EFFECTS OF ENVIRONMENTAL AND AGRONOMIC FACTORS ON KENAF (*HIBISCUS CANNABINUS L.*) IN PO VALLEY

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ABSTRACT: Kenaf (*Hibiscus cannabinus* L.) is a fibre crop that can be used as a biomass crop. Results of trials conducted in the 90's years by University of Bologna in several places of the Po Valley have shown useful indications about the effects of environmental and agronomic factors on yield and duration of the crop cycle. The year effect seemed to be very important on the life cycle duration, from 85 to 160 days between the sowing and the harvest time. The fresh stem yield ranged from 20 to 80 t ha^{-1}, seemingly related to the amount of rainfall. The optimal harvest time seemed to be in the end of September for most of genotypes, whereas long cycle varieties harvested twenty days later have increased production. Trials testing several genotypes without water supply have shown that long cycle cultivars were more productive with a field variation from 11.5 to 16.5 t ha^{-1} of dry matter. In Northern Italy climatic conditions only rescue irrigation seemed to be necessary during dry years. The restoration of 50% of ETM increased the dry biomass yield of 15-25%, but irrigation did not seemed to be economically convenient. The density trials have shown that the limit of 100-120 plants m^{-2} as the optimal for biomass production.
Keywords: kenaf, agronomic factors, yields.

1 INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a short-day annual herbaceous plant that belongs to the Malvaceae family. It has been cultivated widespread mainly for the soft bast fiber in its stems. Among the several applications of Kenaf products, at the present it is an interest as biomass crop for energy production, since yield can reach 90 t ha^{-1} of fresh material [7].

The present work aims to summarise results of trials conducted in the 90's years by University of Bologna in several places of the Po Valley regarding the effect of environmental and agronomic factors on yields, in order to define the right agronomic practices.

The effect of the crop cycle duration, sowing and harvest time, irrigation and plant population were tested on several genotypes mainly to investigate the effect on fibre yields and quality; interesting information can be extracted also about the effect on biomass yields.

2 MATERIAL AND METHODS

2.1 Crop cycle duration

Field trials were carried out near Ferrara. Two sowing times (beginning of April and May) and two harvest times (120 and 150 days after sowing) and its combinations were tested for 2 years. Genotype was Taiwan; sowing was carried out mechanically with 200 germinable seeds per m^2; distance between the rows was 17 cm.

Rainfall for the period May-September was around 430 mm for both the years.

2.2 Genotypes

Field trials were carried out for 4 years near Ferrara and Bologna. In total 13 genotypes were tested. Sowing was carried out mechanically with 200 germinable seeds per m^2; distance between the rows was 17 cm.

Mean of rainfall of the 4 year for the period May-September was 309 mm.

2.3 Irrigation

Growth and yield response of Kenaf to water supply were investigated for 2 years near Bologna on 2 cultivars (BG 52-38 and Everglades41) under regimes of non-irrigated and twice weekly input with restoration of 100% of ETM. Plant population were 50 plants m^{-2}, crop cycle was from first decade of May until end of October (146-151 days from emergence).

Meteorological trend was similar for all experimental years, with a range of rainfalls between 317 and 345 mm.

2.4 Plant population

Field trials were carried out for two years near Ferrara, the effect of 3 densities (50, 100 and 200 plants m^{-2}) were tested. Distance between the rows was 20 cm. Sowing took place mechanically on first decade of May and the harvest on the beginning of October. Used variety was Uzbeksky. During the crop cycle rainfall was around 400 mm.

3 RESULTS

3.1 Crop cycle duration

In general, yields during the experimental years were quite high, around 65,8 t ha^{-1} of biomass. Productions increased significantly with the late harvest (+21,8 t ha^{-1}). This trend was more accentuated in the early sowing respect to the late ones (Fig. 1), meanly the first sowing increased yields of 19 t ha^{-1}.

Figure 1: Effect of late harvest (as % of the increase respect to the early harvest) on fresh biomass yield (middle line) and its combinations with sowing times

Each daily delay of harvest increased yield of 0,93 t ha^{-1} in the early sowing and of 0,52 t ha-1 in the late sowing.

For both the sowing times, the stem percentage respect to the total fresh biomass increased significantly with the delay of harvest, instead of leaves percentage that reached the maximum value in the combination early sowing and harvest (Fig. 2), when the ratio stem on leaf was lower than 1,5. In all the other cases it ranged between 2,5 and 3.

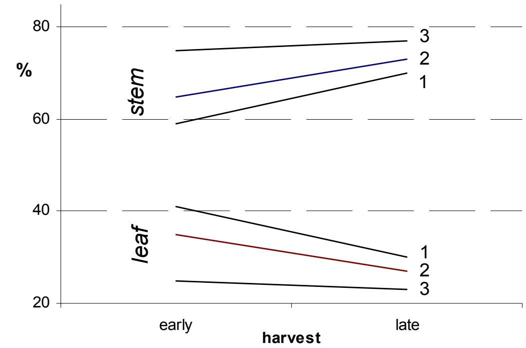

Figure 2: Effect of the harvest time (line 2) and its combination with sowing time (line 1 = early; line 3 = late) on percentage of fresh stem and leaf respect to the whole plant

Interaction between sowing and harvest time on dry production was significant. With the early sowing were obtained high values of yields delaying the harvest; whereas with the late sowing higher and similar values were obtained harvesting in advance (Fig. 3) [3].

