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EFFECT OF POTASSIUM, BORON AND ZINC ON NITROGEN CONTENT IN BAST AND CORE FIBRES FOR TWO KENAF VARIETIES (*Hibiscus cannabinus*L.)

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ABSTRACT

The purpose of this project was to determine the meaning of the potassium, boron and zinc on the nitrogen content and relation between the rate of nitrogen content and kenaf fiber yield. Two varieties of kenaf, namely; FHH 925 and 4383, were planted on 26 September 2013. Different levels of potassium as muriate of potash, boron as boraxand zinc as zinc chloride applied to the plants. The samples selected from five plants in each plot and nitrogen contents in core and bast fibers analyzed. The best nitrogen content, fresh stem yield, dry stem yield, dry bast yield and dry core yield were achieved from FHH 925 variety when potassium added at a level of 150 kg/ha. For 4383 variety, the best result for nitrogen content was when potassium, boron and zinc used at 150, 1.0 and 5.0 kg/ha, respectively. While the other best parameters of fiber yield found when potassium added alone at the rate of 100kg/ha. In fact, the result of this variety was not too much different from the control treatment (not added any potassium, boron and zinc). The findings revealed that potassium fertilizer was certainly necessary for the both kenaf varieties in order to obtain the highest nitrogen content in the fiber that later will determine the quality of the kenaf fiber.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is native of tropical Africa. Kenaf is one of the rapidest growing plants, C3 plant (three carbon compound).Also, it is new sources of Bioenergy as an industrial crop and also it has great potential to be planted and used in Malaysia. Kenaf planting has increased around the world due to kenaf hassignificant biomass yield and the raised fiber content (Hossain *et al.,* 2010). Webber and Bledsoe, (2002) who reported the stem and biomass yields were important factors in selecting kenaf varieties for fiber production. The rate of the dry weight of bast and core fibers in thekenaf stem dividedby 60-75% of the dry weight for internal core.

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Also, about 25-40% ofthe outer bast stem (Alexopoulou *et al.,* 2000). Potassium is one of the vital minerals for every major stage of protein synthesis. In all growth steps, potassium regulates the plant cells for the production of proteins and enzymes, and the production is impossible without an adequate amount of it. When potassium is a deficit, the plants are not making proteins even though there is an abundance of available nitrogen. Vastlevels of available potassium improve the physical quality, illness resistance, and it increases crop yield and plays significant roles in enhancing crop quality. Shengxian (1998) and Tatar *et al.* (2010) suggested that, nitrogen and potassium fertilization were useful for production and to obtain higher yield of ramie (*Boehmeria nivea*). Borondirectly and indirectly involved in many physiological and biochemical processes through plant growth, such as cell elongation and division. Cell wall biosynthesis, membrane function, nitrogen metabolism and photosynthesis (Blevins and Lukaszewski, 1998). On the other hand, Hafeez *et al.* (2013) reported that thezinc is a very essential plant nutrient for all sorts of crops. It is adeficit in all parts of the globe with different types of soils. Under these conditions apply of zinc fertilizer is necessary for healthy crop growth and higher yields. This study hypothesized that the combination between potassium, boron and zinc, which would increase nitrogen content in kenaf fiber and increase fiber yield. Potassium, boron and zinc are critical for growth, physiological and biochemical processes. This importance pushes for using those kinds of fertilizers for kenaf plant. Since till now to the best of authors' knowledge, there are no intelligences on the effect of a combination between potassium, boron and zinc on the nitrogen content in the kenaf fiber.Hence, the first aim of this study was to determine the impact of the fertilizers usedon the nitrogen content in the fiber. The second goal was to determine the effect of fertilizers with nitrogen content on the fiber yield such as fresh stem yield, dry stem yield, dry bast yield and dry core yield.

MATERIALS AND METHODS

Experiment location

The experiment 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.).

