 1000 seed weight.

Key words: Kenaf cultivars (*Hibiscus cannabinus* L.), plant density, nitrogen fertilization, yield, yield components, fiber and seed properties, correlation.

INTRODUCTION

Kenaf (*Hibiscus cannabinus,* L) is a herbaceous, warm season, annual autoallogamous plant of the Malvaceae Family, well adapted to different environments .It is a rapidly growing annual crop of great interest as a source for low cost natural fiber and as feed stock for energy production. As fibrous crop kenaf appears to have enormous potential to become a valuable biomass crop for the future. The kenaf stem is composed of an internal crop comprising 60–75% of the dry weight and outer bast stem totaling 25 – 40%. Recent research has demonstrated numerous potential uses for each of these two materials, which often must be separated from each other. Products from the kenaf core include oil/chemical absorbents bedding materials from animals and insulation paneling. The main product of kenaf bast fibers in paper, which the whole plant has high protein and good digestibility and may be palletized. It is will known that kenaf stem consists of two fractions, bark and core, which distinguished by their anatomical characteristics and chemical composition and considered as two distinct types of raw materials. The bark is readity and produces a high quality pulp comparable to that produced from soft – woods, whereas the core richer in lignin, gives pulps with poor strength characteristics (Watson et al 1976). In many countries of the world, kenaf is produced as a successful substitute of jute to obtaining fiber for paper pulp production (Alba 1993). It proved to be adaptable to a wide variation of conditions.

The physical properties of kenaf fiber enable it to be applicable in nearly all applications where jute is now used and it can be spun and woven on jute machinery. In Egypt, kenaf is considered as an important member of the bast crops group, where its fibers are isolate from other stem tissues by a retting process. Kenaf is grown to obtain facturing burlap, sacks and twine. Moreover, kenaf seeds contain similar oil which extracted from cotton seeds as edible for human use, it is better than cotton seed oil because it is free from gossipole poison material which found in cotton seed oil.

Nowadays, Egypt promotes culture kenaf to minimize hard currency paid annually for jute fiber importation. In addition, kenaf is more tolerant to relatively high soil salinity and is more adapted to different soil types than most other summer crops. Kenaf in Egypt is cultivated now on small area so, it is essential therefore, most work in the plant breeding program is to develop to create new recommended varieties which surpass that commercial cultivars. In addition to developing of kenaf for high yielding ability, Kenaf varieties according to their reaction to flowering are divided to early and late maturity varieties. In most of recent research works, $Tianung_2$ produced the greatest stalk yields with dry stalk yields normally ranging from 11 to 18 ton/ha. Many investigators studied the differences between kenaf cultivars such as Momtaz et al (1979), Muchow (1979a,b), Salih (1981), Osman and Momtaz (1982), Sij and Turner (1988) , El-Kady et al (1990) , El-Shimy et al (1990), Nafees et al., (1993), Webber et al (1993), El-Kady and El-Sweify (1995), Mambelli and Grandi (1995), Manzanares et al., (1996), El-Farouk and El-Sweify (1998), Mostafa (2003), Alexopoulou et al (2007) and Kipriotis et al (2007).

Plant density is one of the most important aspects directly related to fiber yield in kenaf. The optimum plant density has not been determined with precision and cane vary with the mechanization system available and fiber use. Muchow (1979 a, b) studied the response of kenaf cv. $Guantemala_4$ over a range of densities 100,000 to 900,000 plants/ha. under irrigated tropical conditions and did not detect a significant differences for yield. Researchers in Spain reported that the best pant density was 400,000 plant/ha. (Manzanares et al (1996). The optimum plant density to produce the maximum yield can also vary within cultivars. Campbell and White (1982) in Maryland (USA) found that cultivar Cuba2032 required a plant density of 500,000 to 700,000 plants/ha. for maximum yields. Bukhtiar et al (1990) proposed 444,000 plants/ha as the optimum plant density for fiber production. Webber et al (2001) describing kenaf production, mentioned the final plant density of 185,000 to 370,000 plants/ha as the desirable for maximum yields. Mostafa (2003) concluded that a plant population of 126,000 plant/fed (3 plants/hill) from the promising strain 105/16-2 gave the best quantity and quality of kenaf fiber in sandy soil. Also Acreche et al (2005) sown kenaf cultivars (Cuba 108, Endor and Tianung 1) with 20 and 40 plants/m^2 and concluded that 40 plants/m^2 resulted in the best dry bark and fiber quality.

Nitrogen is referred as balance wheel of plant nutrition, it has an active role to raise the efficiency of other nutrients as well as raising kenaf productivity. Nitrogen is the nutrient element frequently deficient in Egyptian soil. Therefore, adequate supply of nitrogen is essential for optimum yield and quality of kenaf. One of advantages of the crop is it can be successfully grown in a wide range of soil types from high organic peat soil to sandy desert soils. Although kenaf grows better on well drained fertile soils with a neutral PH, the crop can with stand late season flooding, low soil fertility and a wide range of soil PH values. As with other crops proper fertility maintenance especially for supplemental nitrogen application is needed to optimum to optimize kenaf yields and minimize production cost.

Concerning the response of kenaf to N fertilization, several authors found significant increase in yield and quality of kenaf due to the increase of N levels up to 40 and 60 kg N/fed

(Massey 1974; Momtaz et al 1978 and 1979; Adamson et al., 1979; Salih 1981; Bhangoo et al., 1986; Sahsah et al., 1986; Sij and Turner 1988; Manzanares et al., 1996; Wibber 1996; Alexopoulou et al 2007 and Kipriotis et al 2007). In all these response, the significant increase of yield and quality was attributed to the significant increase of N fertilization.

