

Growth Responses of Two Kenaf Varieties (*Hibiscus cannabinus* L.) Applied by Different Levels of Potassium, Boron and Zinc

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Abstract

The aim of this study was to determine the effect of potassium, boron and zinc rates on the growth of kenaf. Seeds of two kenaf varieties namely; FH-952 and 4383 variety were planted on 26 September 2013. Plant growth was determined for both varieties. The growth characteristics which consist of plant height, stem diameter and leaf number were measured every two weeks for five times consecutively. The best result was achieved for both characteristics; stem diameter and leaf number for FH-952 variety when potassium and boron added at rates of 150 and 1.5 kg/ha, respectively except plant height was better when potassium was at the same rate while boron and zinc were controlled. The results showed a significant impression on the kenaf growth. It would be apposite to choose better varieties of kenaf for the production purpose with using better controlling of macro and micronutrients.

Keywords: macronutrient, micronutrient, kenaf varieties, crop performance

1. Introduction

One of the most potential sources of fiber in the cottage industry around the world is kenaf (*Hibiscus cannabinus* L.). The high fiber content of kenaf fiber leads to increase the importance of planting kenaf all over the world (Alexopoulou et al., 2000). Manzanares et al. (1997) stated that, kenaf is a very quickly growing plant and has great potential to be used as industrial crop globally since it contains high fiber materials or lignocellulosic material. It is also one of the best natural fibers which are used for a wide range of applications. Kenaf is a high-yielding cordage crop habitually grown for the production of twine, rope and sackcloth. Recent applications of kenaf include paper products, building materials and absorbents (Sabharwal et al., 1994, Kalaycioglu & Nemli, 2006). Kenaf grows quickly, its stem rises to a height of (3.7-5.5 m) in a 4-5 month growing season and its stem diameter was ranged between 25-51 mm (Ashori et al., 2006).

Potassium is very important for the growth stage of the plant, with the highest uptake rates often reached during the vegetative step (Marschner, 2012). Potassium contributes in nitrogen use efficiency as well (Gething, 1993). The highest plant reached from highest addition of potassium combination with highest nitrogen dose used although Webber (1996) reported that nitrogen has no effect on plant height in kenaf plant. Also, boron fertilizer is directly and indirectly involved in a lot of physiological and biochemical processes through plant growth, for example cell elongation and division, cell wall biosynthesis, tissue function, nitrogen metabolism and photosynthesis (Blevins & Lukaszewski, 1998). Cell wall strength, cell division, fruit and seed development, and sugar transport are plant functions related to boron. However, Hafeez et al. (2013) reported that, one of the vital plant nutrients is zinc for all sorts of crops. It is deficient in all parts of the globe with different types of soils. Believed that, the yield of rice is increased due to add zinc for the plants and crop is continuing to health growth by application zinc.

The hypothesized combination between potassium, boron and zinc would increase plant height and stem diameter of kenaf varieties. The importance of the potassium, boron and zinc for the kenaf growth are encouraging us for supplementing those fertilizers' application, since till now there are no reports on the effects

of potassium with boron and zinc on the kenaf growth. Also the information on the kenaf varieties and its relation to this kind of fertilizers are very limited. Thus, the objective of this study was to determine the influence of potassium, boron and zinc concentrations on the growth of kenaf (plant height, stem diameter and leaf number) for two common varieties.

2. Method

2.1 Study Site

The study was conducted in Taman Pertanian Universiti, Seksyen Tanaman Ladang Kongsi Petak C, Universiti Putra Malaysia, Serdang, Selangor, Malaysia (2°59'11.5"N, 101°42'29.9"E, 50 m a.s.l.).

2.2 Plant Materials

Two kenaf varieties namely; FH-952 and 4383 varieties were used in the experiment, with three levels of potassium, three levels of boron and two levels of zinc, and also one level of each of nitrogen and phosphorus.

