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EFFECT OF BIOCHAR ON K AND P RELEASE FROM K-FELDSPAR AND ROCK PHOSPHATE AND ITS IMPACT ON SOME GROWTH PARAMETER OF MAIZE PLANT

[135]

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ABSTRACT

Pot experiments were carried out using sandy soil (collected from Ismailia Agricultural Research Station), in the greenhouse of Agric. Res. Center, Giza, Egypt to study the effect of biochar application on K and P release - from their natural bearing minerals i.e., K- feldspar and rock phosphate - as well as some growth parameter such as dry weight, plant height, available K, P and their uptake. Sixty three pots were filled with sandy soil (10 kg). Biochar was added to all pots, expect the control, at the rates of 0, 1.5 and 3 tonfed^{-1}. The studied minerals are K- feldspar and rock phosphate as source of K and P respectively. Bentonite was also studied because it is the most common mineral used for reclamation of sandy soil .Each mineral was added at rate of 0,1.5, 3 tonfed^{-1}. The experimental pots are as follows : biochar alone, K- feldspar alone , rock phosphate alone, bentonite alone, biochar + K feldspar, biochar + rock phosphate and biochar + bentonite .Maize seeds were planted as the common way 6 grains for each pot inoculated with P and K solubilizing bacteria , 200 kg /fed N fertilizer $(NH_4)_2SO_4$ was applied and irrigated as needed. Grown parameters of maize i.e. plant height and dry weight were measured after 2 months of plantation. Available K and P as well as their uptake were determined.

Results revealed that, the use of biochar at a rate of 3 tons fed^{-1} in combination with 3 tons of any of feldspar, rock phosphate and bentonite enhanced significantly(in different ways) growth parameters of maize plants compared to the control treatments .The highest values of plant length and dry matter were 89.0 cm(biochar 3ton fed $^{-1}$ + K- feldspar 3 ton fed-^{1}) and 11.5 g.pot^{-} for (biochar 3 ton fed^{-1} +bentonite 3 ton fed^{-1}),^{1} against 36.7 cm and 2.9 g.pot^{-1} for the control treatment. The highest significant values of P uptake were 22.5, 18.3 and 16.7 mgplant^{-1} for the treatments 3 tonsfed^{-1} of biochar with either 3 ton rock phosphate, 3 ton bentonite or 3 ton K-feldspar respectively. While K uptake were 63.9, 61.8 and 60.1 mgplant^{-1} for biochar (3 tons fed^{-1}) with bentonite (3 tons fed^{-1}), feldspar (3 tonsfed^{-1}) and bentonite (1.5 tonsfed^{-1}). In the same order regarding the available P, the highest the treatment of values were 49.3 mgKg $^{-1}$ for the treatment of 3 ton biochar + 3ton rock phosphate , 24.1 mg Kg $^{-1}$ for the treatment of 3 ton biochar + 1.5 ton bentonite and 24.0 mgkg^{-1} for the treatment of 3 ton biochar + 1.5 ton K- feldspar. At the same time, increasing either K- feldspar or bentonite to 3 ton fed^{-1} had negative effect on available p.

In Spite of the obtained results we can conclude revealed that using biochar alone at a rate of 3 ton fed $^{-1}$ has the best treatment when taking the economic factor into consideration.

Keywords: Biochar; K-feldspar; Rock phosphate; Bentonite; Maize plants

INTRODUCTION

Sandy soils are characterized by weak structure, poor in their total or available plant nutrients, having low water holding capacity, high leaching rate of water and soluble fertilizer, low content organic matter and limited ability to withstand plant growth (**Adzemi et al 2016**). Crop production in Egypt relies completely on the high cost chemical regardless of their high cost and environmental hazards. **(Badr, 2006 and Alori et al 2017).** Biochar is a carbon-rich byproduct produced by ther-

mal degradation of organic materials under an oxygen-depleted environment (**Lehmann, 2007**). **El-Naggar et al 2019** reported that several investigators. **Aslam et al 2014, Zhu et al 2015** and **(Abdur Rehman and Razzaq (2017)** and others. They studied the effect of biochar on soil physical properties, they stated that biochar decreases the soil bulk density, increases physical properties such as infiltration rate and total soil porosity. **El-Naggar et al (2019)** and others claimed the adding biochar to soils increased their pH value, cation exchange capacity and available P and K.

