THE INFLUENSE OF SOWING TIME AND PLANT POPULATION ON KENAF GROWTH AND YIELDS

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ABSTRACT: Kenaf is a multi-purpose crop since the two stem fractions (bark and core) can be used for a number of industrial applications. The main aim of this work was to investigate the effect of sowing time (17/6/03 and 6/7/03) and plant population (200,000 and 400,000 plants/ha) on growth and yields of two kenaf varieties (Tainung 2 and Everglades 41) in the pedoclimatic conditions of central Greece. A large number of measurements (plant height, stem diameter and leaf area meter) and harvests were carried out throughout the growing season in order to monitor the growth and yields of kenaf. It was found that between the two sowing times the early sowing resulted in higher yields, while between the two plant populations the most productive was the high one. It should be pointed out that in both cases statistically significant differences were recorded only in very few cases ($P<0.05$, LSD Test). Further to that the peak yields for the early sowing came up to 23.2 t/ha, while for the late sowing was 18 t/ha. At the same time the peak yields for the plots with the high density was 20.2 t/ha, while for the plots with the low density was 19 t/ha. It's worth mentioning that both varieties gave almost the same growth and productivity with a small superiority of Tainung 2 over Everglades 41 (20 versus to 19.2 t/ha).

Keywords: kenaf, biomass production, yields

1 INTRODUCTION

Kenaf is an annual herbaceous rapidly growing crop of great interest as biomass source and low cost natural fiber. It is characterized as a multi-purpose crop since the two stem fractions (bark and core) can be used for a number of industrial applications.

The sowing date is strongly depends on the specific pedoclimatic conditions of the area of cultivation. Early planting dates often result in poor emergence and slow, non-competitive growth. On the other hand, the late planting dates will often results in reduced yield potential due to the reduced solar radiation availability. Due to the fact that the vegetative growth for the late-maturity kenaf varieties continues until the appearance of the first flowers (middle of September for the Mediterranean region), the sowing should take place as soon as the soil temperature is higher than 15 ^{0}C in order the vegetative stage of the crop is as long as possible.

A large number of research works have been carried out worldwide in order to determine the appropriate plant population that results in maximization of the crop's yields. In the view of this plant populations between 99,000 plants/ha to 932,000 plants/ha have been tested for several kenaf varieties throughout the world. In most of these research works it is reported that the increase of the plant density from 150,000 to 350,000 plants/ha resulted in maximization of the dry matter yields (1, 2, 3, 4, 5, 6). The choice of an optimum population (7, 8, 9 10) must consider not only the response of the components of yield, but also its influence on the growth form of the plant in terms of the ease of management.

Since weeds can be efficiently controlled by pre-sowing or pre-emergence herbicides and insects may be controlled by aerial spraying, the only management factors requiring consideration are harvesting and handling. Also the lower the population was the greater the degree of branching was. This suggests that an intermediate population should achieve a satisfactory balance. A harvest population of 200,000 to 250,000 plants/ha is generally recommended.

The main aim of this work was to investigate the effect of sowing time and plant population on growth and yields of two kenaf varieties (late-maturity varieties) in the pedoclimatic conditions of central Greece.

2 APPROACH

2.1 Experimental site and treatments

In spring 2003 a kenaf field trial was established in Aliartos (central Greece). The site coordinates were latitude 38^{0}22, longitude 23^{0}10 and altitude 114m above the sea level. The climate in Aliartos is characterized as dry with 400mm/year mean precipitation. The soil type was SL with relatively low organic matter (less than 1%) and had been left fallow for more than twenty four years.

The under study factors were two sowing times (17/5/2003 and 7/6/2003), two plant populations (200,000 and 400,000 plants/ha) and two late-maturity kenaf varieties (Tainung 2 and Everglades 41). The experimental layout was a factorial 2^3 in three blocks. The area of each plot was 48m^2 and the distances between the rows were 50 cm. A drip irrigation system was used in order to irrigate the crop and to carry out the top nitrogen fertilization of 75 kg N/ha when the plants had a height of 40 cm. It should be noted that all works took place by hand.

2.2 Data collection

Throughout the growing period a series of growth measurements were carried out including plant height (with or without the flowers), basal stem diameter (with or without the bark) and leaf area meter (LAI). For the plant height and stem diameter measurements a total number of five marked plants per plot were used and the height measurements were repeated every two weeks, while in the case of stem measurements every four weeks.