Therefore, the main objectives of the present investigation were to study yield and quality of three kenaf cultivars, namely Tianung, Hindi and Giza 3 as affected by plant density and nitrogen fertilization in order to find out the optimum plant density and nitrogen fertilization level for more fiber and seed production, in addition to obtaine great fiber and seed properties as responded to such agronomic practices.

MATERIALS AND METHODS

For maximizing the productivity and quality of kenaf crop in clay soil, two field experiments were conducted during the two successive summer seasons 2007 and 2008 at the Experimental Farm of Kafr El-Hamam Agric. Res. Station, El-Sharkia Governorate, Egypt. This site is located at 30°-35 N latitude and 30°-57 É longitude with an elevation of about 7 meters above mean sea level. This location represents the conditions and circumstances of East Nile Delta Region. Soil of experimental site was clay in texture physical and chemical analysis of the experimental field (0-30 cm depth) at the two summer seasons of 2007 and 2008 are presented in Table 1.

Table1.Some physical and chemical properties of the experimental sites

Soil analysis	2007 season	2008 season
I. Physical analysis		
Clay	44..87	45.60
Silt	29.10	30.50
Sand	26.03	23.90
Organic matter	1.97	2.57
$CaCO_3$	3.26	2.50
$ECdsm^{-1}$	1.45	1.26
Soil type	Clay	Clay
II. Chemical analysis		
PH	8.15	7.49
Available N (ppm)	67.95	75.55
Available P (ppm)	19.35	21.23
Available K (ppm)	299.36	325.65

The experiment included 27 treatments which were the combination of the three kenaf cultivars (Tianung, imported from Nigeria; Hindi imported from India and Giza 3 local cultivar, respectively), the three plant densities 25, 50 and 75 plants/m² in addition to, the three nitrogen levels 20, 40 and 60 kg N/fed. Phosphorus and potassium fertilizers were applied as basal dressing at sowing as super phosphate (15.5 % P_2O_5) and potassium sulphate (48 % K_2O), respectively. Nitrogen was added in the form of amonium nitrate 33.5 % N in three splits given at 15 days by interval at 15, 30 and 45 days after sowing. Irrigation was practiced using flooding irrigation. Kenaf followed by wheat in the first season and Egyptian clover in the second one respectively. A split split plot design with four replications was used where the main plots were occupied by the three kenaf cultivars, whereas plant density and N levels were allotted in the first and second sub plots, respectively. The experimental unit area was 10.5m^2 (3 × 3.5m) including 7 ridges, spacing were 50cm between ridges. Cultivation was done on one side of the ridge on 23 and 25 May in the first and second seasons, respectively. Each hill was sown with about five seeds and it was thinned to two plants / hill followed by fertilization. The distance between hills according to the following experimental factors as follows:-

1-21cm between hills (25 plants/m^2) a plant density of 126984 plants/ fed.

2-14cm between hills (50 plants/m^2) a plant density of 188476 plants/ fed.

3-7cm between hills (75 plants/m^2) a plant density of 380952 plants/ fed.

Weed control was carried out manually with the first weeding at 2 weeks after planting (2 WAP), which was later followed by two additional weeding at 4 and 6 WAP. The other cultural practices for growing kenaf under these conditions were applied. At maturity stage ten random guarded plants from each plot were taken to be used in measurements of yield components. In addition the central three ridges in each plot were harvested to estimate seed and green yield per unit area then, calculated seed and green yields per feddan and after retted obtain fiber yield. The retting process made in Fiber Crops, Research Section, Field Crops Research Institute, ARC to extract kenaf fiber and study its quantity and quality parameters.

Characters Studied

Green yield and its components

Plant height (cm), technical length (cm), fruiting zone length (cm), stem diameter (mm), green yield/plant (g), green yield/fed (tons) and fiber yield/fed (tons).

Seed yield and its components

No. of capsules/ plant, No. of seeds/capsule, 1000 seed weight (g), seed yield/ plant (g), seed yield/fed (kg) and oil yield/fed (kg).

Fiber and seed properties

Fiber length (cm), fiber percentage, fiber fineness (N.m) calculated according to Radwan and Momtaz (1966). Oil and fiber content were determined by A.O.A.C (1980).

Statistical Analysis

Data were statistically analyzed according to the procedure mentioned by Snedecor and Cochran (1982) as a split split plot design. Combined analysis was performed for each character over the two seasons as described by LeClerg et al (1966).The differences between means were compared according to Duncan's new multiple range test (Duncan 1955).

Correlation studies

Correlation coefficients were computed between green and seed yields as well as some of their attributed characters i.e. green yield/plant, plant height, technical length, stem diameter, fiber length, fiber yield/fed, seed yield/fed, seed yield/plant, oil yield/fed, number of capsules/ plant, number of seeds/ capsule and 1000 seed weight. Average mean of the two seasons for the studied kenaf cultivars as affected by plant density and nitrogen fertilization were employed for each character in the combined analysis for the two seasons to calculate person correlation coefficient (r) using following equation:

$$r = SPxy/\sqrt{(SSx \times SSy)}$$

$SPxy = \Sigma xy - (\Sigma x.\Sigma y)/n$, $SSx = \Sigma x^2 - (\Sigma x)^2/n$ and $SSy = \Sigma xy - (\Sigma y)^2/n$

The tabulated (r) value was used to test the significancyof (r) value with degree of freedom(n-2).

RESULTS AND DESCUTIONS

Green Yield and its Components

Results in Table 2 show mean values of three kenaf cultivars as affected by plant density and nitrogen levels in the two growing seasons and their combined analysis.