This investigation aimed to study the effect of biochar on K and P release from their bearing mineral K- feldspar and rock phosphate and its effect on some maize plant parameter i.e. dry matter, plant height, available K and P and their uptake. Bentonite was considered in this study as it is one of the most common sediments used in sandy soil reclamations

MATERIALS AND METHODS

Pot experiments were carried out in the greenhouse of Agric. Res. Center, Giza Egypt to study the effect of biochar application on some natural amendments, i.e., K-feldspar and rock phosphate and bentonite on release of K and P from their natural deposits and their effect on maize plant parameters, i.e. dry weight and plant height, P and K uptake and available P and K in soil. K-Feldspar and bentonite were purchased from ICMI Company, Giza, Egypt, while rock phosphate was purchased from Al-Ahram Company, While biochar was prepared from green residue of potato plants. Sandy soils used in this experiment, was collected from Ismailia Agricultural Research Station El-Ismailia Governorate, Egypt. Some properties of all these materials and soil are determined according to the methods described by **Page et al (1982)** and presented in **Tables (1)**. Pots of 35 cm height and 30 cm diameter were filled with 10 kg of sandy soil which was thoroughly mixed and homogenized with the studied material. Nitrogen fertilizer was added in the form of ammonium sulfate (20.5% N) at the a rate of 200 kg fed^{-1}. Each pot was seeded with six maize seeds (tri-hybrid 168) which were inoculated overnight. Irrigation followed the usual program for maize irrigation. The maize seedlings were thinned out and four plants were left in each pot. The experiment comprised of 21 treatments each in three replicates arranged in split plot design **(Gomez and Gomez, 1984)** where the biochar represents the main plot in three rates of 0, 1.5 and 3 tons per fed and the natural minerals (feldspar, bentonite and rock phosphate) represents the sub plot also in the same rates (0, 1.5 and 3 ton fed^{-1}). The treatments received no biochar or natural minerals reserved as control. After 60 days from seeding, maize plants were uprooted and exposed to plant height (cm) measuring, then oven dried at 70°C up to a constant dry weight (g pot^{-1}). The dried plant samples were digested and K and P uptake were estimated (mg $plant^{-1}$). The remained soil in pots was also sampled for the determination of soil available P and K (mg. kg^{-1}) **(Jackson, 1976)**.

All the obtained results were statistically analyzed to compare the means through L. S. D. test at significance probability of 0.05 according to **Gomez and Gomez (1984).**

RESULTS AND DISCUSSIO

The used materials in this experiment were analyzed according to **Page et al (1982)** and the obtained the results as shown in **Table (1).**

Table 1. Some characteristic of the used materials natural mineral

Characterisites	k-Feldspar	Bentonite	Rock phosphate	Biochar	Soil
Particle Size Distribution					
Sand	89.7	12.4	93.5	45.1	86.3
Silt	8.1	30.2	6.0	14.5	10.2
Clay	2.2	57.3	0.5	6.3	3.5
Texture	sand	clay	Sand	Loamy sand	sand
pH 1:2.5	8.5	7.3	7.4	8.8	7.9
Ece, $dS.m^{-1}$	15.9	5.3	3.4	0.8	0.8
SP%	20	145	28	47.50	14
CEC $Cmol.Kg^{-1}$	5.1	79.7	4.3	12.7	3.9
Total P_2O_5 %	0.3	0.6	15.5	1.1	0.2
Total K_2O %	8.2	1.8	0.4	1.3	0.1
Available P $mgkg^{-1}$	0.4	37.6	38.3	319.5	2.2
Available K $mgkg^{-1}$	42.5	28.5	4.5	1800	19.9