2.3 Experimental Design

Factorials (2×3×3×2) with three replications were arranged in Randomized Complete Block Design (RCBD). The first factor was two varieties of kenaf, the second factor was three rates of potassium, the third factor was three rates of boron and the last factor was two rates of zinc. Sixty six seeds were placed in a soil depth of 1.5 - 3.0 cm in the plot. The size of the plot was 1 m², and the distance between plants was 5 cm and 30 cm from row to row. Three rates of muriate of potash (0, 100 and 150 kg/ha) were used twice. The first half application (50 and 75 kg/ha) was applied during planting. The second dose like the first instalment plus three rates of boron as borax (0, 1.0 and 1.5 kg/ha) and two rates of zinc as zinc chloride (0 and 5 kg/ha) were added after three weeks of planting. Nitrogen fertilizer was also used in the form of urea (46% N: 200 kg/ha). It was applied in two splits (100 kg/ha) for each plot. The first split was added during planting and the second split was after a month of planting. Triple super phosphate was added (90 kg/ha) during planting. Three replications of control (Potassium (K) = 0, Boron (B) = 0 and Zinc (Z) = 0 kg/ha)) were conducted to observe the performance of both the varieties.

2.4 Soil Samples and Analysis

The soil samples (Ultisol) were taken from the depth of 0 to 15cm in the farm. The samples were transported to the laboratory. Then, the soil was air-dried and sieved through a 2 mm pore size sieve. Soil texture was determined by the relative quantities of sand, silt, and clay using pipette method (Black & Day 1965). Total organic carbon and total nitrogen were measured by CNS analyzer machine (model: LECO TruMac CNS Analyzer), available P was determined by Bray-I method as described by Kuo (1996), pH was measured in soil/water (1:2.5) suspension and also electrical conductivity EC was measured. The concentrations of nitrogen (N), phosphorus (P) and potassium (K) in the solution, were determined using an autoanalyzer (QuikChem, Series 8000, Lachat Instruments Inc., USA) and the concentrations of iron (Fe), calcium (Ca), magnesium (Mg), manganese (Mn), zinc (Zn) and copper (Cu) were also determined by atomic absorption spectrophotometer (Perkin-Elmer 5100 PC) (Jones, 2001). The initial physical and chemical properties of the soil are presented in Table 1.

Table 1. The initial physical and chemical properties of the soil used in the experiment

Soil properties	Unit	Content
Sand		46.07
Silt	%	9.92
Clay		43.92
pH (H ₂ O)		6.00
EC	µS/cm	108.5
Carbon	%	1.45
Nitrogen		0.10
Phosphor		1.56
Potassium		80.17
Calcium		451.10
Magnesium		95.76
Manganese	µg/g	7.26
Copper		ND
Zinc		0.93
Iron		73.30

ND = not detected.

2.5 Growth Measurements

Plant height (Ht), stem diameter (SD) and leaf number (LN) were determined from five plants in each plot. Every two weeks, plant height was measured by using a steel ruler. The height was measured from cotyledon level up to the base at the terminal bud. Measurement of stem diameter (5cm above ground level) was performed by using a digital vernier caliper. Also, leaf number was counted every two weeks when the main veins were visible (Hossain et al., 2013). However, the data of growth parameters were collected from the mean of every two weeks with the mean of the harvesting day at 75 days after planting.

2.6 Botanical Characteristics of Selected Kenaf Varieties

The botanical characteristics for FH-952 and 4383 kenaf varieties can be described as follows:

Kenaf stem: Figure 1(A and B) shows the whole kenaf plants for the variety FH-952 at harvesting day (75 DAP) while, Figure 1(C) shows plant height of the kenaf variety 4383 on the same harvesting day. In general, 4383 variety is shorter and having smaller stem diameter than FH-952 variety.

Leaves: Generally kenaf has two different kinds of leaf, divided and entire leaves as can be seen in Figure 1(D and E). Kenaf variety and age of plant affect the leaf shape. Figure 1 (D) shows the leaf shape of kenaf variety FH-952 while, Figure 1 (E) shows leaf shape for the variety 4383. The second variety is producing leaves as cordate (heart-shaped).

Flowers: Kenaf flowers are large, light yellow, creamy colored and also as bell-shaped and widely open and both varieties have the same flower color and shape (Figure 1 (A)).