Cultivar differences

Analysis of variance indicated that the three kenaf cultivars varied significantly in green yield/fed and all of its attributed characters. Tianung cultivar ranked first and surpassed significantly the other two kenaf cultivars and produced the highest values of plant height, technical length, green yield/plant, green yield/fed and fiber yield/fed. Opposite results were recorded with regard to fruiting zone length and stem diameter. The superiority ratios for Tianung cultivar over Giza 3 cultivar were 10.41, 15.71, 25.16, 28.22 and 69.37 % for the five green traits as average for the two seasons, respectively. However Giza3 cultivar recorded the highest estimate for fruiting zone length and stem diameter traits and superior Tianung cultivar by 12.95 and 30.86 % as average for the two seasons, respectively. The cultivars differences in green characters are might be due to differences in genetic constitution of the studied cultivars. Several workers reported significant cultivars differences in green yield components and yield potentiality among kenaf cultivars (Momtaz et al 1979; Muchow et al., 1979 a, b; Salih 1981; Osman and Momtaz 1982; Sij and Turner 1988; Nafees et al., 1993; Webber 1993; El-Kady et al 1990; El-Shimy et al 1990; El-Kady and El-Sweify 1995; Mambelli and Grandi 1995; Manzanares et al 1996; El-Farouk and El-Swefy 1998; Mostafa 2003; Alexopoulou et al 2007 and Kipriotis et al 2007.

Plant density

Results in Table 2 show that plant density significantly affected all green characters in the two seasons and their combined. Plant height, technical length, green yield /fed and fiber yield /fed were significantly increased by increasing plant density from 25 up to 75 plants /m² as average for the two,

Table 2. Mean values of plant height, technical length, fruiting zone length and stem diameter for three kenaf cultivars as responded to plant density and nitrogen fertilization in 2007 and 2008 summer seasons and their combined analysis

Characters / Treatments and interaction	Plant height (cm)			Technical length (cm)			Fruiting zone length (cm)			Stem diameter (mm)		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Cultivars (c):												
C_1: Tianung	364.21a	373.24a	368.73a	313.05a	317.89a	315.47a	51.16b	55.35b	53.26c	10.05c	11.63b	10.84c
C_2: Hindi	338.84b	348.41b	343.63b	279.28b	287.16b	283.22b	59.56a	61.25a	60.41b	12.50b	13.68b	13.09b
C_3: $Giza_3$	327.77c	340.17b	333.97c	267.49c	277.78c	272.64c	60.28a	62.39a	61.34a	14.52a	16.84a	15.68a
F. test	**	*	**	**	**	**	*	*	**	**	*	**
Plant density (D):												
D_1: 25 plants/m^2	326.32b	338.13b	332.23c	262.52c	271.00b	266.76c	63.80a	67.13a	65.47a	13.62a	15.06a	14.34a
D_2: 50 plants/m^2	349.98a	360.49a	355.24b	293.53b	302.27a	297.90b	56.45b	58.22b	57.34b	12.31ab	13.95ab	13.13b
D_3: 75 plants/m^2	354.53a	363.21a	358.87a	303.77a	309.56a	306.67a	50.76c	53.65b	52.21c	11.14b	13.14b	12.14b
F. test	*	*	**	**	*	**	**	*	**	*	*	**
Nitrogen levels (N):												
N_1: 20kg N/fed	325.32c	338.24c	331.78c	265.97c	276.79c	271.38c	59.35a	61.45a	60.40a	10.41b	12.21b	11.31c
N_2: 40 kg N/fed	348.69b	358.09b	353.39b	291.39b	297.93b	294.66b	57.30a	60.16a	58.73b	13.19a	17.70a	13.95b
N_3: 60 kg N/fed	356.81a	365.49a	361.15a	302.46a	308.11a	305.29a	54.35b	57.38b	55.87c	13.47a	15.23a	14.35a
F. test	**	**	**	**	**	**	*	*	**	*	*	**
Interaction:												
C×D	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
C×N	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
D×N	N.S	*	N.S	N.S	*	N.S	N.S	N.S	N.S	*	N.S	N.S
C×D×N	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 2. Cont.

Treatments and interaction \ Characters	Green yield/plant (g)			Green yield/fed (ton)			Fiber yield/fed (ton)		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Cultivars (c):									
C_1: Tianung	188.80a	222.45a	205.63a	19.300a	21.168a	20.234a	1.069a	1.231a	1.150a
C_2: Hindi	162.22b	208.91b	185.57b	16.808b	19.377b	18.093b	0.815b	1.021a	0.918b
C_3: $Giza_3$	144.71c	183.89c	164.30c	15.318c	16.243c	15.781c	0.643b	0.715b	0.619c
F. test	**	**	**	*	**	**	*	**	**
Plant density (D):									
D_1: 25 plants/m^2	182.91a	213.19a	198.05a	16.102b	17.657b	16.880b	0.658b	0.788b	0.723b
D_2: 50 plants/m^2	158.83b	201.12b	179.98b	17.318a	19.242a	18.280a	0.895a	1.040a	0.968a
D_3: 75 plants/m^2	153.98b	200.94b	177.46b	18.007a	19.889a	18.948a	0.975a	1.139a	1.057a
F. test	*	*	**	**	**	**	**	**	**
Nitrogen levels (N):									
N_1: 20kg N/fed	152.46b	180.02c	166.24c	15.178b	15.718b	15.448c	0.595b	0.676b	0.636c
N_2: 40 kg N/fed	169.34a	214.60b	191.97b	17.439a	20.299a	19.119b	0.940a	1.112a	1.026b
N_3: 60 kg N/fed	173.93a	220.63a	197.28a	18.311a	20.771a	19.541a	0.993a	1.179a	1.086a
F. test	*	**	**	**	**	**	**	*	**
Interaction:									
C×D	*	N.S	N.S	*	*	**	N.S	N.S	N.S
C×N	*	N.S	N.S	*	N.S	N.S	*	N.S	N.S
D×N	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
C×D×N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