Field experiment

The field test was laid out in randomized complete block design (RCBD) with factorial design with three replications. The first factor was two varieties, namely; FHH 925 and 4383 variety. The second factor was three levels of potassium. The third and last factors were three levels of boron and two levels of zinc.Sixty-six seeds planted on 26 September 2013 in depth of 1.5 to 3.0 cm in the plot with the size of 1 m^2. The space between plants was 5 cm, and 30 cm was between rows. Fertilizer applied and incorporated at a rate of 0, 100 and 150 kg/ha as muriate of potash for potassium thatsplit into two times. The first time was half application rate (0, 50 and 75 kg/ha) applied during planting. The second dose was like the first installment plus three levels of boron as borax (0, 1.0 and 1.5 kg/ha). Also, with two levels of zinc as zinc chloride (0 and 5 kg/ha) thatadded after three weeks of planting. Nitrogen fertilizer also applied in the form of urea (46% N) at a rate of 200 kg/ha. It applied in two splits (100 kg/ha) for each plot. The first divisionadded through planting, and the second divided was after a month of planting.

Triple superphosphate was added 90 kg/ha while seedling as basal fertilizer. Kenaf fibers harvested at 75 days after planting (75 DAP). The plants harvested at 10 cm above ground level, and five stems collected as a sample from each plot. Then, the samples transported to the laboratory and oven dried at 65 °C for 48 hours. The powder was prepared to determine nitrogen content. Plant tissue (0.1g) weighed into the flask. Then, added $^1/_2$ Kjeldahl catalyst tablet and 10ml of concentration H_2SO_4. Next, it heated of the digestion block heaters in a fume cupboard at 150 °C for anhour and ahalf. Then increased temperature at 350 °C for 2 hours until the solution change to colorless. After digestion, the samples were left in the room temperature for 2-3 hours. Total nitrogen was measured using an autoanalyser (QuikChem, Series 8000, Lachat Instruments Inc., USA).

Biomass measurements

After harvesting, five plants were selected randomly. Then, it was transported to the laboratory for biomass measurements. The leavesdetached from the stems, and then stem was freshly weighted. Best and core fibers were separated manually by peeling them. Next, stem (bast and core) was dried in the oven at 65°C for 48 hours until the constant weight obtained. Total dry stem yield, dry bast yield and dry core yield determined.

Soil analysis

The soil samples were taken from the depth of 0 to 15cm in the farm. The samples were transported to the laboratory. Then, it air-dried and sieved through a 2 mm pore size sieve. Soil texture determined by the relative quantities of sand, silt and clay by pipette method (Black, 1965). Total organic carbon and total nitrogen determinedthrough CNS analyzer mechanism (model: LECO TruMac CNS Analyzer). Available Pdetermined by Bray-I method as described by Kuo (1996), pH measured in soil/water (1:2.5) suspension and also the electrical conductivity EC measured. Nitrogen concentrations, phosphorus and potassium in the solution, determined with an autoanalyser (QuikChem, Series 8000, Lachat Instruments Inc., USA). Iron concentrations, calcium, magnesium, manganese, zincand copperalso determined through atomic absorption spectrophotometer (Perkin-Elmer 5100 PC) (Jones, 2001). Theoriginal physical and chemical properties of the soil presented in Table 1.

Table 1. Physical and chemical properties of the soil used in the trial

Soil properties											
C	N	pH	EC	P	K	Ca	Mg	Mn	Cu	Zn	Fe
%			µS/ cm	µg/g							
1.45	0.10	6.00	108.50	1.56	80.17	451.10	95.76	7.26	ND	0.93	73.30
				Sand	Silt	Clay					
				%							
				46.07	9.92	43.92					

ND= not detected

Data analysis

Data on nitrogen content and fiber yield exposed to Analysis of Variance (ANOVA), by SAS Statistics 9.3 (2002-2010) and mean comparison performed by SNK (Student-Newman-Keuls) at $P \leq 0.05$.

RESULTS

Effect of potassium, boron and zinc fertilization and variety of the nitrogen content of kenaf fiber

Effect of fertilizers and kenaf varieties on the nitrogen content for both stem sections (bast and core) presented in Table 2 and Figure 1. The nitrogen content on bast and core fibers together in the kenaf FHH 925 variety were significant and more than 4383 variety. However, the nitrogen content was increased with an increased rate of potassium. When potassium not treated, the nitrogen content was only about 3.0% and this value increased up to 3.1 and 3.3 % when potassium was applied at 100 and 150 kg/ha, respectively. Despite, the nitrogen content was dropped when the rate of boron increases.

