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Industrial Crops and Products 21 (2005) 223–227
INDUSTRIAL CROPS AND PRODUCTS
AN INTERNATIONAL JOURNAL
www.elsevier.com/locate/indcrop

Kenaf (*Hibiscus cannabinus* L.) based substrates for the production of compact plants

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Received 9 July 2003; accepted 2 April 2004

Abstract

Growth media based on whole-stem kenaf (*Hibiscus cannabinus* L.) and sand have been used to produce compact lettuce (*Lactuca sativa* L.) and pepper (*Capsicum annuum* L.) plants. Seeds were sown directly in kenaf-containing substrates and growth was recorded for up to 100 days after sowing. The presence of whole-stem kenaf (core and bark), even at a ratio of 10:90 (kenaf:sand), inhibited plant growth expressed as plant height, leaf number, and plant fresh and dry weight. When plants were subsequently transplanted to a kenaf-free substrate, growth continued at a similar rate to that of the control (sown and grown in peat and sand). The inhibitory effect of kenaf is located both in the core and bark, but is decreased by soaking the kenaf in NH_4NO_3 prior to use. A possible role for whole-stem kenaf (core and bark) in the production of compact plants is proposed.

Keywords: Kenaf; Substrate; Germination; Growth; Pepper; Lettuce

1. Introduction

Kenaf (*Hibiscus cannabinus* L.) is being increasingly cultivated in Greece, where yields of fresh biomass range from 52.3 to 88.9 t ha^{-1}, corresponding to a dry mass of 13.3–24.0 t ha^{-1} (Alexopoulou et al., 2000). The shoot constitutes 51–79% of the fresh weight of the plant (McMillin et al., 1998), and of the total fibre 25–40% is derived from the bark and 60–75% from the cortex (Sellers et al., 1993).

Kenaf is used for the production of high quality paper (Kaldor et al., 1990), animal feed (Webber, 1993) and other industrial purposes. Kenaf core has also been proposed as a constituent of growth media for tomato (Pill et al., 1995; Pill and Bischoff, 1998) and potted ornamentals (Wang, 1994). The suitability of kenaf core for inclusion in growth media depends on the size and percentage of kenaf in relation to the other components of the media (Webber et al., 1999). Enrichment with nitrogen may also be required to avoid growth suppression, possibly due to microbial immobilization within the kenaf (Pill and Bischoff, 1998).

We have observed prolonged growth suppression in non-enriched substrates based on whole-stem (core and bark) kenaf, rather than kenaf core alone, which indicate their use for the production of compact plants. The results of these experiments are reported here.

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0926-6690/$ – see front matter
doi:10.1016/j.indcrop.2004.04.008

2. Materials and methods

Kenaf (*H. cannabinus* L. cv. Cuba 108) was sown in the vicinity of Ancient Olympia in southern Greece and following emergence plants were thinned to a spacing of 20 cm × 60 cm. Fertilizer was applied as a base dressing of 700 kg ha^{-1} 11 15 15 (N-P-K) and a top dressing of 500 kg ha^{-1} NH_4NO_3 (60 days after sowing). Plants were harvested by hand 170 days after sowing, by which time most of the leaves had abscised. Stems were cut 5 cm above the soil surface and stacked upright in a dry, aerated shelter for 3 months prior to use. Whole stems (core and bark) were cut and ground in a mill to produce an approximately homogenous product (0.2–3.0 cm) for incorporation into substrates.

Kenaf-based substrates were prepared by mixing ground kenaf with washed riverbed sand in different proportions—10:90%, 25:75%, 50:50% (v/v). Mixtures of sphagnum peat and sand in corresponding ratios (v/v) were used as controls. All the substrates were fertilized with 0.3 g l^{-1} KNO_3 and 0.75 g l^{-1} superphosphate (0 20 0), whereas the pH of substrates containing peat was corrected to 6.5 by the addition of ground marble.

In the first experiment, seeds of lettuce (*Lactuca sativa* L. cv. Parris Island) and pepper (*Capsicum annuum* L. cv. California Wonder) were sown by hand in the various substrate mixtures contained in plastic seed trays (17 cm × 6 cm). After sowing, the seed trays were lightly watered and placed in an unheated greenhouse, with additional watering as and when required. Forty plants of each species were transplanted at the two-leaf stage to 7 cm × 7 cm pots containing a substrate of the same composition, while 30 days later the plants were transplanted to larger (12 cm × 17 cm) pots again filled with the corresponding substrate. Plant height and leaf number were recorded every 10 days, whereas the fresh and dry weight of uprooted plants were measured 40, 70 and 100 days after sowing.