The results of X ray diffraction pattern of K-feldspar sample revealed that quartz is the dominant mineral as indicated by the presence of diffraction peaks at 3.34°A and 4.26°A. Orthoclase was the second predominant mineral as indicated by the presence of diffraction peaks at 3.19°A., 4.03°A and 3.08°A. From the intensity of the diffraction peaks, it appears that K feldspar (orthoclase) constitutes about 40% of the minerals present in the studied sample**.**

Fig. (2) revealed that quartz is also the dominant mineral as indicated by the presence and intensity of diffraction peaks at 3.33°A and 4.26°A. Calcite is the second dominant mineral as indicated by the presence of the intensity of diffraction peaks at 3.03°A and 2.28°A. While apatite was found as the third dominant mineral, its diffraction peaks at 2.81, 2.77 and 2.72°A and intensity declare it constitutes > 40 % of the sample.

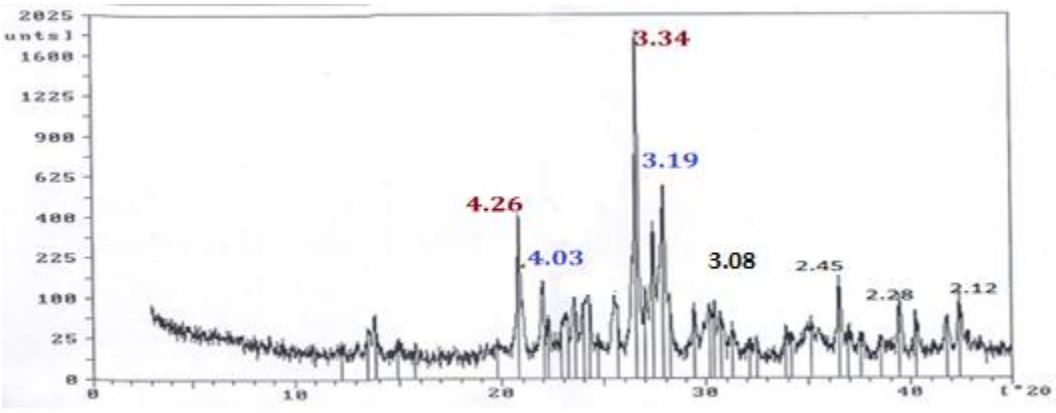

Fig. 1. X-ray diffraction pattern of feldspar sample

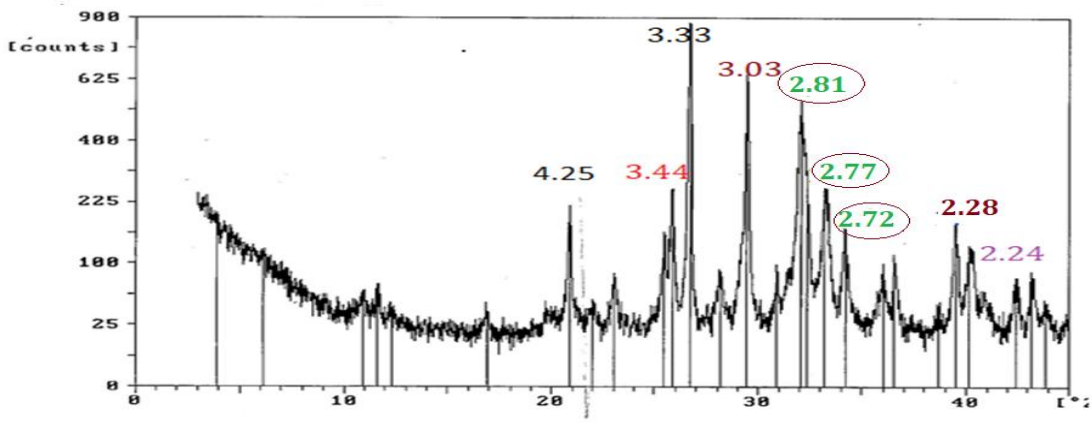

Fig. 2. X-ray diffraction pattern of rock phosphate sample

The third studied mineral Bentonite was detected from **Fig. (3)** which revealed the presence of diffraction peak at 15.3°A, and it is from the expanding type as the 15.3 peak expanding to 16.7 upon glycol solvation. Other minerals like quartz and feldspar are also presents.

