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RESIDUAL EFFECT OF POTASSIUM FERTILIZER AND BIOCHAR ON GROWTH AND YIELD OF CORN IN THE SECOND SEASON

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Abstract

Application of biochar can increased availability of plant nutrient and yield. Relaying field experimen as conducted in inceptisol with aim to determined of residual potassium fertilizer and biochar application on growth and yield of corn in the second season. Randomized Block Design was used with three replication. The treaments were residual application of potassium and biochar consist of bi ar only (30 t ha^{-1}), and biochar plus several level of potassium apllication (0, 50, 100, 150 and 200 kg ha^{-1}), included plication of 200 kg ha^{-1} potassium without biochar. Basal fertliz n the first season was 90 kg N ha^{-1} and 100 kg $P_2 0_5$, and in the second season was used 90 kg N ha^{-1}. The result showed that residual biochar alone or combine with different level of Potassium application increased yield of corn. Residual biochar increased avalilabilty of plant nutrient N, P, K, Ca, and Na in the soil.

Key word : biochar, corn, potassium, residual, yield

Introduction

Farm intensification technology applied in the farm without added some organic matters will decreased C-organic soil content in the soil. These condition will reduce efficiency of fertlizer application. Application of manure and organic fertilizer can increased soil fertility and fertilizer efficieny. In the hot tropic condition decomposation and mineralitation of organic matter increased very fast and it will cause increasing CO_2 emition and global warming (Bol *et al*, 2000), and releasing CO_2 in the atmosfir (Fearnside, 2000). Lower organic mattter content also caused lower cation exchange capasity (CEC) and lower availability of plant nutrient. Efficiency of anorganic fertilizer also low, especially in the tropic where leaching is important aspect for mobile nutrient (Brady and Well, 2008).

In the inceptisol, potassium ussually not available due to fixed by mineral soil. It is become worse due to farmer did not have capasity to buy an organic fertilizer. Plant nutrient availability become one of constraint to increasing plant production. In general, soil plant nutrient content will increased by added ferlitilization, but it also will decrased by plant absortion, volatization, leaching and fixed by colloid soil. To increased fertilizer efficiency one of possibility is combination of application between an organic and organic fertilizer or biochar. Lehmann *et al.* (2003) reported that biochar can maintained nutrient content in the fertilizer to prevent leaching. On the other hand, Widowati *et al.* (2012) stated that biochar can reduced N fertilizer application up to 70%. It due biochar can manage N release by Urea fertilizer in form of NH_4 (Widowati *et al.*, 2011). Similar result also showed in the green house experiment that increased potassium fertilizer did not increased leaching of potassium in 30-60 days after sowing (Widowati *et al.*, 2012).

Biochar is organic charcol product of pyrolysis (convert of thermo condition without oxigen), and will used is an alternatif to produced energy, returning carbon and nutrient to the soil (Laird, 2008). Biochar from pyrolysis is type of carbon amorf consist of many carbon symbiosis and ash (Chun *et al.*, 2004). During process of pyrolysis, condition of temperature, and time will affected characteristic of biochar (Antal and Gronil, 2003). In lower temperature (< 500 0C) composition of material may high affected biochar characteristic and also the application in the soil such as exchange cation capacity (CEC), and nutrinet content (Gaskin et al., 2008). Several reserach result showed that char increased growth and yield of maize (Major et al., 2010), soybean (Tagoe et al., 2008), cowpea

(Glaser et al. 2002), rice (Steiner et al., 2007). Lower concentration of carbon in low temperature range from 380 kg from biochar of chicken (Chan et al., 2008), 692 kg for wheat (Chun et al., 2004), and 700 kg from Pinus chip (Gaskin et al., 2008). Nitrogen content of biochar range from 1,4 kg (pinus), 19 kg (peanut) and 40 gr (chicken wase) (Chan et al., 2007). Lower concentration of P and K found in biochar of pinus 0,089 and 0,659 g kg-1 respectively, and biochar chicken 33,6 and 45,6 gr kg-1 (Gaskin et al., 2008). Concentration of P and K in biochar of organic wase product was 0,72% and 0,93% (Widowati et al., 2011).