In the second experiment, seeds of lettuce cv. Parris Island were sown in seed trays containing substrates of peat-sand (50:50). At the two-leaf stage, plants were transplanted to 7 cm × 7 cm pots containing substrates prepared from a 50:50 mixture of sand and kenaf, which had been separated into core and bark prior to grinding. Half of the kenaf in each substrate was soaked in 15 g l^{-1} N (in the form of NH_4NO_3) for 5 days prior to sowing, whereas the other half was soaked in water for the same time. Plants were transplanted together with the root ball (including sand and peat) and grown as in the first experiment for a further 50 days.

Results were analyzed with the aid of the statistical program Statgraphics using the method of analysis of variance followed by a comparison of the means ($P = 0.05$).

3. Results and discussion

The inclusion of whole-stem kenaf (core and bark) in the potting compost reduced the rate of growth of lettuce and pepper (Table 1). In all mixtures containing kenaf, even at a ratio of 10:90 (kenaf:sand), the height of the plants 60 days after transplantation was significantly lower than that of the control, in which peat replaced the kenaf constituent of the compost, and related to the ratio of kenaf:sand within the compost. In addition, the number of leaves per plant, 60 days after transplantation, was significantly lower in substrates containing kenaf than in those containing peat. When plants were retained in the same substrate for a further 40 days, those that had been planted in a kenaf-sand medium showed a significantly lower fresh and dry weight in comparison with those in a peat-sand medium (Table 2). Inhibition of periwinkle (*Vinca minor* L.) growth by fine ground core kenaf (0.2–0.5 cm) was observed by Webber et al. (1999), whereas coarse-grade kenaf (0.5–2.7 cm) produced growth that was similar or greater than that in substrates without kenaf. Although the kenaf used in the present experiments was coarsely ground, it included bark material. Moreover, the peppers and lettuce were sown directly in these substrates; hence the plants were subjected to inhibition from the stage of germination, whereas the periwinkle plants of Webber et al. (1999) were already 3 weeks old prior to planting in the kenaf-based substrates.

Russo et al. (1997) reported that extracts of kenaf inhibited the germination of seeds and that inhibition was reduced by weathering of the kenaf prior to extraction. Although 3 months elapsed between harvest and the use of kenaf in the present experiments, the material was not subject to weathering so that any plant

Table 1
Plant height and leaf number of lettuce and pepper 60 days after transplantation to substrates containing sand plus varying proportions of kenaf or peat

Substrate	Species			
	Lettuce		Pepper	
	Height (cm)	Number of leaves	Height (cm)	Number of leaves
Kenaf/sand 50–50	19.1 a	2.8 c	38.9 e	3.3 e
Kenaf/sand 25–75	35.5 c	5.5 b	63.7 d	4.5 de
Kenaf/sand 10–90	50.5 c	6.4 b	63.6 d	4.6 d
Peat/sand 50–50	164.4 a	12.6 a	248.6 a	13.5 a
Peat/sand 25–75	145.3 b	12.4 a	218 b	12.1 b
Peat/sand 10–90	136.8 b	11.7 a	111.8 c	8.3 c
L.S.D. ($P = 0.05$)	15.31	1.31	23.14	1.23

Means within the same column followed by a different letter are significantly different ($P = 0.05$).

Table 2
Fresh and dry weight of lettuce and pepper plants 100 days after sowing in kenaf-sand and peat-sand substrates

Substrate	Lettuce		Pepper	
	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
Kenaf/sand 10/90	13.08 a	1.88 a	5.45 a	0.78 c
Kenaf/sand 25/75	10.24 b	1.62 b	1.91 b	0.27 b
Kenaf/sand 50/50	1.21 c	0.24 c	1.26 c	0.18 a
Peat/sand 10/90	49.52 d	7.82 d	31.38 d	3.26 d
Peat/sand 25/75	77.88 e	8.25 e	76.4 e	7.55 e
Peat/sand 50/50	113.24 f	10.82 f	78.46 f	8.14 f
L.S.D. ($P = 0.05$)	0.502	0.058	0.312	0.066

Means within the same column followed by a different letter are significantly different ($P = 0.05$).

growth inhibitory substances would be retained. When plants were transferred from the kenaf-containing media to peat-sand media, the rate of growth increased and was similar to that of plants which had been maintained in peat-sand for the duration of the experiment (Figs. 1 and 2). It is therefore apparent that the inhibitory action of kenaf is temporary and may be reversed by transplantation to kenaf-free media.