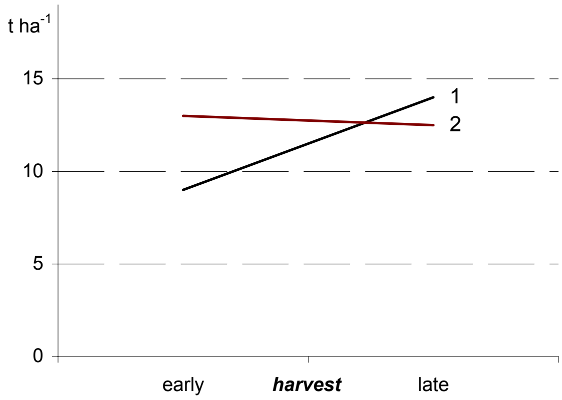

Figure 3: Combined effects of the harvest and sowing time (line 1 = early; line 2 = late) on dry yield

Other researches showed that from 85 to 160 days between the sowing and the harvest time, the plant height increased from 100 cm to more than 200 cm, the fresh biomass production from 35 to 95 t ha^{-1} and the stem from 20 to 80 t ha^{-1} [6].

In any case the year effect seems to be very important on the life cycle duration. These effects seemed to be linked also to the amount of rainfall.

In the Po Valley conditions the optimal crop cycle was from May to the end of September/beginning of October, since stem continued to grow until the middle of October, with a range between 120 and 150 days from sowing to harvest. This was confirmed also by daily growth rate, that in the best combinations reached 400 kg ha^{-1} day^{-1} sowing on the beginning of May and harvesting on September [3].

3.2 Genotype

Trials evinced differences in the above ground yields among tested genotypes and a relevant effect of the year. Most interesting varieties exceeded 60 t ha^{-1} of fresh biomass and in the best situations also 90 t ha^{-1}. At the harvest the portion of stem, for both fresh and dry yields, was around 75-80% respect to the whole plant. BG 52-38 shown best performance among the tested cultivars (Table I) [7].

Table I: Biometric and yields characteristics of some tested cultivars (mean of 4 years).

Genotype	Height (cm)	Fresh Biomass Yield (t ha^{-1})	Stem / Plant (%)		Stem Yield (t ha^{-1})	
			fresh	dry	fresh	dry
BG 52-38	212	64,6	79,7	82,5	51,4	11,4
BG 52-71	205	65,0	79,1	80,2	51,0	10,3
Taiwan	197	61,7	77,5	79,8	47,7	10,3
Cuba 108	189	59,1	75,1	78,4	44,4	9,4
Cuba 961	169	58,0	74,7	76,8	43,2	9,2
Cuba 2032	182	56,0	76,1	77,5	42,6	8,6
C 2032 Australia	183	55,0	75,4	77,9	41,5	8,9
Uzbeksky	201	54,6	79,3	81,9	43,2	9,1
G4	177	54,9	77,4	79,0	42,4	8,4
G 30-31	191	67,3	77,8	80,4	52,4	11,1
G 40-65 57	183	55,9	73,4	76,2	40,9	8,5
G 49	204	56,4	74,7	77,0	42,1	8,9
PI 256038	179	56,3	77,4	78,4	43,6	8,9

Other experiences testing several genotypes without water supply have shown that long cycle cultivars were more productive, about 14 t ha^{-1} of total dry matter, with a field variation from 11,5 to 16,5 t ha^{-1}, due to the higher stem and the bigger base stem diameter. Tainung2, Everglades41, Salvador shown a high percentage of stems (73-74%) and a dry content of 20% [6].

3.3 Irrigation

The aerial dry yield in the non-irrigated regime ranged between 13 and 14 t ha^{-1}, whereas irrigated treatments shown yields values from 38 to 57% higher than the non-irrigated regime (Fig. 4).

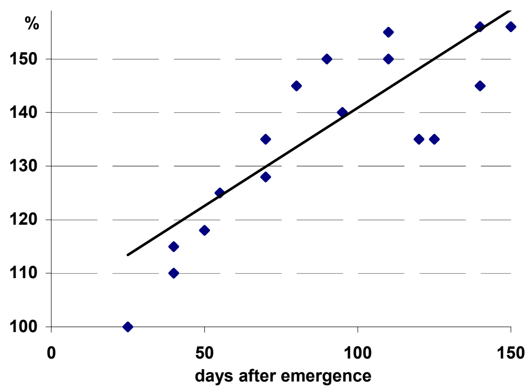

Figure 4: Effect of irrigation on total dry yield

Stem dry weight growth was linear, with a yield level of almost 13 t ha^{-1} in the non-irrigated regime and between 18 and 20 t ha^{-1} in the irrigated ones.