Additionally, a total number of eight harvests carried out (from July to December) in order to describe the accumulation of fresh and dry matter yields and yields components (stems and leaves). The harvests were carried out every three weeks in an area of one square meter per plot. In each harvest date samples from each fraction (leaves, bark and core) were taken and oven dried until constant weight for dry matter determinations. Moreover, samples from the leaves were taken and used for the leaf area index (LAI) measurements.

3 RESULTS

3.1 Plant height and stem diameter

The plots that were sown earlier developed plants with higher plant height (308 cm) and smaller stem diameter (18.23 mm) compared to the ones that the sowing postponed twenty days (283 cm plant height and 19.94 mm stem diameter).

Between the two applied plant populations it was found that the low density produced 6% higher plants compared to the high density (305 and 286 cm, respectively) with larger stem diameter (20.99 and 17.19 mm, respectively).

The two cultivated varieties developed plants with almost the same plant height, while the stem diameter was higher for the variety Everglades 41 (19.43 mm).

Table I. Plant height (cm) with or without the part of the stems with flowers.

Treatments	Plant height	Plant height without flowers
Sowing dates		
S_1: 17/5/2003	308	269
S_2: 5/6/2003	283	255
Plant populations		
D_1: 200,000 pl/ha	305	266
D_2: 400,000 pl/ha	286	257
Varieties		
V_1: Tainung 2	295	259
V_2: Everglades 41	296	264
Mean	295	262

Table II. Stem diameter (mm) with or without the bark

Treatments	Stem diameter	Stem diameter without bark
Sowing dates		
S_1: 17/5/2003	18.23	15.31
S_2: 5/6/2003	19.94	16.66
Plant populations		
D_1: 200,000 pl/ha	20.99	17.37
D_2: 400,000 pl/ha	17.19	14.59
Varieties		
V_1: Tainung 2	18.75	15.68
V_2: Everglades 41	19.43	16.29
Mean	19.03	15.98

As it is shown in Table I the upper part of the stem with the flowers represents only the 11% of the total plant height due to the fact that the cultivated varieties are late-maturity ones and developed the first flowers at the end of September.

3.2 Leaf area index (LAI)

As it is shown in Figure 1 the Leaf Area Index (LAI) reached its peak values (5), averaged overall treatments, at the end of September 2003 (120 days from emergence). Thereafter, LAI starting gradually to decline due to the stems defoliation and at the end of October 2003 (158 days from emergence) was 3.13, averaged overall treatments.