seasons. The excess percentage from the combined analysis between the highest and the lowest plant density for the four green traits were 8.02, 14.96, 12.25 and 46.20%, respectively. However fruiting zone length, stem diameter and green yield / plant traits were decreases by 20.25, 15.34 and 10.40%, respectively as average for the two seasons. The increase in plant height and technical length /plant with increasing plant density was might be due to the competition among plants for light. Moreover, the increase in green yield /fed as well as fiber yield/fed may be due to the increase in number of plants per unit area. Similar findings were reported by Massey (1974), Momtaz et al (1978), Muchow et al (1979 a, b), Campbell and White (1982), Sahsah et al (1986), Bhangoo et al (1986), Amaducci et al (1990) Bukhtiar et al (1990), Nafees et al (1993), Bajpal et al(1994), Manzanares et al., (1996), El-Farouk and El-Sweify (1998),Webber et al., (2001), Mostafa (2003) and Acreche et al (2005).

Nitrogen level effect

Nitrogen increment produced a significant increase in green yield and its components except fruiting zone length which decreased significantly with increasing nitrogen levels. Plant height, technical length, stem diameter, green yield/plant, green yield/fed and fiber yield/ fed were increased significantly with increasing nitrogen levels from 20 up to 60 kg N/fed. The increments as a ratios from the combined analysis between the maximum dose and the minimum one were 8.85, 12.50, 26.88, 18.67, 26.50 and 70.75 % for the six traits as average for the two seasons, respectively. However, fruiting zone length was decreased by 7.5 % with increasing nitrogen levels. These results could be explained the favourable effect of nitrogen element which attributed to the increase in cells number, size and merestimatic activity, as well as increase the internodes, finally plant growth and green yield of kenaf crop. Several authors found significant increase in yield and yield attributes of kenaf crop (Massey 1974; Momtaz et al., 1977 and 1978; Adamson et al 1979; Salih 1981; Bhangoo et al (1986); Sahsah et al., 1986; Manzanares et al., 1996; Webber 1996; Alexopoulou et al., 2007 and Kipriotis et al., 2007).

Seed Yield and its Components:

Mean values of seed yield and its components of three kenaf cultivars as affected by plant density and nitrogen levels in 2007 and 2008 seasons as well as their combined analysis are presented in Table 3.

Cultivar differences

Statistical analysis of variance showed significant differences among mean values of the three kenaf cultivars in number of capsules / plant, number of seeds/capsule, 1000 seed weight, seed yield/fed and oil yield/fed. $Giza_3$ cultivar ranked first and surpassed significantly the other two kenaf cultivars and recorded the

Table 3. Mean values of number of capsules / plant, number of seeds / capsule and 1000 seed weight for three kenaf cultivars as responded to plant density and nitrogen fertilization in 2007 and 2008 summer seasons and their combined analysis

Characters / Treatments and interaction	Number of capsules / plant			Number of seeds / capsule			1000 seed weight (g)		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Cultivars (c):									
C_1: Tianung	44.91c	46.25b	45.58c	12.58b	14.92c	13.75c	21.13b	22.08b	21.61c
C_2: Hindi	49.03b	49.98b	49.51b	15.43a	18.13b	16.78b	22.20b	23.86b	23.03
C_3: $Giza_3$	55.03a	59.52a	57.28a	16.70a	21.05a	18.88a	24.56a	26.02a	25.29a
F. test	**	*	**	*	**	**	*	**	**
Plant density (D):									
D_1: 25 plants/m^2	53.09a	55.70a	54.40a	16.05a	18.78a	17.40a	23.96a	25.07a	24.52a
D_2: 50 plants/m^2	48.13b	50.43b	49.28b	14.72b	17.73b	16.33b	22.41b	24.08b	23.25b
D_3: 75 plants/m^2	47.75b	49.62b	48.69b	13.94b	17.63b	15.79b	21.52b	22.81c	22.17c
F. test	*	*	**	*	*	**	*	**	**
Nitrogen levels (N):									
N_1: 20kg N/fed	46.25b	49.40b	47.88b	14.41c	17.24b	15.83b	21.59b	22.69b	22.14b
N_2: 40 kg N/fed	50.37a	52.46a	51.42a	14.90b	18.24a	16.57a	23.05a	24.44a	23.75a
N_3: 60 kg N/fed	52.25a	53.88a	53.07a	15.40a	18.62a	17.01a	23.25a	24.84a	24.05a
F. test	*	*	**	**	*	**	*	*	*
Interaction:									
C×D	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
C×N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
D×N	N,S	N,S	N,S	N,S	N,S	N,S	N,S	N,S	N,S
C×D×N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 3. Cont.

Treatments and interaction \ Characters	Seed yield plant (g)			Seed yield / fed (kg)			Oil yield / fed (kg)		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Cultivars (c):									
C_1: Tianung	17.25c	17.90c	17.90c	184.74c	188.51c	186.63c	30.88c	33.28c	32.08c
C_2: Hindi	23.55b	24.89b	24.22b	223.75b	237.01b	230.38b	45.59b	50.48b	48.04b
C_3: $Giza_3$	27.46a	28.40a	27.93a	290.80a	301.27a	296.04a	62.08a	67.40a	64.74a
F. test	**	**	**	**	**	**	**	**	**
Plant density (D):									
D_1: 25 plants/m^2	24.24a	25.05a	24.65a	200.83b	213.63b	207.23b	38.04b	42.72b	40.38b
D_2: 50 plants/m^2	22.39b	23.35b	22.87b	245.37a	254.21a	249.79a	48.74a	52.85a	50.80a
D_3: 75 plants/m^2	21.64b	22.79b	22.22b	253.10a	258.94a	256.02a	51.77a	55.59a	53.68a
F. test	*	*	*	**	**	**	**	**	**
Nitrogen levels (N):									
N_1: 20kg N/fed	21.08b	22.33c	21.68b	192.18b	203.17b	197.68b	36.41b	40.42b	38.42b
N_2: 40 kg N/fed	22.92a	23.74b	23.33a	250.48a	259.27a	254.88a	49.93a	54.37a	52.15a
N_3: 60 kg N/fed	24.31a	25.13a	24.72a	256.64a	264.34a	260.49a	52.21a	56.37a	54.29a
F. test	*	**	**	**	**	**	**	*	**
Interaction:									
C×D	N.S	N.S	N.S	N.S	*	N.S	*	N.S	N.S
C×N	N.S	N.S	N.S	N.S	*	N.S	**	*	**
D×N	N,S	N,S	N,S	**	*	**	*	**	**
C×D×N	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S