Table 2. Ananalysis of variance (ANOVA) for the influence of different treatments and their interactions of the nitrogen content (%) in the kenaf fiber and fiber yield at 75 DAP

Source of variation	DF	Mean S. Nitrogen (%)	Mean S. FSY*** (t/ha)	Mean S. DSY (t/ha)	Mean S. DBY (t/ha)	Mean S. DCY (t/ha)
V**	1	1.758*	15095.32*	1041.72*	79.55*	544.00*
K	2	1.279*	8733.07*	697.39*	55.79*	357.81*
B	2	0.869*	856.27*	74.12*	4.79*	44.00*
Z	1	0.008^{ns}	4797.46*	395.75*	34.10*	192.98*
V×K	2	0.700*	2616.46*	174.58*	12.01*	97.76*
V×B	2	0.145*	50.90*	2.69^{ns}	0.01^{ns}	2.97*
V×Z	1	0.017^{ns}	1242.29*	106.52*	5.40*	63.37*
K×B	4	0.648*	2100.01*	148.44*	13.28*	75.45*
K×Z	2	0.059^{ns}	2827.73*	192.49*	14.94*	99.80*
B×Z	2	0.375*	920.87*	76.98*	10.68*	32.06*
K×B×Z	4	0.146*	1375.58*	112.01*	10.27*	55.41*
V×K×B	4	0.893*	1102.01*	77.58*	5.33*	41.88*
V×K×Z	2	0.229*	7474.16*	579.18*	51.82*	279.97*
V×B×Z	2	0.020^{ns}	447.27*	33.38*	2.83*	18.40*
V×K×B×Z	4	0.156*	2354.39	168.18*	18.83*	75.33*

** Significantly different (SNK, P ≤ 0.05), ns= not significant*
***V= Variety, K= Potassium, B= Boron and Z= Zinc.*
****FSY= Fresh stem yield, DSY= Dry stem yield, DBY= Dry bast yield and DCY= Dry core yield.*

The nitrogen content in the control treatment was better when compared to other treatments when applying several levels of boron. Also, this study found that the zinc was not significantly affected on the nitrogen content in kenaf fibers, and this might be due to zinc that may be toxic to kenaf plants.

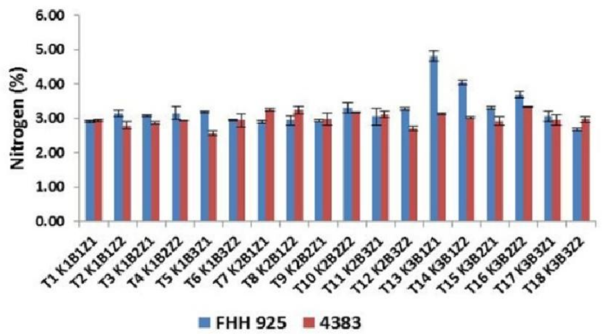

Figure . Influence of different levels of fertilizers on nitrogen (%) of kenaf fiber; FHH 925 and 4383. Values are means ± standard error of the mean

Effect of potassium, boron and zinc fertilization and variety on the fiber yield of kenaf

The total fresh stem yield, total dry stem, dry bast and dry core yield for all the treatments presented in Figures 2,3,4 and 5.

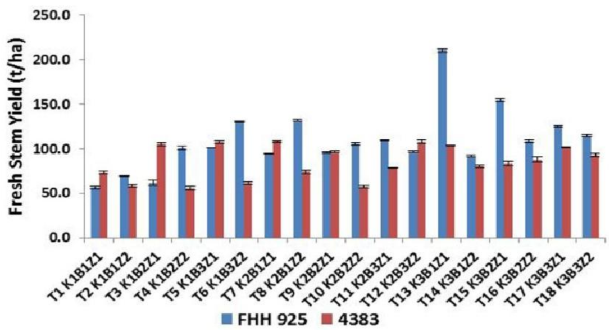

Figure . Inflenceof different levelsof fertilizerson FSY (t/ha) of kenaf fiber; FHH 925 and 4383. Values are means ± standard error of the mean