Several studies showed that biochar increased nutrient retention, especially Nitrogen content in tropical areas (Lehmann et al., 2003; Steiner et al., 2008). When lossing of nutrient due to leaching proses can reduced it mean there is several nutrient still in the soil will used as residual for next crop. Residual plant nutrient after harvest can be used as statues of nutrient availablity in low, high or very high. This condition is important to decided there is needed or not to apply fertilizer. Low or high dosage of fertilizer applied will affected amount of nutrient to be absorb or rested in the soil. Widowati *et al*., (2014) showed that the sole application of biochar increased maize production (6.24 Mg ha-1) by 14% compared sole application of KCl fertilizer (5.45 Mg ha-1). In contrast, dual application of biochar and 75% lower dosage of KCl fertilizer application increased maize production by 29%.

Increasing residual of biochar and potassium will give as same as the yield of crop in the second season crop. This asumption supported by Mayor *et al.,* (2010) reported that yield of corn did not increased in the first season, but increased in the second season after applied of biochar. Information on these aspect is very limited, and the objective of this experimnt is to determine the residual effect of fertilizer especially Potassium and biochar on growth and yield of corn in the second season.

MATERIALS AND METHODS

Relay field experiment was conducted from September 2012 to February 2013 in Inceptisol at Tunggulwulung village, Sub district Lowokwaru. Malang City. Material experiement of biochar 30 t ha^{-1} was made from organic wase, and proces by pyrolysis method during February 2012. The cultivar used in second planting Artiwi 3 was planted at September 2012. All treatments were laid in Randomized Block Design with three replicaations. In the first planting all treatment was applied by using urea fertlizer with dosage 90 kg N ha^{-1}. Fertilizer of urea applied twice (1/3 used 6 days after planting and 2/3 used at four week after palnting). All dosage of Phospfat applied 6 days after planting. Potassium fertilizer applied as same as treatment in 1 and 4 week after planting consist of B0K200 (KCl 200 kg ha^{-1}), B30KO (biochar, without KCl), B30K50 (biochar + 50 kg KCl ha^{-1}), B30K100 (biochar + 100 kg KCl ha^{-1}), B30K150 (biochar + 150 kg KCl ha^{-1}), and B30K200 (biochar + 200 kg KCl ha^{-1}). Basal fertilizer for the second season was 90 kg Urea ha^{-1} without P and K fertilzer. Total number of plot was 21 with size 3 m x 4 m. To maintenance of experiment was done by weeding twice and,and irigation twice per-week. Plant spacing was 80 x 25 cm, 1 seed per-hole and total number of plant population was 50.0000 $hectare^{-1}$.

Soil sample taken out after harvest in the first and second season, and analysis for organic content (Walkey & Balck), N (Kjedahl), Availability of P (Bray 1), Potassium availability (NH_40AC 1 N pH 7), K total (HCl 25%), Ca, Mg and Na. There were five samples of plant was obeserved for plant high, stem diameters, leaf area index, stem dry matter, leaf, plant dry matters, length and diameter of ear, dry seed weight, potassium content in the leaf (70 das), and seed after harvest (130 das). and K absorbtion.

Observation for dry matters production of plant was put in the oven with tempereture 70 ºC during 2 x 24 hour. Uptake of N, P, K of maize crops from total dry matter excuted by uptake and nutrient content. Data analysis used software program SPSS versi 13.00.

RESULTS AND DISCUSSION

Crop growth

Residual biochar of 30 t ha^{-1} with and without additions of Pottasium fertilizer application showed the highest plant high compared with other's treatment. On the other hand, residual of biochar followed by increased dosage of Potassium application from 50 kg up to 200 kg $hectare^{-1}$ reduced plant high significantly (Table 1). Application of 200 kg KCl ha^{-1} decreased plant high about 28,40 cm compared with 50 kg KCl ha^{-1}. Residual biochar alone showed increased plant high as same as trend observation on stem diameter and leaf size, although stem diameter did not significantly different compared with residual bichar added potassium applications. Biochar as soil amandement caused better root development and higher drymatter

production (Table 2) and as high as seed yield of maize (Table 4). Potassium fertilizer didn't increased crop growth and grain yield of maize (Table 4).