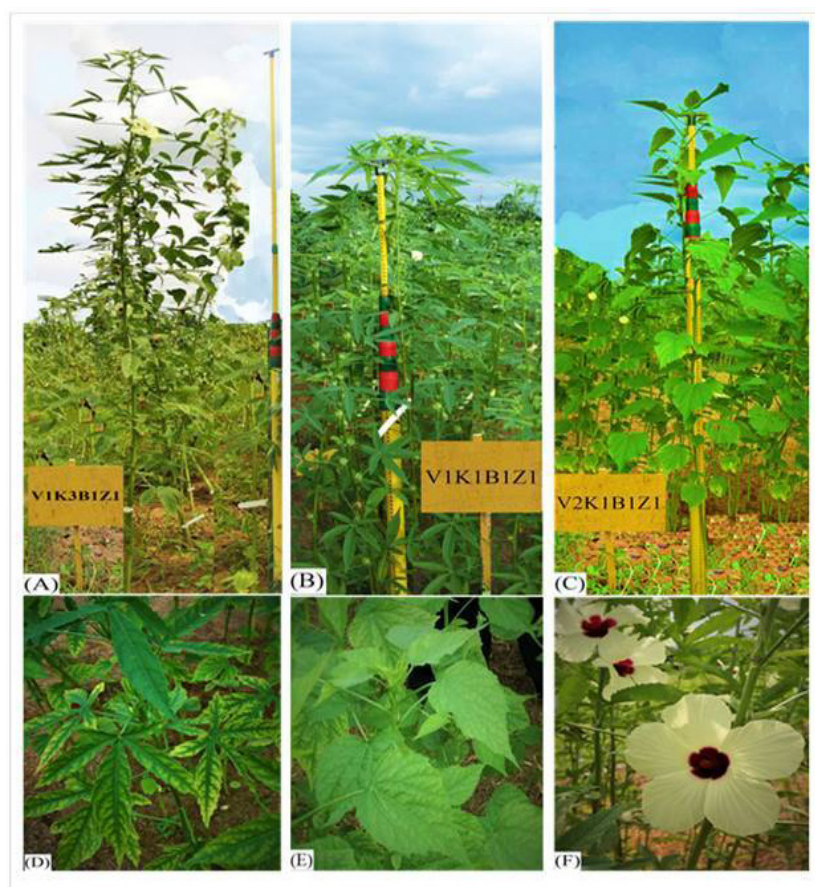


Figure 1. Stem, leaves and flowers of the two kenaf varieties (FH-952 and 4383)

(A) plant height of variety FH-952 when potassium at level 150 kg/ha, but boron and zinc were controlled; (B) plant height of variety FH-952 when fertilizers were controlled (not added); (C) plant height of variety 4383 when fertilizers were controlled (not added); (D) leaf shapes of variety FH-952; (E) leaf shapes of variety 4383; (F) kenaf flowers.

2.7 Data Analysis

Data on plant height, stem diameter and leaf number were subjected to Analysis of Variance (ANOVA), using SAS Statistics 9.3 (2002-2010). Mean comparison was performed by SNK (Student-Newman-Keuls) at $P \leq 0.05$.

3. Results

The mean comparisons of plant growth (plant height, stem diameter and leaf number) of kenaf at different potassium, boron and zinc rates and also varieties are shown in Table 3. Results indicated that kenaf variety had significant effects on all the measured characteristics. The highest values for the characteristics were obtained from the variety FH-952 except for leaf number. The leaf number was better in the 4383 variety. The plant height was significantly affected by potassium when it was at K rate of 150 kg/ha (Table 2 and Figure 2). Also, that parameter was significant at different rates of boron and the best result for plant height appeared when boron was at rate 1.0 kg/ha, but it was decreased with increasing rate of boron. The ratio of plant height was decreased when zinc was at the second rate (5 kg/ha).