Data of the obtained chemical analyses are presented in **Tables (2, 3 and 4)** and discussed here after.

Table (2) shows the effect of biochar and different natural minerals on dry weight and plant height of maize plant. The data reveal that application of K -feldspar alone at rate from 0 to 3 ton fed^{-1} increased significantly dry weight of maize plant (from 2.9 to 3.7 $g.pot^{-1}$) although this increase is significant much higher dry weight was obtained by adding biochar alone, as dry weight value increased from 2.8 to 10.4 $g.pot^{-1}$ upon increasing

rate of biochar (alone) from 0 to 3 ton fed^{-1}. Thus biochar (alone) has much better effect on dry weight of maize plant than K- feldspar alone. Regarding the effect of rock phosphate(alone) on dry weight of maize plant, by increasing its rate from 1.5 to 3 ton.fed^{-1} had the same dry weight (3.9 g.pot). Although this increase is significant its much less than that obtained by adding 3 ton biochar alone.

Adding biochar +rock phosphate together at 3 ton fed $^{-1}$ each had no significant effect. However, the highest value of dry weight (11.5 g.pot^{-1} obtained by adding biochar with bentonite at 3 ton / fed each. That value 11.5 g .pot $^{-1}$ is only higher by almost one gram than that obtained from using biochar alone (3 ton/fed). This result ascertained the better effect of biochar alone. Than adding it with any other natural minerals especially when economic factor is taken into consideration.

Maize plant height was also studied and results are given in **Table (2)**.

Data reveal that biochar application (alone) by increasing rate up to 3 ton fed^{-1} increased significantly plant height. Also adding K feldspar (alone) by increasing rate up to 3 ton fed^{-1} increased significantly plant height. However there Exist a big difference between value of increase in each case ,as average height is 85.7 cm in case of 3 ton fed^{-1} biochar alone compared to 47.7 cm in case of 3 ton fed^{-1} K- feldspar alone. The highest value obtained for plant height is 89.0 cm upon adding biochar + K- feldspar at 3 ton fed each.

In case of rock phosphate the highest value of plant height is 87.6 cm obtained by adding rock phosphate with biochar at rate of 3 ton fed^{-1} each. No significant difference existed between the two values (87.7 cm in case of biochar + rock phosphate 3ton fed each and 85.7 cm obtained when adding 3ton fed biochar alone, especially when considering economic factor. Almost similar results or worse are obtained in case of using bentonite as the highest value of plant height (85.7 cm) obtained when adding 3 ton fed biochar alone while lower value (83.7 cm) obtained by adding biochar + bentonite together by 3 ton fed^{-1} each. This result also ascertains the superiority of biochar compared to either K- feldspar or rock phosphate.

Data in **Table (3)** show that there is no increase in P uptake with increasing the rate of K-feldspar applied (alone without biochar) from 0 to 3 ton fed^{-1}. However increasing biochar (alone) from 0 to 3 ton fed-^{1} increased significantly P uptake from 1.3 to 16.0 mg plant^{-1}. It can be noticed also that adding biochar with K feldspar at a rate of 3 ton fed each, no significant increase in P uptake was obtained (from 16.0 to 16.7) mg plant^{-1}. In case of rock phosphate (alone without biochar) the increase in P uptake was not significant, even at a rate of 3 ton fed^{-1}. The highest significant value in P uptake value of (22.5 mg plant^{-1}) was obtained by adding rock phosphate + biochar together at a rat 3 ton fed^{-1} each. Bentonite either applied alone or with biochar (at any rate of application) increased slightly P uptake but not significantly. It can be noticed also that the highest value for P uptake (22.5 mg plant^{-1}) is in accordance with the highest value of available P (49.3 mgkg^{-1} soil).