Tabel 1. Plant high, Stem diameter, and Leaf size at 70 days after planting

Treatment	Plant high (cm)	Stem diameter (cm)	Leaf size (cm^2)
B0K200	233.82 b	2.46 a	5493.22 a
B30K0	252.83 c	3.02 b	6712.51 b
B30K50	250.69 c	2.80 b	6397.63 b
B30K100	230.18 ab	2.93 b	6581.94 b
B30K150	227.67 ab	2.87 b	6601.77 b
B30K200	222.29 a	2.89 b	6310.49 b
LSD 0.05	60.99	0.20	487.68

Within each column, means followed by the same letter do not differ significantly at LSD 0.05

Dry matters producton showed the same trend with stem diameter. Residual biochar with or withiout addition of potassium fertilizer application showed higher dry matters of leaf, stem, and total biomass production compared with no biochar added 200 kg KCl ha^{-1}(Table 2). Total dry matters production is production of drymatters during plant growth. In the short period, fertilizer and added to biochar increased plant growth (Lehmann *et al.*, 2003).

Table 2. Drymatter of leaf, stem,and total biomass production of maize crop at 70 das

Treatment	Leaf dry matters ($t\ ha^{-1}$)	Stem dry matters ($t\ ha^{-1}$)	Total biomass production ($t\ ha^{-1}$)
B0K200	1.90 a	2.81 a	4.71 a
B30K0	2.69 cd	4.06 b	6.75 b
B30K50	2.42 b	4.00 b	6.42 b
B30K100	2.78 d	3.92 b	6.70 b
B30K150	2.55 bcd	3.67 b	6.22 b
B30K200	2.47 bc	3.79 b	6.27 b
LSD 0.05	0.25	0.43	0.58

Within each column, means followed by the same letter do not differ significantly at LSD 0.05

Nutrient content and Uptake of N, P, K

Application of biochar can suplied enough nutrient for the second crop especially for P and K. It is showed that the crop didn't defficiency of nutrient (Table 3). Macro nutrient of total N (0.7-0.26%), P (60-185 mg kg^{-1}) and K (0.50-0,90 me 100 g^{-1}) available in the soil after harvest the first season will available for the second crop.

Residual effect of K fertilizer with and without biochar gave same affect on level of N and P in the leave or P in the grain (Table 3). Residual of biochar increased P and K content in grain (Fig 2 and 3). Nutrient uptake by crop depend upon the availability of nutrient in the soil. It is showed that combination of residual biochar and increasing K feritlizer decreased absorbtion of Potassium (Fig. 3).

Table 3. Content of N, P, K in the leaf (70 das) and Grain of maize (130 das)

Treatment	Nitrogen content Leaf (%)	Grain (%)	P content leaf(%)	Grain (%)	K content leaf (%)	Grain (%)
B0K200	3.22 a	1.43 a	0.29 a	0.16 a	0.08 a	0.13 ab
B30K0	3.37 a	1.77 b	0.31 a	0.16 a	0.14 bc	0.12 a
B30K50	3.24 a	2.04 b	0.28 a	0.20 a	0.13 b	0.16 bc
B30K100	3.24 a	2.01 b	0.28 a	0.18 a	0.13 bc	0.13 a
B30K150	3.26 a	2.00 b	0.29 a	0.16 a	0.13 b	0.13 a
B30K200	3.32 a	1.83 b	0.30 a	0.20 a	0.16 c	0.17 c
BNT 0.05	0.26	0.33	0.04	0.08	0.03	0.03

Within each column, means followed by the same letter do not differ significantly at LSD 0.05

