PERFORMANCE OF THREE CULTIVARS OF KENAF (*HIBISCUS CANNABINUS* L.) IN ZINC AND CHROMIUM CONTAMINATED SOILS

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ABSTRACT: Soils contaminated with heavy metals can contribute significantly to desertification, loss of ecosystem services, and high levels of heavy metals in the soil are determinants of growth, crop productivity and biomass quality. Production of Kenaf in soils contaminated with heavy metals has been the subject of discussion in several forums, since this crop shows some suitability for phytoremediation, and the biomass being produced can still present an economical aggregated value. Therefore, this study aimed to evaluate the performance of three kenaf cultivars in soils contaminated with Zinc and Chromium. The study was performed in a pot essay and the plants were tested in clay soils. The soils were artificially contaminated, and the concentrations chosen were based on the limits established by the Decree Law 276 of 2009 (Portuguese regulation that establishes the regime for the use of sewage sludge in agricultural soils) - Zn: 450 mg/kg; Cr: 300 mg/kg. Results showed that the three cultivars were affected by soil contamination. Hong-Zong was only affected by Cr and not by Zn. In the case of Funong 992, both metals affected the yield, but Cr more than Zn, although differences were not statistically significant. With H328, both metals affected the yields and no significant differences were observed among Cr and Zn effect. In Zn contaminated soils Hong-Zong and Funong 992 cultivars performed significantly better than H328 cultivar. In Cr contaminated soils, Funong 992 cultivar performed significantly better than Hong-Zong cultivar or H328 cultivar. Funong 992 showed to be the best cultivar to crop in Zn or Cr contaminated soils once to both metals, the yields were the highest.
Keywords: kenaf, energy crops, polluted soil, heavy metals, land use

1 INTRODUCTION

Decreasing of natural resources quality and environmental services is an issue that has been addressed in many forums at the global level, associated with climate change as a consequence of deforestation and inadequate agricultural practices. The soil, being a natural resource of vital importance for the development of the species, when exposed to inappropriate uses, can suffer irreparable damages and condition its security and productivity for agricultural purposes [1]. Considering that the high levels of contamination of soils by heavy metals can cause a greater accumulation of metals in biomass, which in the case of food crops it can be very harmful to human health [2], cultivating Kenaf (*Hibiscus cannabinus* L.), an energy crop and a non-food crop [3-6] is considered a good option. Producing kenaf in contaminated soils is indicated as a viable possibility, not only for the high economic value of its byproducts [7-8] but also for its ability to adapt to stress conditions [9-12] and phytoremediation of soil contaminated with heavy metals [13-15]. The production of Kenaf in heavy metal contaminated soils reduce also the risks associated with land use conflicts since contaminated land is less productive and therefore it is not considered for the production of food crops [16], [17]. Thus, producing energy and non-food crops in contaminated land not only helps to meet energy and biomaterial needs but can also contribute to the recovery of these areas, restoring ecosystem services and possibly contributing to socioeconomic growth. Therefore, as a topic of great interest, we have seen the need to conduct this study with the aim of understanding how three kenaf cultivars behave when grown on soils contaminated with heavy metals, namely zinc and chromium.

2 MATERIALS AND METHODS

The experiment started in May 2018 on the Caparica campus of the Universidade Nova de Lisboa, a temperate region, with higher precipitation in the winter than in the summer, with an average temperature of 16.7 °C and annual mean precipitation of 706 mm [18].

2.1 Experimental layout

Three kenaf cultivars (H328, Hong-Zong and Funong 992, developed by IBFC in China) were tested in pots with 1.5 kg of clay soil artificially contaminated with saline solutions containing $ZnCl_2$ for Zinc contamination or $CrCl_3.6H_2O$ for chromium contamination (Table I), based on the limits established by the Decree Law 276 of 2009 (Portuguese regulation that establishes the regime for the use of sewage sludge in agricultural soils)[19].