highest estimates of seed characters under study. The superiority ratios of $Giza_3$ over Tianung cultivar from the combined analysis for the two seasons were 25.67, 37.09, 17.03, 58.87 and 101.81 % for the previous traits, respectively. It could be concluded that these differences between kenaf cultivars may be due to variability in genetic constituents of the studied cultivars. Similar results are in accordance with those of Momtaz et al (1979), Muchow (1979a,b), Salih (1981), Osman and Momtaz (1982), El-Kady et al (1990), El-Shimy et al (1990), Nafees et al., (1993), El-Kady and El-Sweify (1995), Mambelli and Grandi (1995), Manzanares et al., (1996), El-Farouk and El-Sweify (1998), Mostafa (2003), Alexopoulou et al (2007) and Kipriotis et al (2007).

Plant density

Analysis of variance for data presented in Table 3 showed significant reduction in number of capsules/ plant, number of seeds/ capsule, 1000 seed weight and seed yield/ plant with increasing plant density in both seasons and their combined without significant reduction between 50 and 75 plants /m^2 for the four previous traits. The decrement as a ratios from the combined analysis between the maximum plant density and the minimum one were 10.50, 9.25, 9.58 and 9.86 % for the four previous traits, respectively. These results may be due to more competition among relatively more plant per unit area to researching for nutrients and water. On the other hand, seed yield/fed and oil yield/ fed were increased significantly with increasing plant density from 25 up to 75 plants/m^2, without significant differences between 50 and 75 plants/m^2 for the two abovementioned traits in the two seasons and over them. The superiority ratios between the highest plant density and the lowest one were 23.54 and 32.94 % for seed and oil yields/fed traits as average for the two seasons, respectively. The increments in seed yield/fed as well as oil yield/fed with increasing plant density may be due to the increase in number of plant per unit area. These findings are in similar trend with those of Massey (1974), Momtaz et al (1978), Muchow (1979 a, b), Campbell and White (1982), Bhangoo et al (1986), Sahsah et al (1986), Amaducci et al (1990), Bukhtiar et al (1990), Nafees et al (1993), Bajpal et al (1994), El-Farouk and El-Sweify (1998), Manzanares et al., (1996), Webber et al., (2001), Mostafa (2003) and Acreche et al (2005).

Nitrogen level effect

In both seasons and their combined each N increment up to the addition of 60 kgN/fed yielded a significant increase in all seed characters i.e. number of capsules / plant, number of seeds/capsule, 1000 seed weight, seed yield/plant, seed yield/fed and oil yield/ fed, without significant differences between added 40 and 60 kg N/fed for all studied seed characters as average for the two seasons, respectively. The increments as ratios from the combined analysis between the maximum dose and the minimum one were 10.84, 7.45, 8.63, 14.02, 31.77 and 41.31 % for the six previous traits, respectively. It is clear that seed yield and its components recorded response to moderate level of nitrogen (40 kg N/fed), that was enough for produce high seed yield and its components under the condition of this study. On the other hand, there was a progressive and constant increase in number of capsules/plant, number of seed per capsule, 1000 seed weight and seed yield/fed with increase in the amount of nitrogen fertilization in both seasons. This show that the soil nitrogen content is not enough to kenaf requirement. However, nitrogen may increase the leaf area and consequently increase the amount of light energy intercepted by leaves partitioned to fruiting organs. This accounts for the increase in the amount of metabolites synthesized by plants and this owen much to the increase in number of branches, number of capsules /plant and number of seeds /capsule leading to the increase in seed yield. These results are in accordance with those of Massey (1974), Momtaz et al (1977 and 1978), Adamson et al (1979), Salih (1981), Bhangoo et al (1986), Sij and Turner (1988), Manzanaers et al., (1996), Webber et al (1996), Alexopoulou et al., (2007) and Kipriotis et al., (2007).

Fiber and Seed Properties

Mean values of fiber and seed properties for three kenaf cultivars as affected by plant density and nitrogen fertilization in 2007 and 2008 seasons and their combined analysis are presented in Table 4.

Cultivar differences

Analysis of variance show significant effect of cultivars on fiber and seed properties. The foreign cultivar Tianung was the best one for technological properties of kenaf fiber with mean values of 300.64 cm, 5.59 % and 144.47 N.m for fiber length, fiber percentage and fiber fineness traits as average for the two seasons, respectively. The superiority ratios for Tianung cultivar over $Giza_3$ cultivar were 15.58, 24.69 and 17.34 % for fiber length, fiber percentage and fiber fineness traits as average for the two seasons, respectively. Moreover $Giza_3$ cultivar surpassed the other foreign two kenaf cultivars for seed oil percentage being 21.81 %. On the other hand, the superiority ratios between the first cultivar (Tianung) and the second one (Hindi) were 10.20, 11.09 and 13.14 %, for fiber length, fiber % and fiber fineness traits, respectively as average for both seasons. However these superiority ratios reach to 17.92 % for seed oil percentage between Tianung and Hindi cultivars as average for both seasons also. Similar results were reported by Momtaz et al., (1979), Muchow (1979a, b), Salih (1981), Osman and Momtaz (1982), Sij and Turner (1988), El-Kady et al., (1990),