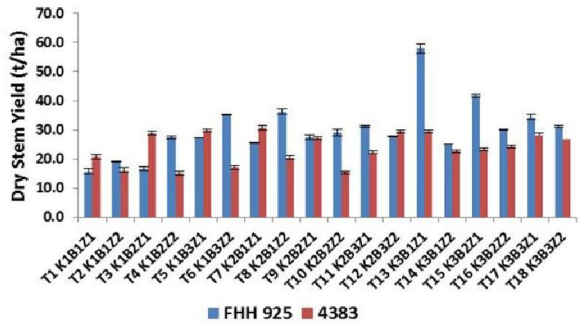

Figure . Influenceof different levels of fertilizerson DSY (t/ha) of kenaf fiber; FHH 925 and 4383. Values are means ± standard error of the mean

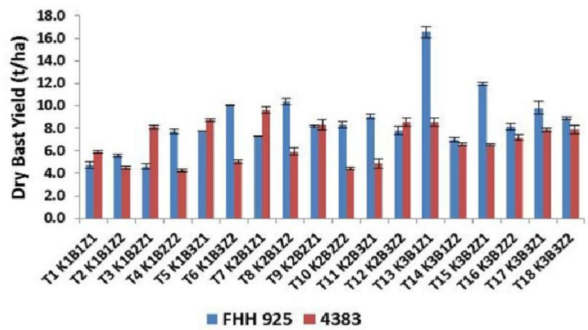

Figure . Impact of fertilizers on DBY (t/ha) of kenaf fiber; FHH 925 and 4383. Values are means ± standard error of the mean

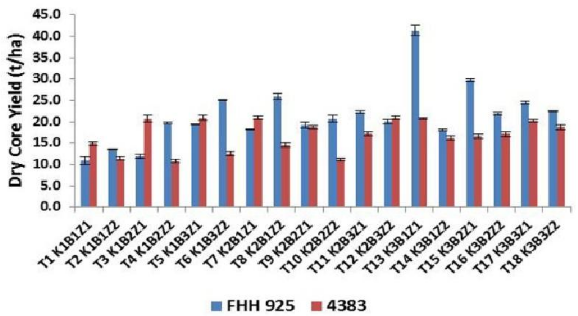

Figure . Impact of fertilizers on DCY (t/ha) of kenaf fiber; FHH 925 and 4383. Values are means ± standard error of the mean

The total fresh stem yield, total dry stem yield, dry bast yield and dry core yield were significant between varieties. FHH 925 was better than 4383 variety as can see in Figures 2 to 5.

Relationship of potassium, boron and zinc to nitrogen content in the fiber and effect of them on the bast and core fiber yield of kenaf

Kenaf is a dicotyledonous plant. Kenaf stem has three layers. First is an outer cortical also mentioned to as 'bast" tissue layer called phloem. The second layer is an inner woody "core" tissue layer called xylem. The last one is a thin central pith layer which consist of sponge-like tissue with mostly non-ferrous cells (Aji *et al.,* 2009). In this study, potassium, boron and zinc nutrientsadded for two kenaf varieties to develop chemical and physical properties of fibers. It is necessary to understand which factors have better performance for changing those layers. Also, it is necessary to obtain the best results of quality and quantity of kenaf fiber. The correlation of fertilizers and nitrogen content in the fiber and also effecting of them on a fresh and dry fiber yields in bast and core showed in (Table 2 and Figure 6). Generally, FHH 925 variety was better than 4383 variety for all parameters. The nitrogen content dramatically increased with increasing levels of potassium.