Table 2. Growth parameters of two varieties of kenaf at different potassium, boron and zinc levels

Treatment	Plant Height (cm)	Stem Diameter (mm)	Leaf Number
Variety			
FH-952	93.5 \pm 1.6 ^a	7.8 \pm 0.3 ^a	35.2 \pm 1.3 ^b
4383	77.3 \pm 1.5 ^b	6.7 \pm 0.3 ^b	38.6 \pm 1.8 ^a
Potassium kg/ha			
0	77.9 \pm 1.5 ^c	6.2 \pm 0.2 ^c	32.5 \pm 1.7 ^c
100	86.8 \pm 1.6 ^b	7.4 \pm 0.3 ^b	36.6 \pm 1.4 ^b
150	91.5 \pm 1.5 ^a	8.1 \pm 0.3 ^a	41.6 \pm 1.6 ^a
Boron kg/ha			
0	83.4 \pm 1.1 ^c	7.0 \pm 0.2 ^b	36.4 \pm 1.5 ^b
1.0	87.1 \pm 1.9 ^a	7.2 \pm 0.3 ^b	34.8 \pm 1.5 ^c
1.5	85.7 \pm 1.6 ^b	7.5 \pm 0.3 ^a	39.5 \pm 1.7 ^a
Zinc kg/ha			
0	87.8 \pm 1.6 ^a	7.5 \pm 0.3 ^a	37.3 \pm 1.4 ^a
5.0	83.0 \pm 1.7 ^b	7.0 \pm 0.3 ^b	36.6 \pm 1.7 ^a

Means within the column that have same letter are not significantly different (SNK, $P \leq 0.05$). Values are means \pm standard error of the mean.

V = Variety, V1 = FH-952 and V2 = 4383.

K = Potassium, B = Boron and Z = Zinc. K1, B1, Z1 = 0 (Control), K2 = 100 kg/ha, K3 = 150 kg/ha, B2 = 1.0 kg/ha, B3 = 1.5 kg/ha, Z2 = 5.0 kg/ha.

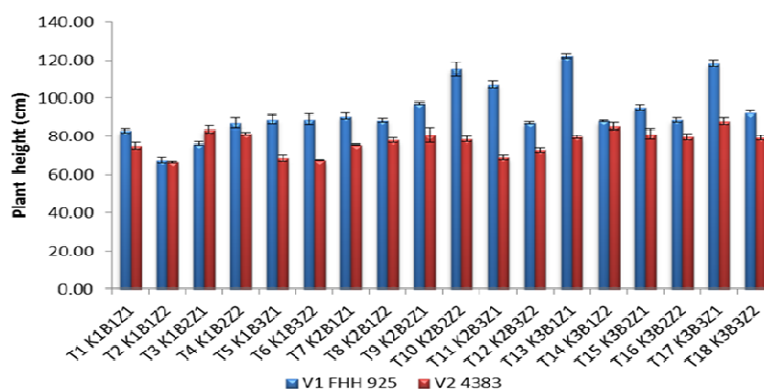


Figure 2. The effect of different levels of potassium, boron and zinc on the plant height of the kenaf varieties FH-952 and variety 4383. Values are means \pm standard error of the mean

The biggest stem diameter was significantly observed at 150 and 1.5 kg/ha of potassium and boron respectively but that value was decreased in the control treatment which was found at 6.2 and 7.0 mm, respectively (Table 2 and Figure 3). However, stem diameter was better when zinc was controlled (not added). The reason might be that 5 kg/ha of zinc was very high for kenaf plant.

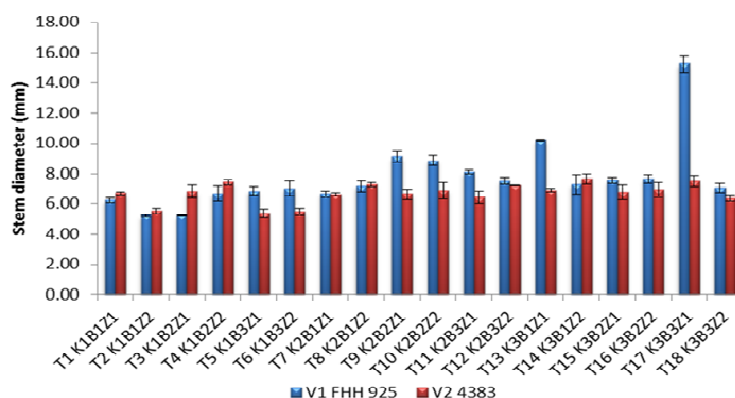


Figure 3. The effect of different levels of potassium, boron and zinc on the stem diameter of the kenaf varieties FH-952 and variety 4383. Values are means \pm standard error of the mean

The best plant that has the highest leaf number was again in the rates of 150 and 1.5 kg/ha potassium and boron, respectively but it was not significant at different rates of zinc (Table 2 and Figure 4).