Table I: Levels of contamination tested (mg.kg^{-1}) for each metal studied and salt used for the contamination

Metal	Contamination	Salt
Zn	450	$ZnCl_2$
Cr	300	$CrCl_3.6H_2O$

For each Kenaf cultivar, three replicates were established for each of the contaminants and their respective control treatments, as shown in Figure 1.

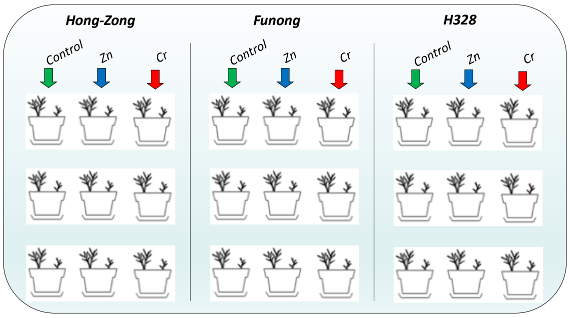

Figure 1: Experimental layout

Kenaf seeds were sown, and each pot received only one cultivar, making nine pots per cultivar. Soon after sowing, the pots were irrigated with 0.05dm^3 of tap water in order to break dormancy of the seeds and ensure the need for water for germination. Care was taken to collect the respective leachates, which were incorporated into the soil along with the irrigation water. After plants reached 20 cm, they were thinned to reach 5 plants per pot. In all pots, nutritional requirements were also guaranteed by fertilization with NPK (23g of P_2O_5.m^{-2}, 17.8g of K_2O.m^{-2}, 3g of Nitrolusal.m^{-2} and 3g of Urea.m^{-2}). Irrigation with a 0.05 dm^3 of tap water was applied five times a week throughout the crop cycle.

The harvest was performed in November 2018, when the following biometric parameters were determined:

Plant height - using a tape measure, the measurement was made from the base, near the ground, to the highest point.

Number of leaves - the leaves of the plant were counted and registered, including leaves from new shoots.

Leaf area - it was determined using the application Easy leaf area, a free and open source software that rapidly measures leaf area in digital images (photographs or scanner images)[20].

Crop productivity - the plants were removed from the soil and cleaned of any loose soil, then the fresh weight of the aerial biomass was measured. The biomass was dried in a low heat oven (70°C) overnight and then weighed again to obtain its dry weight.

3 RESULTS AND DISCUSSION

3.1 Height of kenaf plants

Kenaf is a crop that grows well in soils contaminated with zinc and chromium, especially in soils containing zinc (Figure 2). In this case, there were no major changes in crop growth, only a slight decrease in Funong 992 (not significant to control) and H328 cultivars. In the case of the Hong-Zong, zinc did not affect the height of this cultivar, and plants even showed a higher height than control. In soils containing chromium, the growth of kenaf was more compromised, resulting in a reduction in plant height in a range of 11cm to 23cm.

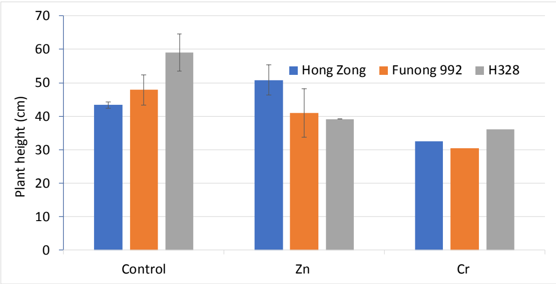

Figure 2: Height of three cultivars of Kenaf grown in clay soils contaminated by zinc and chromium

3.2 Number of leaves and leaf area

Figure 3 shows the number of leaves counted for each kenaf cultivar, for the different treatments.