Table 4. Mean values of fiber and seed properties for three kenaf cultivars as responded to plant density and nitrogen fertilization in 2007 and 2008 summer seasons and their combined analysis

Characters / Treatments and interaction	Fiber length (cm)			Fiber percentage			Fiber fineness (N.m)			Oil percentage		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Cultivars (c):												
C_1: Tianung	293.70a	307.58a	300.64a	5.44a	5.74a	5.59a	138.50a	150.44a	144.47a	16.50b	17.48b	16.99b
C_2: Hindi	262.66b	277.30b	269.98b	4.79ab	5.15ab	4.97ab	121.62b	129.33b	125.48b	20.23a	21.17a	20.70a
C_3: $Giza_3$	244.85c	262.75c	253.80c	4.12b	4.29b	4.21b	116.06c	122.78c	119.42c	21.30a	22.15a	21.73a
F. test	**	**	**	*	*	*	**	**	**	*	*	**
Plant density (D):												
D_1: 25 plants/m²	255.66c	270.32b	262.99c	3.98b	4.32b	4.15b	119.11c	125.18b	122.15c	18.46b	19.38b	18.92b
D_2: 50 plants/m²	268.31b	285.57a	276.94b	5.05a	5.27a	5.16a	126.59b	137.02a	131.81b	19.50a	20.37a	19.94a
D_3: 75 plants/m²	277.24a	291.72a	284.48a	5.31a	5.60a	5.46a	130.48a	140.36a	135.42a	20.07a	21.05a	20.56a
F. test	**	*	**	*	*	**	**	*	**	*	*	**
Nitrogen levels (N):												
N_1: 20kg N/fed	249.84c	266.12c	257.98c	3.85b	4.20b	4.03b	138.26a	144.44a	141.35a	18.42b	19.26b	18.84b
N_2: 40 kg N/fed	271.45b	286.69b	279.07b	5.16a	5.39a	5.28a	122.74b	131.98b	127.36b	19.56a	20.59a	20.08a
N_3: 60 kg N/fed	279.92a	294.80a	287.36a	5.34a	5.59a	5.47a	115.18c	126.14c	120.66c	20.06a	20.94a	20.50a
F. test	**	**	**	**	*	**	**	**	**	*	*	**
Interaction:												
C×D	N.S	N.S	N.S	N.S	N.S	N.S	*	**	**	N.S	N.S	N.S
C×N	*	N.S	N.S	N.S	N.S	N.S	**	*	**	N.S	N.S	N.S
D×N	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
C×D×N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

El-Shimy et al., (1990), Nafees et al., (1993), Webber (1993), El-Kady and El-Sweify (1995), Mambelli and Grandi (1995), El-Farouk and El-Sweify (1998), Mostafa (2003), Acreche et al., (2005), Alexopoulou et al., (2007) and Kipriotis et al., (2007).

Plant density

Data presented in Table 4 revealed that plant density significantly affected fiber and seed properties i.e. fiber length, fiber percentage, fiber fineness and oil percentage. It is clear that there were gradual increments in the mean values of all fiber and seed properties with increasing plant density up to 75 plants/m² without significant differences between 50 and 75 plants/m² for fiber percentage, and oil percentage traits. The excess percentage from the combined analysis between the highest and the lowestplant density for fiber and seed quality i.e fiber length, fiber%, fiber fineness and oil % were 8.17, 31.57, 10.86 and 8.67 %, as average for the two seasons, respectively. These results are in agreement with those obtained by Massey (1974), Momtaz et al., (1978), Muchow (1979 a,b), Campbell and White (1982), Bhangoo et al., (1986), Sahsah et al (1986), Amaducci et al (1990), Nafees et al., (1993), Bajpal et al., (1994), Manzanares et al., (1996), El-Farouk and El-Sweify (1998), Webber et al.,(2001), and Mostafa (2003).

Nitrogen level effect

Analysis of variance for data presented in Table 4 revealed that increasing N levels from 20 up to 60 kg N/fed increased significantly fiber length, fiber percentage and oil percentage. However fiber fineness decreased significantly with increasing N levels. The increments as ratios from the combined analysis between the maximum dose of nitrogen and the minimum one were 11.39, 35.73 and 8.81 % for fiber length, fiber percentage and oil percentage traits, respectively. Moreover the decrement in fiber fineness as nitrogen increased was 14.64 %.

These results could explained the favourable effect of nitrogen as nutrient as building merestimatic activity cell division, content of mono saccharid and in turn contain cellulose in secondary cell wall also increase cellulose in fiber cell. Similar results are in accordance with those of Massey (1974), Momtaz et al 1977 and 1978), Salih (1981), Bhangoo et al., (1986), Sahsah et al., (1986), Manzanares et al., (1996), Webber et al (1996), Alexopoulou et al (2007) and Kipriotis et al (2007).