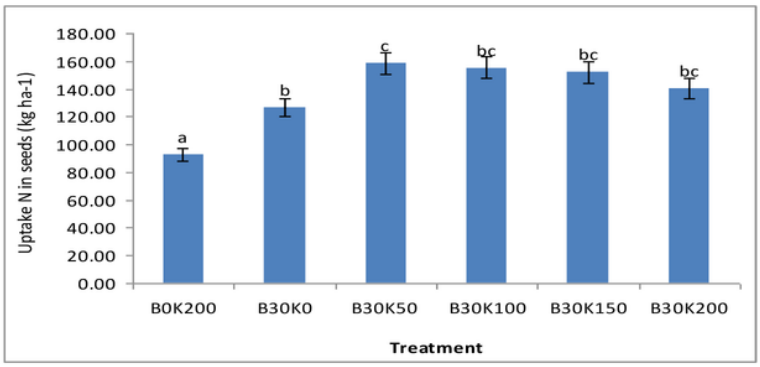

Figure 1. Nitrogen uptake in the grain at harvest

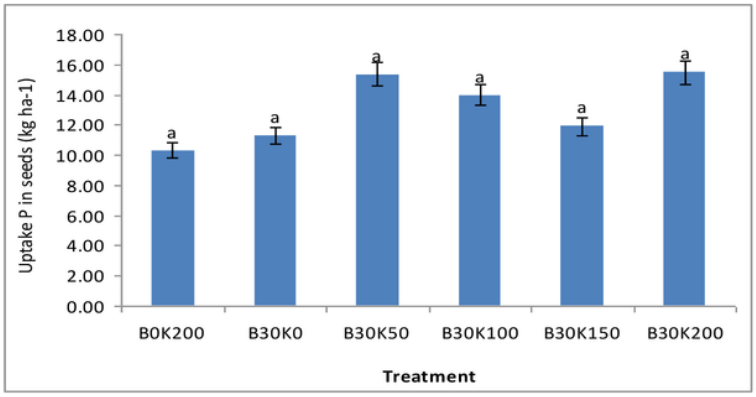

Figure 2. Posfor uptake in the grain at harvest

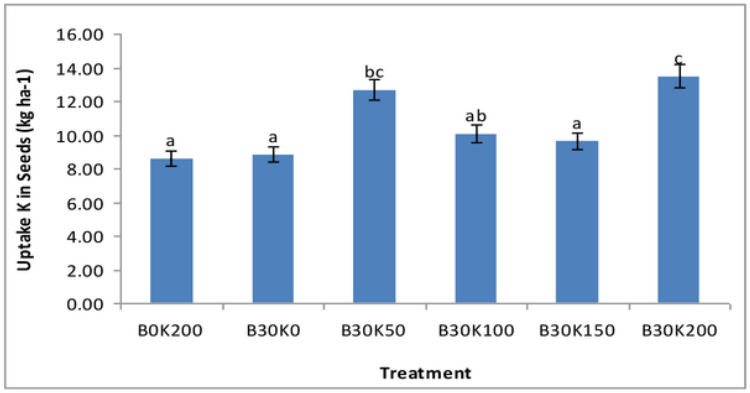

Figure 3. Potassium uptake in the grain of Maize at harvest.

Plant yield and carbohidrat content in the grain of maize

Plant growth and yield didnot affected by residual fertilizer of Phosfat and Potassum. from first season crop. It is assume that available nutrient from

first season still enough to support crop growth during the second season (Table 4). This result showed that residual of biochar gave the good effect for availability of nutrient P and K, and for growth and yield.

Residual of biochar alone or combine with potassium increased ear size, ear length, grain size (1000 g), and grain yield plant^{-1}, grain yield (ton ha^{-1}). Grain yield increased from residual biochar alone was lower (11%) compared with residual biochar combined with Potassium fertilizer (18-20%). In the first season biochar did not increased yield significantly. Residual biochar gave high signifantly effect to the crop by time to time, the same effect was found also by Steiner *et al.* (2007) and Major *et al.* (2010).