Regarding K uptake values in **Table (3)** reveal that increasing the rate of K- feldspar (alone without biochar) from 0 to 3 ton fed^{-1} increased significantly K uptake from 8.5 to 16.4 mgplant^{-1}. Adding biochar (alone) with increasing rates from (0 to 3 ton fed-1) increased significantly K uptake (from 8.5 to 56.0 mg plant^{-1}). The highest value of K-uptake (61.8 mg plant^{-1}) obtained by adding K-feldspar + biochar at a rate of 3 ton fed each. This is in accordance with the highest value of available K which reached 181.8 mg.kg^{-1} soil

Rock phosphate, however, increase significantly K uptake when added alone without biochar at 1.5 ton fed (13.4 mgplant^{-1}). While 3 ton fed had no significant increase also bentonite behave almost similar to rock phosphate regarding K uptake.

Effect of biochar alone or combined with either feldspar, bentonite or rock phosphate on available of P and K.

Data in **Table (4)** show that available P significantly increased as a result increasing the rate of biochar alone up to 3 ton fed however increasing rate of application up to 3 ton fed $^{-1}$ of either K-feldspar alone or bentonite alone has no significant increase in available P. The opposite was true in case of increasing rock phosphate alone from 0 to 3 ton fed^{-1}.The available P increased significantly to 4.4 mgKg^{-1} in case of rock phosphate alone (3 ton fed^{-1}). However no significant increase in available P when K-feldspar or bentonite were applied alone up to 3 ton fed $^{-1}$.

The highest value of available P (49.3 mg.Kg^{-1}) was obtained by adding 3 ton fed^{-1} biochar + 3ton rock phosphate Other values of available P obtained in case of K- Feldspar + biochar or bentonite + biochar are 23.7 and 23.9 mg.plant^{-1} respectively.

Table 2. Effect of biochar with either feldspar ,rock phosphate or bentonite on maize plant dry weight and plant height

Amendments Rates	**Feldspar(ton.fed^{-1})**				**Rock phosphate (ton.fed^{-1})**				**Bentonite (ton.fed^{-1})**			
rates	**0**	**1.5**	**3**	**rates**	**0**	**1.5**	**3**	**rates**	**0**	**1.5**	**3**	**rates**
Dry weight/ g.pot-^{1}												
Control without biochar	2.9	3.2	3.7	3.3	2.9	3.9	3.9	3.5	2.8	3.0	3.7	3.2
Biochar. 1.5 Ton fed^{-1}.	4.2	7.8	8.1	6.7	4.2	9.2	9.6	7.6	4.2	4.7	5.7	4.8
Biochar. 3 Ton fed^{-1}	10.4	10.7	11.0	10.7	10.4	10.9	11.1	10.7	10.4	10.7	11.5	10.8
Means	5.8	7.2	7.6	------	5.8	8.0	8.2	-------	5.8	6.3	6.7	-------
LSD@)0.05												
Amendment	0.4				0.4				0.4			
Biochar	0.2				0.7				0.7			
Amend X Biochar	0.2				0.5				0.7			
Plant height(cm)												
Control without biochar	36.7	42.3	47.7	42.2	36.7	50.3	53.0	46.6	36.6	41.3	46.0	41.3
Biochar. 1.5 Ton fed^{-1}	50.3	69.7	74.3	64.8	50.3	79.7	86.3	72.1	50.3	49.0	49.8	49.7
Biochar. 3 Ton fed^{-1}	85.7	85.9	89.0	86.8	85.7	86.7	87.6	86.3	85.6	84.7	83.7	84.7
Means	57.6	65.9	70.3	------	57.5	72.2	75.6	------	57.5	58.3	60.0	-------
LSD@)0.05												
Amendent.	5.7				4.0				5.3			
Biochar	07.4				4.2				5.3			
Amend X Biochar.	5.6				4.9				6.4			

Table 3. Effect of biochar with either K-feldspar, rock phosphate or bentonite on P and K uptake (mg plant $^{-1}$) by maize plants