In Po Valley conditions, trials carried out in 1990, showed that with rainfalls of 150 mm between June and

September, and only two rescue irrigations of 40 mm, it has been possible to obtain biomass productions higher than 65 t ha^{-1}. The restoration of 100% of ETM increased also the production of cellulose from 7 to 11 t ha^{-1}, whereas a restoration of 50% (130 mm) increased of 15-25% biomass yield and of 9-18% the dry matter, depending also on the year [1; 5; 6].

3.4 Plant population

Results shown that plant population affected significantly plant height and base stem diameter. Both biometrical characteristics decreased increasing density.

Tested densities not affected significantly biomass productions, since mean fresh and dry weight of the plants and also of stems and leaves decreased almost proportionally with increasing plant population. Independently by plant population, reached yields were quite sufficient. Fresh biomass productions ranged between 50 and 80 t ha^{-1}, with 80-90% of stems, whereas dry yields between 12 and 17 t ha^{-1}.

The effects of lower densities than 100 plants m^{-2} showed that yields increased until 90 plants m^{-2} [4].

Plants survival decreased in higher densities situations because of a higher competition among the plants. At the harvest plant population was very low respect to the target density (Fig. 5), observing on field at maximum 100-120 plants m^{-2} higher than 50 cm [2].

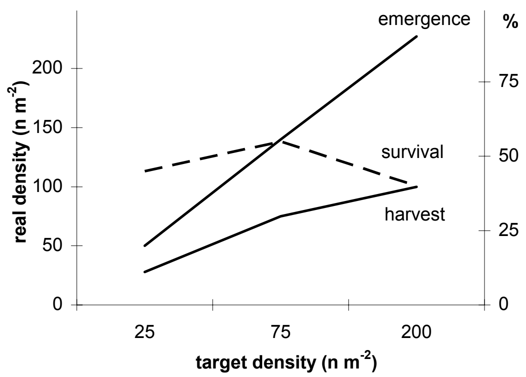

Figure 5: Survival of plants (%) and target and real density at emergence and at harvest.

4 CONCLUSION

The duration of the crop cycle and its temporal placing affected productions qualitatively and quantitatively. As biomass crop, long duration of the crop cycle is important. This can be obtained with an early sowing and a late harvest, that have to be defined in relation to the plant physiology and the climatic condition. In the Po Valley conditions the optimal crop cycle was from May to the end of September/beginning of October, with a range between 120 and 150 days from sowing to harvest.

In general, in Po valley conditions late varieties shown best yields, moreover late harvest increased biomass yields.

Water supplies, even though it can increase yield of 40-50%, seemed to be not economically convenient. Obtained yields without water supply were quite good. This means that in Po Valley climatic conditions only rescue irrigations seemed to be necessary during dry years, mainly when rain is missing during July.

Kenaf reduced individual growth increasing plant density as well as for plant survival. The limit of 100-120 plants m^{-2} was the optimal for biomass production.

At present much research is in act in Europe, such as EU project “BioKenaf”, aiming at re-qualification of kenaf as multipurpose crop.

5 REFERENCES

[1] M.T. Amaducci, R. Benati, G. Venturi, 1995. Accrescimento e produttività del Kenaf (Hibiscus cannabinus L.) in condizioni di disponibilità idrica differenziata. Agronomia, anno XXIX – n. 1: 60-65.

[2] M.T. Amaducci, G. Venturi, R. Benati, 1990. Effetti della densità di investimento del kenaf. L’Informatore Agrario, supplemento al n 25:27-32.

[3] R. Benati, M.T. Amaducci, G. Venturi, 1990. Effetti di durata e collocazione nel tempo del ciclo colturale del kenaf, informatore agrario. L’Informatore Agrario, supplemento al n 25: 18-26.

[4] R. Benati, M. Bimbatti, M. Di Candilo, G. Venturi, 1992. Kenaf: effetti combinati della densità di investimento e della distanza tra le file. L’informatore Agrario, 8/92: 103-107.

[5] S. Mambelli, S. Grandi, M.T. Amaducci, G. Venturi, 1993. Effects of harvesting date and irrigation on kenaf fibre content. Second European Symposium “Industrial crops and Products”, Pisa, 22-24 novembre.

[6] M. Mazzanti, Effetti dell’epoca di raccolta e dell’apporto irriguo sul contenuto in fibra del kenaf (*Hibiscus cannabinus* L.)” tesi di laurea. Relatore M.T. Amaducci. Università di Bologna, a.a. 1993-’94.

[7] G. Venturi, R. Benati, M.T. Amaducci, 1990. Valutazione della adattabilità di alcune cultivar di ibisco all’ambiente padana. L’Informatore Agrario, supplemento al n 25: 9-17.