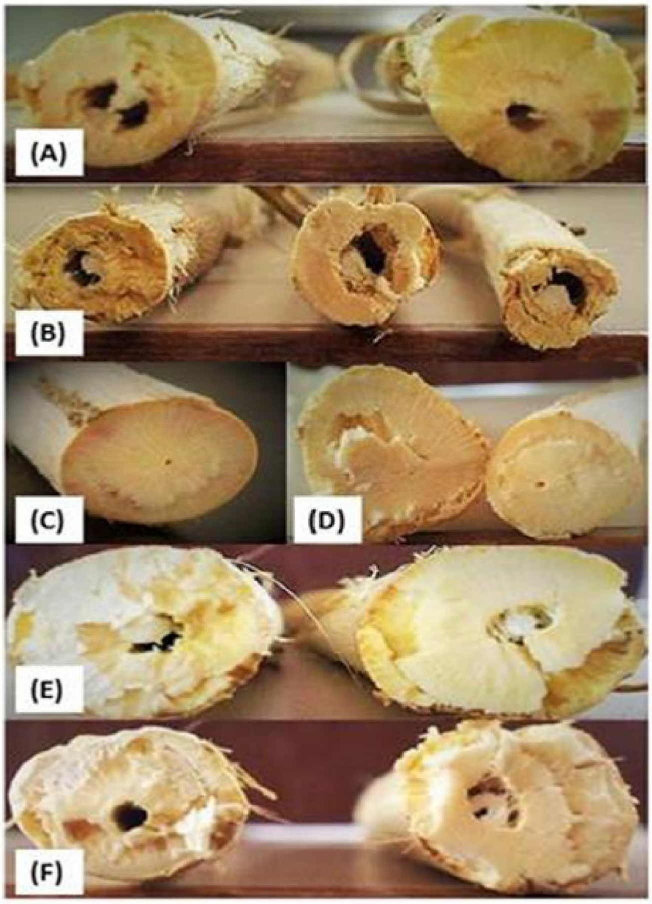

Figure .Images of kenaf stem cross-cut after 48-hours oven dried at 65 °C. (A) FHH 925 when potassium, boron and zinc as control; (B) 4383 when potassium, boron and zinc as a control; (C) FHH 925 and (D)4383, both varieties with potassiumat the rate of 150 kg/ha; (E) FHH 925 and (F) 4383, both varieties with potassium, boron and zinc at the high levels of 150, 1.5 and 5.0 kg/ha, respectively

DISCUSSION

The kenaf crop was cultivated to evaluate the effect of fertilizers on the nitrogen content and then affected on the fiber yields. The nitrogen content on both stem parts; bast and core together for kenaf FHH 925 variety was more than 4383 variety. Results related to the findings by Hossain *et al.* (2011) who used five kenaf varieties, such as V36, G4, KK60, HC2 and HC95. They reported that the rate of major and minor minerals are changed evidently with kenaf plant components and varieties and the highest nitrogen content in the stem were appeared on G4 and HC2 varieties, respectively. The ANOVA shows that the main interaction between fertilizers and varieties was significant. Despite, the interaction between varieties and zinc and also varieties with boron and zinc was not significant (Table 2). Nitrogen content increased with increasing rate of the potassium. It reached up to 4.82% when potassium at the rate of 150kg/ha. While the nitrogen content only to be 2.92%in the control treatment. This finding is in agreement with the results of Hossain *et al.* (2011) and Igras and Danyte (2007).

Who said that many physiological and biochemical processes are affected by potassium fertilizer, and it is playing an important role of these processes in plants.Also, Salih *et al.* (2014a) found that potassium was more important for the kenaf. However, the rate of nitrogen was dropped when increasing zinc by 5 kg/ha in treatment (K3B1Z2), this rate of zinc might be high for kenaf plants, and it might cause to phytotoxicity. Similar results obtained by Chaney (1993) who said that heavy metals, excess in the plants is strongly affected on the photosynthesis. Phytotoxicity can occur due to high levels of zinc in plants. This study also showed that the nitrogen content decreased continuously when boron and zinc added at the rate of 1.5 and 5 kg/ha, respectively (Figure 1).The nitrogen content significantly changed for 4383 variety. The highest value of nitrogen content was found at 3.33% in the treatment 16 when potassium, boron and zinc were applied to the rate of 150, 1.0 and 5.0 kg/ha, respectively. Nitrogen content dropped when increasing the rate of boron to 2.95% in treatment 17, and the result was same as the control treatment (Figure 1). Hardy *et al.* (2014), who considered that the excess rate of boron can be toxic to plants.