Interaction Effect

Analysis of variance revealed that the interaction between kenaf cultivars and plant density was significant on green yield/fed and fiber fineness Table 5. It is clearly evident that the highest green yield/fed was obtained from Tianung cultivar when planted with 75 plants/m², without significant difference between 50 and 75 plants/m^2 in this respect. This means that 50 plants/ m^2 was enough to maximize green yield/ fed and recorded the highest estimate of fiber

Table 5. The significant interaction between cultivars and plant density (C× D) on green yield / fed fiber fineness (combined analysis for 2007 and 2008 seasons)

Characters	Green yield/ fed / (ton)			Fiber fineness (N.m)		
	Plant density			Plant density		
Cultivars	25 plants/ m^2	50 plants/ m^2	75 plants / m^2	25 plants/ m^2	50 plants/ m^2	75 plants /m^2
Tianung	B 19.046a	A 20.430a	A 21.330a	B 125.080a	A 152.651a	A 155.680a
Hindi	AB 17.387b	A 18.189b	A 18.701b	B 113.862b	A 129.460b	A 133.108b
$Giza_3$	B 14.205c	A 16.222c	A 16.914c	C 97.491c	B 113.293c	A 117.446c

Table 6. The significant interaction between cultivars and nitrogen levels (C× N) on fiber fineness and oil yield /fed (combined analysis for 2007 and 2008 seasons)

Characters	Fiber fineness (N.m)			Oil yield / fed (kg)		
	Nitrogen levels			Nitrogen levels		
Cultivars	20 kg N/ fed	40 kg N/ fed	60 kg N/ fed	20 kg N/ fed	40 kg N/ fed	60 kg N/ fed
Tianung	A 160.59a	B 145.51a	C 127.31a	B 23.56c	A 35.31c	A 37.37c
Hindi	A 141.29b	B 127.75b	C 107.39b	B 38.08b	A 51.96b	A 54.06b
$Giza_3$	A 122.17c	B 108.81c	C 97.28c	B 53.60a	A 69.17a	A 71.44a

Table 7. The significant interaction between plant density and nitrogen levels (D× N) on seed yield /fed and oil yield /fed (combined analysis for 2007 and 2008 seasons)

Characters	Seed yield /fed (kg)			Oil yield / fed (kg)		
	Nitrogen levels			Nitrogen levels		
Plant density	20 kg N/ fed	40 kg N/ fed	60 kg N/ fed	20 kg N/ fed	40 kg N/ fed	60 kg N/ fed
25 plants/ m^2	B 172.23c	A 222.16c	A 227.30b	B 32.24c	A 43.69c	A 45.21c
50 plants/ m^2	B 206.44b	A 268.54b	A 274.39a	B 40.12b	A 54.80b	A 57.46b
75 plants /m^2	B 214.44a	A 273.93a	A 279.77a	B 42.89a	A 57.96a	A 60.19a

fineness as average for the two seasons. Combined analysis over the two seasons for data presented in Table 6 indicate the significant interaction between kenaf cultivars and the nitrogen levels for fiber fineness and oil yield/fed. It is clear that the finest fibers were obtained from Tianung cultivar when fertilized with 20 kg N/fed. However the highest oil yield/fed was obtained from Giza 3 cultivar when fertilized with 60 kg N/fed, without significant difference between 40 and 60 kgN/fed.

The plant density X nitrogen levels interaction affected seed yield/fed and oil yield/fed as average for the two seasons Table 7. Results in the same Table revealed that the highest seed and oil yields/fed were obtained when cultivars planted with 50 plants/m^2 and fertilized with 60 kg N/fed, without significant difference between 40 and 60 kgN/fed in this case. Similar results were reported by Bhangoo et al., (1986) and Manzanares et al., (1996).

Correlation Studies

Simple correlation coefficient between yields of green and seed per feddan and some of their attributed characters for the three studied kenaf cultivars as affected by plant density and nitrogen levels from the combined analysis for two seasons are presented in Table 8.

Data show positive and highly significant correlation between green yield/fed and each of green yield/plant, plant height, technical length/plant, fiber length and fiber yield/fed.

Green yield / plant correlated positively and highly significantly with each of plant height technical length, fiber length and fiber yield/fed.

Plant height correlated positively and high significantly with each of technical length, fiber length and fiber yield/fed.

Positive and high significant association was found between stem diameter and each of seed yield/fed, seed yield / plant, oil yield/fed, number of capsules / plant, number of seeds/capsule and 1000 seed weight. However, negative and insignificant correlation was observed between stem diameter and each of fiber length and fiber yield/ fed.

Fiber yield / fed was correlated negatively and insignificantly with each of seed yield/fed, seed yield/plant, oil yield/fed and 1000 seed weight.

Concerning the correlation between seed yield / fed and its attributed characters, data in the same table show that seed yield/fed was correlated positively and high significantly with each of seed yield/ plant, oil yield/fed, number of capsules/ plant, number of seeds/ capsule and 1000 seed weight. Also seed yield/ plant was associated positively and high significantly with each of number of capsules/ plant, number of seeds/capsule and 1000 seed weight. Oil yield/fed was

Table 8. Simple correlation coefficient between green and seed yields as well as some of their related characters for three kenaf cultivars as responded to plant density and nitrogen fertilization (Combined analysis for 2007 and 2008 seasons)

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Green yield /fed (ton)	-	0.740**	0.705**	0.664**	-0.263	0.970**	0.988**	-0.070	-0.583	-0.186	-0.347	-0.430	-0.374
2	Green yield / plant (g)		-	0.968**	0.976**	-0.086	0.680**	0.609**	-0.408	-0.426	-0.488	-0.104	-0.205	-0.098
3	Plant height (cm)			-	0.996**	-0.026	0.646**	0.604**	-0.350	-0.399	-0.439	-0.046	-0.124	-0.026
4	Technical length (cm)				-	-0.021	0.604**	0.553**	-0.392	-0.384	-0.472	-0.035	-0.114	-0.011
5	Stem eluameter (mm)					-	-0.469	-0.289	0.738**	0.890**	0.755**	0.988**	0.981**	0.985**
6	Fiber length (cm)						-	0.960**	-0.219	-0.731	-0.332	-0.541	-0.613	-0.567
7	Fiber yield / fad (ton)							-	0.005	-0.581	-0.111	-0.381	-0.453	-0.413
8	Seed yield / fed (kg)								-	0.692**	0.990**	0.670**	0.689**	0.637**
9	Seed yield / plant (g)									-	0.757**	0.925**	0.926**	0.894**
10	Oil yield / fed (kg)										-	0.670**	0.723**	0.665**
11	No. of capsules / plant											-	0.987**	0.990**
12	No. of seeds / capsule												-	0.993**
13	1000 seed weight (g)													-

correlated positively and high significantly with each of number of capsules / plant, number of seeds/ capsule and 1000 seed weight. Number of capsules/plant was associated positively and high significantly with each of number of seeds / capsule and 1000 seed weight.