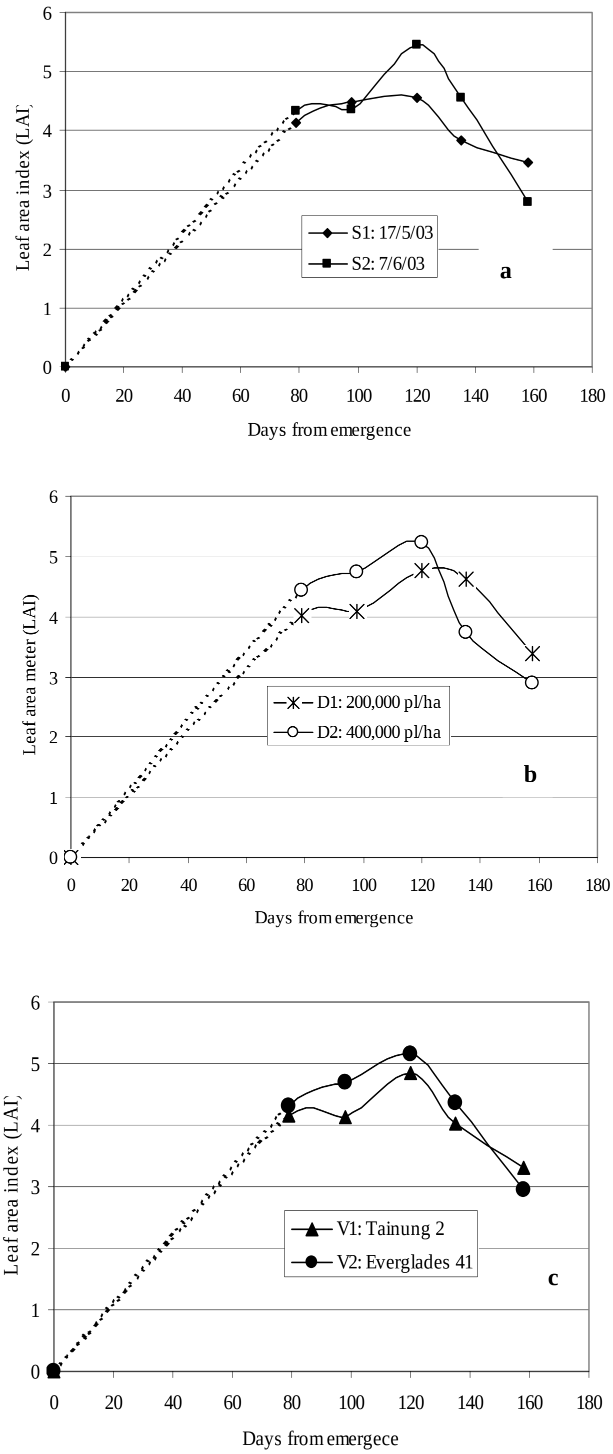

Figure 1. Evolution of Leaf Area Index (LAI) for all the under study factors (sowing dates, plant population and tested varieties)

When LAI reached its peak values statistical significant differences were recorded only between the two sowing dates ($P<0.05$, LSD Test) and was 5.46 for the second sowing and 4.55 for the first sowing (Figure 1a). At the same time a superiority of high density over the low one in terms of LAI was recorded (5.24 and 4.77, respectively – Figure 1b) and of Everglades 41 over Tainung 2 (5.17 and 4.85, respectively – Figure 1c) that it wasn't statistically significant.

3.3 Yields

The accumulation of total dry yields as well as of dry stem yields is presented in Figure 2 for all the under study factors (sowing time, plant population and variety).

It is obvious (Figure 2a) that until the end of October the early sowing performed higher yields that in some cases differ statistically compared to the yields of the late sowing. It should be pointed out that the greatest difference between the two sowing dates was recorded at the time of the yields maximization (end of October, 158 days from the first emergence). At that time the yields of the first sowing (23.2 t/ha) was 22.5% compared to the yields of the late sowing (16 t/ha). At the last two harvests the differences between the two sowing dates become smaller and smaller and resulted in a superiority of only 3% of the early over the late sowing (13.2 and 12.8 t/ha, respectively).

According to figure 2b the high density gave throughout the growing cycle higher yields compared to the low density. The superiority of the high over the low density reached its greater values at the final harvest of the crop (207 days from emergence from the first sowing) and at that time the difference 21% (14.5 versus to 11.5 t/ha) and wasn't statistically significant. At the time of the yields maximization the high density gave a productivity of 20.2 t/ha, while the recorded yields in the plots with the low density was 19 t/ha.

As it is presented in Figure 2c the two varieties (Tainung 2 and Everglades 41) performed almost the same yields throughout the growing period. A trend for slighter higher yields of Tainung 2 over Everglades 41 was recorded from the end of October until the final harvest. This superiority of Tainung 2 over Everglades 41 reached its maximum values at the final harvest (14%). At that time the biomass productivity of Tainung 2 was 20 t/ha, while of Everglades 41 was 19.2 t/ha.

In Tables III and IV the yields of both stem fractions (bark and core) on fresh and dry basis as well as the bark:core ratio at two harvest times (end of October and final harvest) are presented. According to those tables the core fraction represented the 67% of the total dry stem yields at the end of October and the 66% at the final harvest. At the final harvest (Table IV) higher core yields were recorded by the early sowing date (8.87 t/ha), by the high plant population (9.57 t/ha) and by the variety Tainung 2 (9.12 t/ha).