Residual potassium fertlizer in different dosage gave the same effect to yield component and grain yield of maize (Table 5). Phosfat and Potassium combination with biochar gave the effect residual for the second cop. It is due to biochar potentially maintain retention of nutrient in the soil. Fact that more than 90% of ash in biohar did not fixed and available for the crop (Glaser *et al.*, 2002). The data fron this experiment showed that biochqr didnot only as soil conditioner but also incresed caton exchanged capasity. Similar result shown by Liang *et al.* 2008. Application of biochar consists of ash increased cation K, Ca, Mg in the soil and increased soil (Glaser *et al.*, 2001a). Residual biochar increased soil organic (Table 6). Increasing soil oganic matters in the soil is relatite with active decomposition of organic matters (Wilhelm *et al.*, 2004). In the soil degradation of Oxisol in Kenya Kimetu *et al.* (2008) reported that maize production increased twice after three application of biochar 7 t ha^{-1} during two years.

Table 4. Yield and yield component of maize crop in the second season

Treatment	Ear length (cm)	Diameter of ear (cm)	Grain size (1000 g^{-1})	Ear dry weight (g)	Grain yiels per-plant (g)	Grain yiels per-plant (g)
B0K200	17.6 a	5.43 a	302.9 a	21.63 a	122.52 a	6.46 a
B30K0	20.3 b	5.77 b	338.9 b	32.22 b	141.38 b	7.18 b
B30K50	19.9 b	5.82 c	346.7 b	30.29 b	155.46 b	7.77 b
B30K100	19.7 b	5.78 c	348.4 b	32.50 b	154.47 b	7.72 b
B30K150	19.7 b	5.81 c	359.0 b	33.75 b	151.97 b	7.60 b
B30K200	19.2 b	5.97 c	325.2 b	30.01 b	154.26 b	7.71 b
LSD 0.05	1,16	0.20	44.89	6.78	19.49	0.82

Within each column, means followed by the same letter do not differ significantly at LSD 0.05

Availability nutrient (N, P, K, Ca and Mg) incresed after application of biochar in the first season by 39-53% N, 179-208% P, 69-89% K, 14-184% K total, 61-70% Ca, 1-22% Mg respectively (Widowati *et al.*, 2014). This condition was approved hypothesis that grain yield of maize increased during the second season although without added fertilizer P and K. Grain yield of maize in the first season lower (5,46-7,02 t ha^{-1}) compared with the second season (Table 5). It is indicated that biochar gave positif effect to the crop in second season Other data showed that total of N and availabilty of phosfat higher after using bochar as soil amandemen, Widowati *et al.* (2012) stated that biochar can reduced leaching process of potasium and reducing will increased when combined with KCl fertlizer.

Effect of residual potassium fertilizer with or without biochar highly significant in carbohidrat content in the grain seed maize. Application of biochar alone showed lower carbohidrat content and the highest is combine with 150 kg K ha^{-1} and decreased when dosage K fertlizer increased (Figure 4).

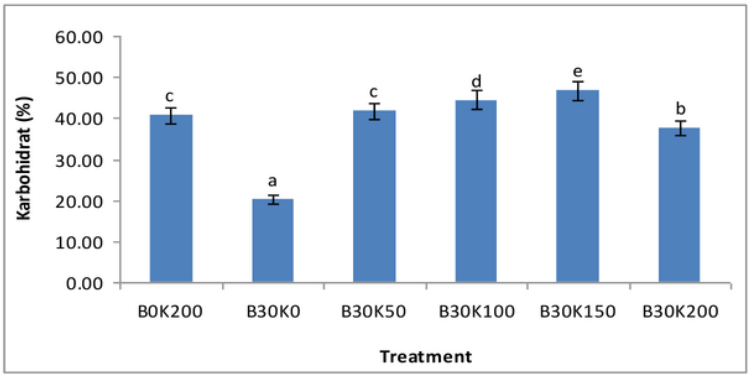

Figure 4. Carbohidrat content in the grain of maize on harvest.