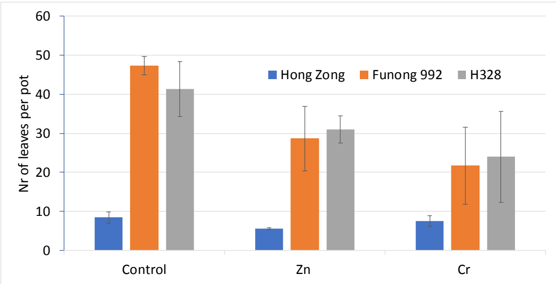

Figure 3: Number of leaves of three cultivars of Kenaf grown in clay soils contaminated by zinc and chromium

In this case, it is possible to see a great variation of this parameter with the contamination, being chromium the metal that most affects the H328 and Funong 992 cultivars, reducing the number of leaves in about 50% and in 10% only in Hong Zong cultivar. In this cultivar, the reduction was not significant. On the other hand, zinc affected more the Hong-Zong cultivar more than the other two cultivars, with a reduction of 35%. But this cultivar was the one that showed the lowest amount of leaves per pot, even in control.

The H328 cultivar in chromium contaminated soils, although presenting better values of leaf number than the other two cultivars, its leaf area presented the lowest values, with about 280cm^2 below the control treatment (Figure 4). Still in the contamination by chromium, the Hong-Zong and Funong 992 cultivars reduced leaf area by 195cm^2 and 190cm^2, respectively. This metal was the one that affected most leaf area to all cultivars.

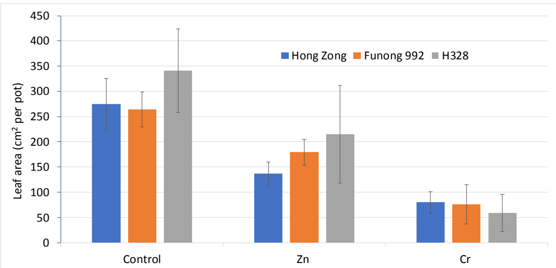

Figure 4: Leaf area of three cultivars of Kenaf grown in clay soils contaminated by zinc and chromium

In zinc contamination, leaf area reduction for the three cultivars ranged from 50% to 68%, and the Funong

992 cultivar was the least affected in terms of leaf area reduction percentage. But cultivar H328 was the one that presented the highest leaf area, either in control and in zinc contaminated pots.

3.3 Biomass Productivity

Figure 5 shows that the productivity of kenaf in zinc contaminated soils was less affected than in soils contaminated by chromium.

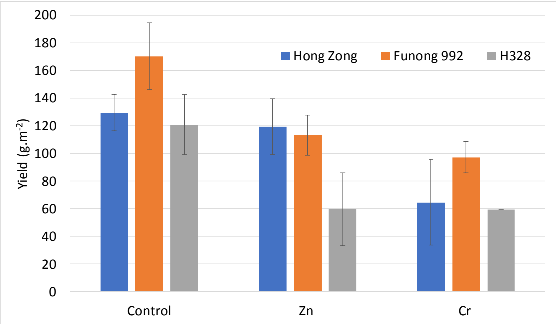

Figure 5: Yield of three cultivars of Kenaf grown in clay soils contaminated by zinc and chromium

Hong-Zong cultivar in zinc contaminated soils showed better yield than the other cultivars (reduction of about 8% of productivity), while in chromium contaminated soils the best yields were shown by the Funong 992 cultivar (reduction of about 43% productivity). The decrease in yield for the H328 cultivar was about 51% in both zinc and chromium contaminated soils.

4 CONCLUSIONS

The performance of kenaf crop is negatively affected by contamination of soils with zinc and chromium, although zinc is the metal that least affects the three studied cultivars.

The results showed that the leaf area values obtained are not directly proportional to the number of leaves counted. Contamination by heavy metals affected not only the number of leaves but also their area.

The H328 cultivar is affected by both metals (zinc and chromium), but the two metals affected this cultivar yield in the same way. On the other hand, effects of zinc and chromium contamination to Hong-Zong and Funong 992 cultivars showed that chromium was the heavy metal that most affected these cultivars, being more prejudicial to Hong-Zong than to Funong 992. Funong 992 showed to be the best cultivar to crop in Zn or Cr contaminated soils once to both metals, the yields were the highest.

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