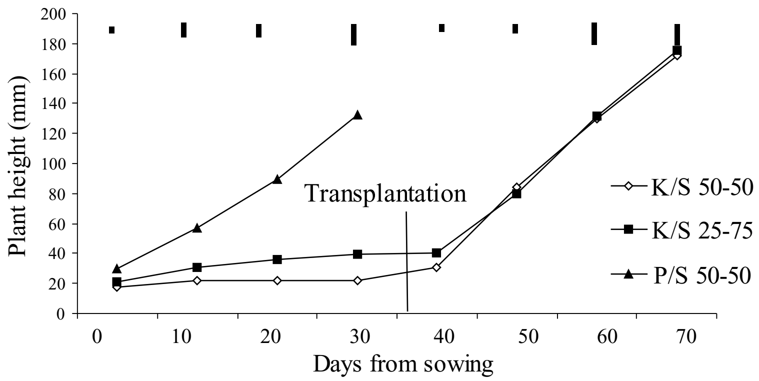

Fig. 1. The growth of lettuce in kenaf-sand media followed by transplantation to a substrate of peat and sand (50:50). Vertical bars indicate L.S.D. ($P = 0.05$).

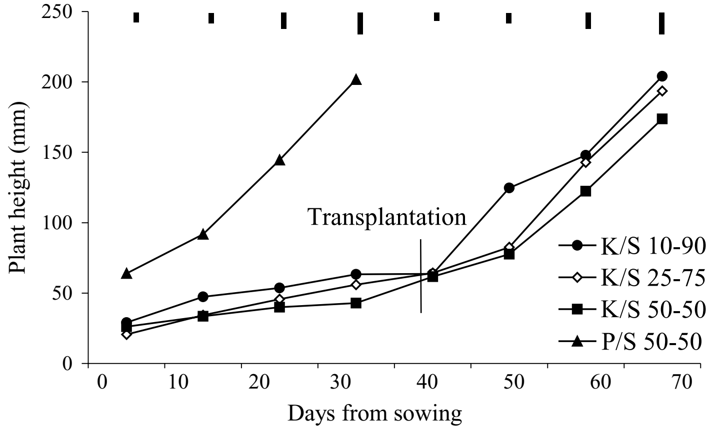

Fig. 2. The growth of pepper in kenaf-sand media followed by transplantation to a substrate of peat and sand (50:50). Vertical bars indicate L.S.D. ($P = 0.05$).

Although most previous studies have used core material (Wang, 1994; Pill et al., 1995; Pill and Bischoff, 1998), the inhibitory effect of kenaf was found to be located both in the core and the bark (Fig. 3). Pill et al. (1995) reported that shoot dry weight of tomatoes grown in a kenaf-based medium was lower than that of the control (without kenaf), but was increased when the kenaf had been soaked in N-containing medium prior to planting. Our results support this observation, since the growth of plants in a kenaf-based substrate that had been soaked in NH_4NO_3 prior to sowing was higher than that of plants in kenaf that had not been treated with N, although growth was still significantly less than the peat-sand control (Fig. 3).

The principal difference between the present results and those reported earlier by other authors (Pill et al., 1995; Pill and Bischoff, 1998) is that whereas the latter were attempting to use a kenaf-based substrate for plant propagation and were therefore using N to overcome any inhibitory effects of kenaf, in the present study, we exploited the inhibitory effect to create slow growing, compact plants. Compact plants are of particular value to floriculture, but can also be valuable to the vegetable plant producer. Because the inhibitory

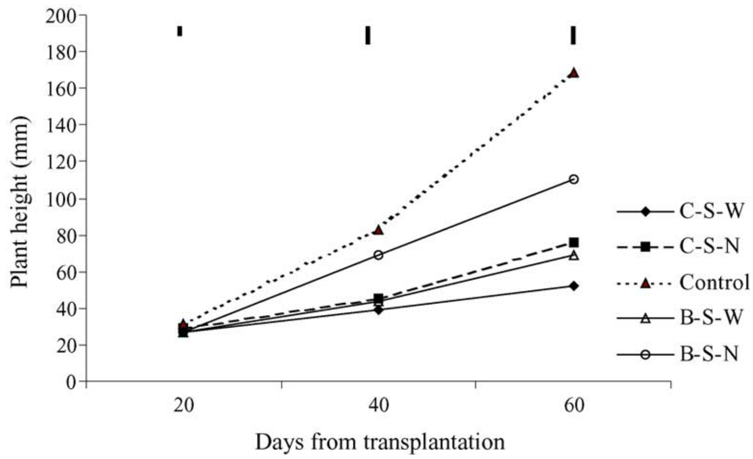

Fig. 3. Lettuce growth in substrates containing kenaf core (C) or bark (B) which had been soaked in water (W) or NH_4NO_3 (N) prior to mixing with sand (S) (50:50), in comparison with the control (peat and sand, 50:50). Vertical bars indicate L.S.D. ($P = 0.05$).

action of kenaf can be overcome by subsequent transfer of plants to a kenaf-free substrate (Figs. 1 and 2), plants may be held for longer in the nursery, thus increasing the flexibility of nursery plant production. For this to be exploited, however, the seed must be sown directly in the kenaf-based substrate, rather than transplanted together with a peat containing root ball (Pill et al., 1995; Pill and Bischoff, 1998), in which case the inhibitory effect is reduced.

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