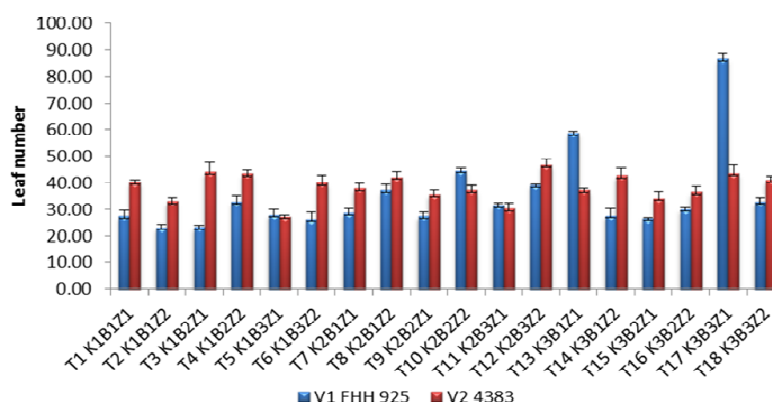


Figure 4. The effect of different levels of potassium, boron and zinc on the leaf number of the kenaf varieties FH-952 and variety 4383. Values are means \pm standard error of the mean

Table 3 shows the significant interaction between potassium, boron and zinc with varieties and also the significant interaction between kenaf variety and potassium, boron and zinc separately.

The plant height was significantly affected by the potassium, boron and zinc when potassium is at rate 3, boron is at rate 1 and zinc is at rate 1. The plant height was reached to 122.2 cm but when potassium, boron and zinc at the second rates 100, 1.0 and 5.0 kg/ha, respectively that value was decreased to 113.73 cm. After that ratio of plant height was dropped to 112.83 cm with increased rate of boron. While, in the control treatment plant height was only about 83.07 cm. But for 4383 variety the plant height did not change significantly when zinc and zinc with boron were applied to the treatments (Figure 2). So, based on the results, potassium was really useful for kenaf growth especially to determine the plant height.

Stem diameter increased significantly up to 15.25 mm when potassium and boron were added at the rate of 150 and 1.5 kg/ha, respectively. That value dropped to 10.22 mm when potassium was applied at the same level but boron was decreased from rate 3 to rate 1 (from 1.5 to 0 kg/ha). Nevertheless, the stem diameter was only 6.24 mm in the control treatment but with zinc addition that value decreased to 5.22 mm in the treatment 2 when potassium, boron and zinc at 0, 0 and 5.0 kg/ha, respectively (Figure 3). Again for 4383 variety stem diameter did not significantly change when zinc and potassium with zinc, and also boron with zinc were applied to the plants. Figure 4 shows the significant effect of fertilizers on the leaf number by all of the fertilizers in the treatment 17 when potassium, boron and zinc at 150, 1.5 and 0 kg/ha, respectively of the FH-952 variety. This leaf number was dropped dramatically when zinc was added. However, potassium and boron did not significant effect on the leaf number for 4383 variety.

Table 3. The analysis of variance (ANOVA) for the effect of different treatments and their interactions on the mean of plant height, stem diameter and leaf number