Finally, number of seeds/capsule was correlated positively and high significantly correlated with 1000 seed weight.

In general it is clear that all characters under study affected each other in positive manner allowing kenaf breeders alternatives in selection to raise kenaf fiber yield in different cultivars. These results agreed with those obtained by Mourad et al (1987) and El-Shimy et al (1990). It could be concluded that plant height, technical length and fiber length had great effect on fiber yield. However number of capsules / plant, number of seed/capsule and 1000 seed weight were important to increase seed yield.Moreover, the breeder must take into consideration these characters to increase fiber and seed yield.

CONCLUSION

After two years of experimentation (2007 and 2008) under the condition of this study it could be concluded that a plant population of 188476 per feddan (50 plants /m^2) and nitrogen fertilization of 60 kgN/fed was recommended to produce the best quantity and quality of fiber from the foreign kenaf cultivar Tianung. However the best quantity and quality of kenaf seed was obtained from the local kenaf cultivar Giza 3 when planted with 188476 per feddan (50 plants / m^2) and fertilized with 40 kg N/fed.

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استجابة بعض أصناف التيل للكثافة النباتية والتسميد النيتروجينى

مهدى محمد مهدى حسين

قسم بحوث محاصيل الالياف – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية.

اجريت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بكفر الحمام بمحافظة الشرقية خلال الموسمين الصيفيين ٢٠٠٧ و ٢٠٠٨ لدراسة مدى استجابة بعض أصناف التيل المستوردة مثل الصنف تياننج المستورد من نيجيريا وكذلك الصنف هندى المستورد من الهند هذا بالاضافة الى الصنف المحلى جيزة٣ لثلاثة مستويات من التسميد النيتروجينى (٢٠و٤٠و٦٠كجم للفدان) تحت ثلاثة كثافات نباتية مختلفة (٢٥و٥٠ و٧٥ نبات /م٢). وقد تم تقدير محصولى السوق الخضراء والبذرة وبعض الصفات المرتبطة بهما وكذلك تم تقدير بعض الصفات التكنواوجية للألياف والبذرة هذا بالاضافة الى تقدير معامل الارتباط ما بين محصولى السوق الخضراء والبذرة وبعضا من الصفات المرتبطة بهما. وكان التصميم المستخدم هو القطع المنشقة مرتان فى أربعة مكررات.

ويمكن تلخيص أهم النتائج المتحصل عليها فى ما يلى:

١- تفوق صنف التيل المستورد تياننج معنوياً على الصنفين الآخرين هندي ، وجيزة٣ في محصول السوق الخضراء ومكوناتها بينما تفوق صنف التيل المحلى جيزة٣ معنوياً على الصنفين الأجنبيين تياننج وهندى في محصول البذرة ومكوناتها. وفيما يختص بالصفات التكنولوجية للالياف والبذرة فقد سجل صنف التيل المستورد تياننج اعلى القيم لصفات طول الالياف، النسبة المئوية للالياف، نعومة الالياف بينما سجل صنف التيل المحلى جيزة٣ اعلى القيم لصفة النسبة المئوية للزيت بالبذرة. ومن ناحية أخرى فقد سجل صنف

التيل المستورد هندى قيم وسطيه لكل الصفات المدروسة ما بين الصنف المستورد تيانتج والصنف المحلى جيزة ٣

٢- أدى زراعة اصناف التيل المختبره بكثافة نباتيه (٥٠ نبات /م٢) الى حدوث زيادة معنوية لمحصولى السوق الخضراء و البذرة وكذلك الصفات المرتبطه بها وكذلك الصفات التكنولوجيه للألياف والبذور.

٣- أدى إضافة ٦٠ كيلو جرام نيتروجين للفدان إلى حدوث زيادة معنويه فى محصول السوق الخضراء والصفات المرتبطه بها بينما أدى ضافة ٤٠ كيلوجرام نيتروجين/ فدان إلى حدوث زيادة معنويه فى محصول البذور والصفات المرتبطه به.

٤- كان التفاعل ما بين عوامل الدراسة الثلاثة غير معنوى فى معظم الصفات المدروسة فيما عدا التفاعل ما بين الاصناف والكثافة النباتية حيث كان هذا التفاعل معنويا لصفتى محصول السوق الخضراء للفدان ونعومة الالياف. أيضاً تلاحظ وجود تفاعل معنوى ما بين الاصناف والتسميد النيتروجينى لصفات نعومة الالياف ومحصول الزيت للفدان. من ناحية اخرى فقد كان التفاعل ما بين الكثافة النباتية والتسميد النيتروجينى معنوياً لصفتى محصول البذرة للفدان ومحصول الزيت للفدان.

٥- كان معامل الإرتباط إيجابيا ومعنويا ما بين محصول السوق الخضراء للفدان وكل من محصول الساق الأخضر للنبات، الطول الفعال، طول الألياف وكذلك محصول الألياف للفدان. ومن ناحية أخرى فقد أرتبط محصول البذرة للفدان معنوياً وإيجابياً مع كل من محصول البذرة للنبات ، محصول الزيت للفدان، عدد كبسولات النبات، عدد بذور الكبسوله ووزن الألف بذرة.