Availability of nutrient in the soil after harvest in the first and second season

Residual effect of Potassium with biochar increased cation of K, Ca, Mg and Na in the soil due to incrased organic in the soil (Table 5). Similar result also found by Major *et al.* (2010), Rondon *et al.* (2007), Steiner *et al.* (2007), and Topoliantz *et al.* (2005) Biochar can incresed soil organic matter in the soil during the first and second season. Fertilizer of N, P and K without application of biochar gave higher availability of nutrient compared with no biochar application. This is one of the reason why grain yield in the second season (6,5-7,8 t ha^{-1}) higher than the first season (5,5-7,0 t ha^{-1}).

Table 5. Nutrient availability in the soil before sowing, after first season (MT I) and after second season (MT II)

	N total (%)			P (mg kg^{-1})			K+ (me 100 g^{-1})			K Total (%)			C organik		
Teatment	Before treatments	First season	Second season	Before treatments	First season	Second season	Before treatments	Fisrt season	Second season	Before treatments	First season	Second season	Tanah awal	MT I	MT II
B0K200	0.14 a	0.17 a	0.11 a	24.38 a	59.97 a	41.84 a	0.25 a	0.46 a	0.35 a	30.91 a	50.20 ab	284.01 b	1.46 a	1.35	1.93 a
B30K0	0.14 a	0.21 b	0.17 c	24.38 a	167.42 b	48.01 ab	0.25 a	0.88 c	1.03 c	30.91 a	122.86 c	234.57 a	1.46 a	1.86 b	2.3 b
B30K50	0.14 a	0.26 c	0.16 bc	24.38 a	173.25 b	91.87 e	0.25 a	0.82 c	0.87 b	30.91 a	142.36 c	526.12 d	1.46 a	1.88 b	2.27 b
B30K100	0.14 a	0.24 c	0.20 d	24.38 a	180.51 b	61.08 c	0.25 a	0.78 bc	1.25 d	30.91 a	63.25 b	891.81 e	1.46 a	1.87 b	2.28 b
B30K150	0.14 a	0.24 c	0.16 b	24.38 a	183.31 b	71.04 d	0.25 a	0.83 c	0.99 c	30.91 a	57.12 ab	355.85 c	1.46 a	1.87 b	2.26 b
B30K200	0.14 a	0.23 b	0.16 b	24.38 a	184.62 b	51.63 b	0.25 a	0.82 c	1.17 d	30.91 a	54.50 ab	334.35 c	1.46 a	1.88 b	2.27 b
LSD 0.05	tn	0.01	0.01	tn	27.23	8.99	tn	0.52	0.13	tn	40.76	27.99	tn	0.15	0.16

Within each column, means followed by the same letter do not differ significantly at LSD 0.05

Table 6. Availability Ca dan Mg in the soil after harvest first season (MT I) and second season (MT II)

	Ca $^{2+}$ (me 100 g^{-1})			Mg^{2+} (me 100 g^{-1})			Na^{+} (me 100 g^{-1})
Treatment	Before treament	First season	Second season	Before treatment	First season	Second sesason	Second season
B0K200	4.49	17.08 a	15.94 a	3.81 a	1.27	3.26 c	0.82 a
B30K0	4.49 a	27.44 bc	22.36 cd	3.82 a	1.27	3.25 c	0.99 b
B30K50	4.50 a	29.08 c	21.82 bc	3.81 a	1.28	3.14 bc	1.19 cd
B30K100	4.50 a	29.06 c	23.29 d	3.81 a	1.55	2.77 b	1.25 d
B30K150	4.48 a	27.57 c	22.02 bc	3.82 a	1.52	4.43 d	1.36 e
B30K200	4.49 a	27.44 bc	21.18 b	3.81 a	1.5	1.99 a	1.15 c
LSD 0.05	tn	5.69	1.11	tn	1.00	0.41	0.06

Within each column, means followed by the same letter do not differ significantly at LSD 0.05

CONCLUSION

Residual effect of Potassium fertilizer combined with biochar supported availability of nutrient for maize crop in the second season. The other side residual effect of biochar increased availabilty of nutrient N, P, K, Ca and Na in the soil. Residual effect of biochar alone or combined with Potassium fertilizer application increased yield of maize crop in the second season.

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PAGE 2

PAGE 3

PAGE 4

PAGE 5

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