On the other hand, the ability to uptake nutrient was different between varieties. KenafFHH 925 varietycan uptake nutrient more than 4383 variety. The result is an agreement with Hossain *et al.* (2011) who indicated that the absorption of nutrients is different between varieties.It is due to the differences of varieties ability to uptake nutrients based on the function of each plant part. All parameters, total fresh stem total dry stem, bast and core yields increased with increasing levels of potassium and boron. That it is related to the findings by Liu *et al.* (2000) who concluded that, potassium has positive and significant correlation with fiber yield of the crop. They said that, stem wood was rich of potassium concentration compared to other parts of ramie plants. Also, this study was an agreement with Glass (2003) and Parry *et al.* (2005) who found that, those four factors nitrogen, phosphorus, potassium and water are critical.It is for healthy development in plant and obtain higher yield economically. However, results are relative with Salih *et al.*(2014b) and Tatar *et al.*(2010). They found that potassium fertilization has the significant effects on the plant height and stem yield in the kenaf and ramie plants. Zinc was not positive effects on the fiber yield as can be seen in Figures 2 to 5. The average of fiber yield fresh and dry decreased with increasing the rate of the zinc. The reason might be due to 5 kg/ha of zinc was very high, and it might be the toxicity of thekenaf plant. This present study is strongly agreement withChaney (1993) who believed that crop yield reduction is occurring due to zinc toxicity. Also, it is a factor to stop thedevelopment, reduction in chlorophyll synthesis and chloroplast degradation, which induced chlorosis. However, it is a factor to reduce the plant's ability to uptake potassium and magnesium except few situations.The increase of nitrogen content in the fiber has been a positive effect on the cell wall in the fiber and also it has been significantlyaffected to increase fresh and dry fiber yield. Also, nitrogen contentpositively affected on the fiber quality and mechanical properties in the kenaf fiber. Similar to finding by Muchow (1990) who reported that the photosynthetic capacity of kenafincreased with increasing rate of nitrogen in leaf. Figures 6 (A) and (B) show the importance of fertilizers, especially potassium on the layers of thekenaf stem. In both figures (A) and (B), when the fertilizers were not added to the plants the xylem (core) has deteriorated. In the end, it leads to decrease fiber yield. The fiber cell wall was rising with increasing rate of potassium in level 1 to level 3.

Figures 6 (C) and (D) show the potassium impact on the stem layers in core fiber, (C) for FHH 925 and (D) for 4383 varieties. Similar with Hossain*et al.* (2010) who reported that plant height and photosynthesis were decreased due to nitrogen, phosphor and potassium deficiency of kenaf and also it leads to decrease biomass accumulation. The correlation between nitrogen content and boron levels was inversely affected the fiber yield. Zinc levels had a negative affect on the totalfresh stem, total dry stem yield, dry bast and dry core yield. Figures. 6 (E) for FHH 925 variety and (F) for 4383 variety shows this fact. In general, potassium had a positive effect for both varieties. Bast and core fiber yield increased due to increasing nitrogen content in the cell wall in the fiber. This change in the layers of the stem was due to the effect of potassium on the polymers of amino acids in proteins of kenaf fiber. Findings agreed with Van Brunt and Sultenfuss (1998) who said that potassium required for many processes of plant growth. As well as it works to increase crop yields due to increasing protein content in plants, building cellulose, improves translocation of sugars and starch and reducing lodging.

Conclusion

This study shows that, nitrogen content and fiber yield bast and core in two kenaf varieties are significant differences in $P \leq 0.05$. Also, all parameters are quite different between varieties. Kenaf FHH 925 variety was better than 4383 variety. Rate of nitrogen content and biomass parameters in both stem parts (bast and core) divided from kenaf FHH 925 variety increased with increasing in the rate of potassium.The biggest value of all parameters was when potassium at the rate of 150 kg/ha without boron and zinc. Nevertheless, FHH 925 was responded significantly to potassium more than responding to boron and zinc. However, kenaf 4383 variety was significant alteredthrough different rates of fertilizers used inthis work. The outcome demonstrated that the variety FHH 925 can consider as the most suitable to grown under better management of the fertilizers, and to get the best fiber yield.

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