Amendements Rate	Feldspar(ton.fed^{-1})				Rock phosphate (ton.fed^{-1})				Bentonite (ton.fed^{-1})			
Rates	**0**	**1.5**	**3**	**measn**	**0**	**1,5**	**3**	**Means**	**0**	**1.5**	**3**	**Means**
P (mg plant^{-1})												
Control without biochar	1.3	1.6	1.8	1.5	1.2	2.8	3.2	2.4	1.2	1.2	1.4	1.3
Biochar. 1.5 Ton fed^{-1}	2.7	5.4	5.9	4.7	2.7	11.0	10.2	8.0	2.7	3.1	4.0	3.3
Biochar. 3 Ton fed^{-1}	16.0	16.0	16.7	16.2	16.0	17.3	22.5	18.6	16.0	17.7	18.3	17.3
Means	6.6	7.0	8.1		6.6	10.4	11.9		6.6	7.3	7.9	
LSD 0.05												
Amendment	1.0				2.3				1.0			
Biochar.	1.6				1.4				1.0			
Amendment X Biochar.	2.1				2.9				1.5			
K (mg plant^{-1})												
Control without biochar	8.5	13.4	16.4	12.7	8.5	13.4	13.8	11.9	8.5	12.2	12.8	11.1
Biochar. 1.5 Ton fed^{-1}	17.3	37.4	40.9	31.9	17.3	38.6	40.7	32.2	17.3	22.4	28.8	22.8
Biochar. 3 Ton fed^{-1}	56.0	59.2	61.8	58.9	55.9	58.4	60.0	58.1	55.9	61.5	63.8	60.4
Means	27.2	36.6	39.6		27.2	36.8	38.2		27.2	32.0	35.1	
LSD 0.05												
Amendment	1.9				2.3				1.8			
Biochar.	2.1				2.5				2.6			
Amendment X Biochar.	2.5				3.4				3.9			

Table 4. Effect of biochar with either feldspar, rock phosphate or bentonite on available of P and K of the studied soil

Amendments Rates	Feldspar(ton.fed^{-1})				Rock phosphate (ton.fed^{-1})				Bentonite (ton.fed^{-1})			
rates	**0**	**1.5**	**3**	**Means**	**0**	**1.5**	**3**	**Means**	**0**	**1.5**	**3**	**Means**
	Available P (mg.Kg^{-1})											
Control without biochar	2.2	2.5	2.9	2.5	2.2	3.7	4.4	3.4	2.2	2.3	2.5	2.4
Biochar. 1.5 Ton fed^{-1}	7.3	8.5	9.0	8.3	7.3	14.8	17.6	13.2	7.3	7.6	8.1	7.7
Biochar. 3 Ton fed^{-1}	23.6	24.0	23.7	23.8	23.6	32.5	49.3	35.1	23.6	24.1	23.9	23.9
Means	11.0	11.7	11.9		11.0	17.0	23.7		11.0	11.3	11.5	
LSD 0.05												
Amendment	1.1 ns				1.2				1.3 ns			
Biochar.	0.5				1.1				0.8			
Amend X Biochar.	1.4				1.8				1.3			
Available K (mg.Kg^{-1})												
control without biochar.	21.4	63.6	75.0	53.3	21.4	31.3	32.4	28.4	21.4	53.6	65.2	46.7
Biochar 1.5 Ton fed^{-1}	61.6	93.4	156.9	103.9	61.6	68.7	68.8	66.3	61.6	84.7	131.4	92.6
Biochar 3 Ton fed^{-1}	137.7	175.1	181.8	164.8	137.6	136.5	139.1	137.7	137.6	161.2	164.5	154.4
Means	73.5	110.7	137.8		73.5	78.8	80.1		73.5	99.8	120.3	
LSD 0.05												
Amendment	5.9				6.9				6.7			
Biochar	8.1				7.0				7.5			
Amend X Biochar	10.4				8.9				11.2			

Regarding the available K values given in **Table (4)** reveal that increasing rate of K- feldspar (alone) up to 3 ton fed^{-1} increased available K significantly from 21.4 to 75.0 $mgkg^{-1}$ and also when added biochar (alone) with increasing rates from (0 to 3 ton fed) also increased significantly K from (21.4 to 137.7 $mg.kg^{-1}$). The highest value of available K (181.8) was obtained for the treatment K-feldspar with biochar at rate of 3 ton fed^{-1} each.