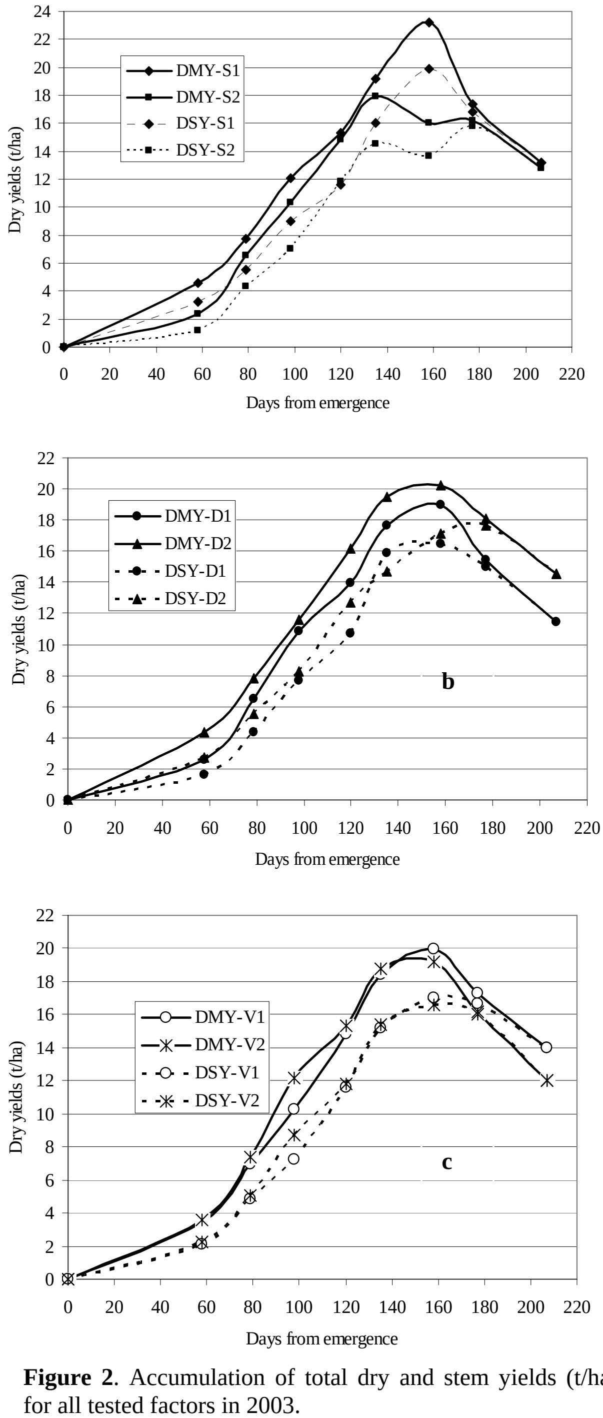

Figure 2. Accumulation of total dry and stem yields (t/ha) for all tested factors in 2003.

4 CONCLUSIONS

- In the course of the trial the early sowing gave higher productivity compared to the late sowing and only in few cases this superiority was statistically significant ($P<0.05$, LSD Test). It should be mentioned that this superiority at the final harvest was quite small (3%).
- A superiority of the high density over the low one was recorded throughout the growing period but this superiority was occasionally statistically significant.
- The growth and yields of the two tested varieties were almost the same with a slight superiority in terms of dry yields of Tainung 2 over Everglades 41.

Table III. Fresh and dry stem yields for both stem fractions (bark and core) and bark:core ratio (158 days emergence).

Treatments	FSY*	DSY*	FBY*	DBY*	FCY*	DCY*	Bark:Core (fresh)	Bark:Core (dry)
Sowing dates								
S_1: 17/5/2003	69.47	19.91	27.77	6.35	41.70	13.56	0.666	0.468
S_2: 5/6/2003	53.11	13.69	20.85	4.66	32.27	9.02	0.646	0.517
Plant populations								
D_1: 200,000 pl/ha	60.55	17.15	23.99	5.41	36.56	11.04	0.656	0.490
D_2: 400,000 pl/ha	62.04	16.44	24.63	5.60	37.41	11.54	0.658	0.485
Varieties								
V_1: Tainung 2	62.63	16.98	25.10	5.61	37.53	11.38	0.669	0.493
V_2: Everglades 41	59.95	16.61	23.51	5.40	36.44	11.20	0.645	0.482
Mean	61.29	16.80	24.31	5.51	36.98	11.29	0.657	0.488

*FSY: Fresh stem yields, DSY: Dry stem yields, FBY: Fresh bark yields, DBY: Dry bark yields, FCY: Fresh core yields, DCY: Dry core yields

Table IV. Fresh and dry stem yields for both stem fractions (bark and core) and bark:core ratio (207 days emergence).

Treatments	FSY*	DSY*	FBY*	DBY*	FCY*	DCY*	Bark:Core (fresh)	Bark:Core (dry)
Sowing dates								
S_1: 17/5/2003	51.46	13.21	18.94	4.34	32.52	8.87	0.582	0.489
S_2: 5/6/2003	51.65	12.78	19.53	4.46	32.12	8.31	0.608	0.537
Plant populations								
D_1: 200,000 pl/ha	46.15	11.47	16.91	3.85	29.24	7.61	0.578	0.506
D_2: 400,000 pl/ha	56.96	14.52	21.56	4.95	35.43	9.57	0.609	0.517
Varieties								
V_1: Tainung 2	55.52	13.98	21.39	4.86	34.13	9.12	0.627	0.533
V_2: Everglades 41	47.59	12.00	17.08	3.94	30.51	8.06	0.560	0.489
Mean	51.55	12.99	19.23	4.40	32.32	8.59	0.595	0.512

*FSY: Fresh stem yields, DSY: Dry stem yields, FBY: Fresh bark yields, DBY: Dry bark yields, FCY: Fresh core yields, DCY: Dry core yields

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