Source of variation	DF	Mean Plant Height (cm)			Mean Stem Diameter (mm)			Mean Leaf Number		
		SS	Mean S.	P>F	SS	Mean S.	P>F	SS	Mean S.	P>F
V	1	7123.18	7123.18	<.0001	30.70	30.70	<.0001	308.72	308.72	<.0001
K	2	465.85	1732.92	<.0001	65.01	32.50	<.0001	1494.58	747.29	<.0001
B	2	256.20	128.10	<.0001	5.63	2.81	0.0003	423.26	211.63	<.0001
Z	1	637.04	637.04	<.0001	7.94	7.94	<.0001	13.23	13.23	0.2301
V×K	2	923.39	461.69	<.0001	21.19	10.59	<.0001	1122.07	561.03	<.0001
V×B	2	615.64	307.82	<.0001	18.85	9.42	<.0001	519.63	259.81	<.0001
V×Z	1	333.90	333.90	<.0001	11.66	11.66	<.0001	495.79	495.79	<.0001
K×B	4	1442.03	360.50	<.0001	22.26	5.56	<.0001	2017.49	504.37	<.0001
K×Z	2	688.43	344.21	<.0001	24.27	12.13	<.0001	2220.75	1110.37	<.0001
B×Z	2	792.73	396.36	<.0001	15.39	7.69	<.0001	521.44	260.72	<.0001
K×B×Z	4	316.35	79.08	<.0001	29.09	7.25	<.0001	1149.49	298.62	<.0001
V×K×B	4	784.47	196.11	<.0001	20.13	5.03	<.0001	895.35	148.83	<.0001
V×K×Z	2	657.75	328.87	<.0001	18.59	9.29	<.0001	1404.44	702.22	<.0001
V×B×Z	2	909.28	454.64	<.0001	9.34	4.64	<.0001	1310.52	655.26	<.0001
V×K×B×Z	4	426.96	106.74	<.0001	10.11	2.52	<.0001	269.48	67.37	<.0001

V = Variety, K = Potassium, B = Boron and Z = Zinc.

4. Discussion

Results presented in this study demonstrate that potassium proportions had significant effect on all the growth characteristics observed in this study. Plant height dramatically increased with increase rate of potassium. It was similar to the findings by Tatar et al. (2010). The researchers believe that, potassium fertilization has the impact on plant height and stem yield. However, according to Abdul-Hamid et al. (2009), height of kenaf plant increased with increasing the level of nitrogen, phosphor and potassium fertilizers and micronutrients. Also, boron had positive effect on the plant height but when the rate of boron increased the height of plants was decreased. This similar to the finding by Gupta (1993) who believed that, it was because of the range between boron deficiency and toxicity is very narrow. However, stem diameter and leaf number varied significantly due to applied boron to the plants. This increase was not only due to the application of boron but it was due to the effect of potassium. This agreement with the findings by Schumann & Sumner (2004) who observed that application of boron fertilizer obviously improved the absorption of other nutrients. This finding was also supported by Hossain et al. (2010). They stated that, different levels of nitrogen, phosphor and potassium had significant effects on the stem diameter, plant height and leaf number when nitrogen, phosphor and potassium were used at 200, 100 and 100 mg/l, respectively. Growth characteristics were decreased when applying zinc at 5 kg/ha. In general zinc has responsibility in decreasing plant height. On the other hand, variety was another factor that affected on the growth process of kenaf. This was in accordance with those of Agbaje et al. (2008) who reported that, plant height changed significantly with different kenaf varieties.

5. Conclusion

The results show that, there are significant differences at $P \leq 0.05$ between varieties of kenaf, and it is found that FH-952 variety was better than 4383 variety for the plant growth (plant height and stem diameter) but about leaf number 4383 variety was better than FH-952 variety. However, potassium and boron at the rate of 150 and 1.5 kg/ha, respectively, had significantly affected on the stem diameter and leaf number but in term of plant height, it was better when boron was at the rate of 1.0 kg/ha. Despite, the plant height, stem diameter and leaf number were better when zinc was controlled (zero rate applied). Nevertheless, FH-952 responded significantly to potassium and boron at 150 and 1.5 kg/ha respectively for stem diameter and leaf number parameters except the plant height. The differences in plant growth, plant height, stem diameter and leaf number suggested that the FH-952 variety can be considered as the most appropriate to be grown under better management of the fertilizers

especially potassium and boron at the rate of 150 and 1.5 kg/ha, respectively. With that, those fertilizers in some conditions effected significantly on the growth parameters for the 4383 variety but results showed that it was not economical. This study suggests that for 4383 variety, the need of potassium, boron and zinc is not critical.

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