Adding rock phosphate alone no significant increase in available K was obtained at low rate (1.5 ton). While increase rate of application up to 3 ton fed increase available to 32.4 mg kg treatment rock phosphate + biochar at any rate had no significant effect.

In case of bentonite alone increasing rate of addition from 0 to 3ton fed^{-1} increased significantly available K from 21.4 to 65.3 $mg.kg^{-1}$.

Adding biochar alone up to 3 ton fed-1 increased significantly available K from (21.4 to 137.7).

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تتأثير البيوتشار على انطلاق كل من الفوسفور والبوتاسيوم من الفلسبار البوتاسى وصخر الفوسفات وتأثيره على بعض خواص النمو لنبات الذرة

[135]

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الموجـــــز

اجريت تجربة اصص باستخدام اراضى رملية (جمعت من محطة الاسماعلية بمركز البحوث الزراعية) فى الصوب الخاصة بمركز البحوث الزراعية – تأثير البوتشار على انطلاق البوتاسيوم والفوسفور من المعادن الحاملة مثل الفلسبارات البوتاسية وصخر الفوسفات على بعض عوامل النمو مثل طول النبات والوزن الجاف والميسر من الفوسفور والبوتاسيوم وامتصاص النبات من هذه العناصر. تم تعبئة 63 اصيص بالرمل سعة 10 كيلو لكل اصيص وكانت الخامات المستخدمة هى الفلسبار البوتاسى وصخر الفوسفات والبنتونيت والفحم. تم إضافة كل خام بالمعادلات الأتيه 0 و1.5 طن و3 طن لكل فدان وكانت المعاملات كالتالى بيوتشار فقط وفلسبار بوتاسى فقط وصخر فوسفات فقط وبنتونيت فقط وكل خام تم اضافتة مع البيوتشار بنفس المعدل. تم زراعة نبات الذرة 6 بذور فى كل اصيص ومعدل اضافة السماد النتروجينى (سلفات امونيوم 20.5%) 200 كجم للفدان وتم دراسة بعض عوامل النمو وامتصاص النبات والميسر فى التربة من البوتاسوم والفوسفور وكانت النتائج كالتالى ساهم: استخدام البيوتشار بمعدل 3 طن للفدان مع كل من الفلسبار البوتاسى وصخر الفوسفات والبنتونيت فى تحسين نمو نبات الذرة مقارنة بمعاملة الكنترول. وكانت اعلى قيمة لطول النبات 89 سم للبيوتشار + الفلسبار 3 طن لكل منهما والوزن الجاف 115 جرام للبيوتشار مع البنونيت 3 طن لكل منهما بالمقارنة ب 36.7 سم و2.9 جرام للكنترول وكانت اعلى قيم لامتصاص الفوسفور 22.5 و18.3 و16.7 مليجرام/اصيص للمعاملات الأتية 3 طن للفدان للبيوتشار مع كل من صخر الفوسفات والبنونيت والفلسبار 3 طن على الترتيب وكانت قيم البوتاسيوم الممتص 63.9 و 61.8 و 60.1 مليجرام لكل نبات للبيوتشار 3 طن للفدان مع كل من 3 طن فلسبار 3 طن بنتونيت و1.5 طن بنتونيت. وكانت اعلى قيم لتركيز الفوسفور الميسر 49.3 مليجرام لكل كيلوجرام للمعاملة 3 طن بيوتشار + 3 طن صخر الفوسفات و24.1 مليجرام لكل كيلوجرام للمعاملة 3 طن بيوتشار + 1.5 طن للفدان بنتونيت.

وتم التوصية بإستخدام البيوتشار منفردا بدون إضافة اى معاملات بالمعدل 3 طن للفدان يعتبر افضل معاملة عند الأخذ فى الأعتبار العوامل الأقتصادية.

الكلمات الدالة: البيوتشار، الفلسبار، صخر الفوسفات، البنتونيت، نبات الذرة

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