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Response of Cassava Crop Cultivated In Sandy Soil To Different Sources of Potassium Fertilizers

Shimaa Kh.H. Hasan[1] andNeama M. Marzouk[2]

[1]Potato and Vegetatively Propagated Vegetables Department , Horticulture Research Institute, A.R.C., Giza, Egypt.

[2]Vegetable Research Dept., Agricultural and Biological Research Division, National Research Centre, Dokki, Cairo, Egypt

Corresponding author: shimaakhamis2000@yahoo.com , neama1980@yahoo.com

Abstract

Field experiment was carried out in new reclaimed lands at the experimental Station of National Research Centre in Nubaria Region, Behira Governorate, North of Egypt, during the two growing seasons of 2017/2018 and 2018/2019. This study aimed to enhance cassava (Indonesian cultivar) productivity by using different sources of potassium fertilizers treatments. Six treatments, *i.e.*,potassium sulphate as mineral fertilizer, K feldspar + bio fertilizer as bio fertilizer, compound K, Aloe extract as natural fertilizer and Humic acid as organic fertilizer were compared to non-potassium fertilizerapplication (control). The experiments were carried out in a Complete Randomized Blocks Design in four replicates. The characters of vegetative growth, (plant height, leaves number per plant, main stems number per plant, main stem diameter,leaves dry matter, total chlorophyll content and leaf area) total yield per fed., tuber roots characters (average tuber roots number, average tuber roots diameter, average tuber roots length, average tuber roots weight and tuber roots dry matter) and chemical contents of tuber roots (starch % and potassium %)were evaluated.The increment in vegetative growth and productivity of cassava plants was evident with fertilizered plantsby mineral potassium, Aloe extract and Humic acid. On the other hand, decrement in vegetative growth and productivity of cassava was observed withnon-adding potassium fertilizertreatment (control).

Keywords: Cassava, potassium, mineral fertilizer, bio fertilizer, compound K, natural, organic,Aloe extract, Humic acid, feldspar rock.

Introduction

Cassava (*Manihot esculenta* Crantz) is a non-traditional vegetable tuber root crop and is one of the important crops in tropical regions of the world (Scott *et al.,* 2000). Cassava is a major staple food as it is produced both for direct human food consumption and industrial use as bread and biscuits. Sometimes, leaves are consumed as a vegetable, which contain high levels of protein. It ranks the fourth food crops in the developing countries because it is a major source of low cost carbohydrates, cheapest caloric source and contains nearly the maximum concentration of starch compared to other crops (Hassan, 2008).

Cassava is a tuber root crop that is characterized by its need for potassium in a large amount. Therefore, the trend towards fertilization with different sources of potassium and knowing which is more beneficial to the plant as a mineral fertilizer, bio-fertilizer, compound K, natural fertilizer and organic fertilizer is important nowadays.

Mineral potassium (K) is an important macro-nutrient and the most abundant cation in higher plants. K has been the target of some researchers mainly because it is essential for enzyme activation (Wiedenhoeft, 2006). The supply of mineral K as potassium sulphute in adequate amounts for cassava is essential to increase the root yield and the starch quality (Uwah*et al*.,2013). Potassium plays an important role in several biochemical and physiological processes of plants (Viana and Kiehl, 2010).Hassan *et al.* (2007) reported that the highest values of cassava plant in sandy soil were given with the moderate fertilizer level; *i.e.*, 96 kg K_2O as compared to 60, 75 and 120 kg K_2O $fed.^{-1}$. Bio-fertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity (Bhardwaj *et al*., 2014). Bio fertilizers are a large population of a specific or a group of beneficial microorganisms for enhancing the productivity of soil. DongZhi*et al.* (2004) concluded that the aqueous leaf extract of Aloe vera could be useful as a natural plant growth regulator. Moreover, Shadia, Ahmad*et al.* (2014) reported that treating basil plant by Aloe extract at 100 % concentration significantly increased plant height, number of branches, dry weight of herbas well as oil yield of basil plant compared with other concentration (25, 50 and 75%). Application of humic acids (HA) has several benefits and agriculturists all over the world are accepting humic acids as an integral part of their fertilizer program. It can be applied directly to the plant foliage in liquid form or to the soil in the form of granules alone or as fertilizer mix. Humic acid is

one of the major components of humus. Humates are natural organic substances, high in humic acid and containing most of known trace minerals necessary to the development of plant life (Senn, 1991). Humic substances are important soil component because they constitute a stable fraction of carbon and improve water holding capacity, pH buffering and thermal insulation (McDonnell *et al*., 2001). Soil application method of humic acid had a significant increases in plant growth characters, photosynthetic pigments, total and marketable yield and tuber root quality of sweet potato. Besides, this application method significantly increased chemical composition of tuber roots and reduced the weight loss and decay percentages (Saif El-Deen*et al*., 2011).

Therefore, the objective of this experiment was to study the effect of response of cassava crop cultived in sandy soil to different sources of potassium fertilizers regarding its growth, productivity and chemical contents.

Materials and Methods

A field experimentswas conducted in newly reclaimed lands during the two successive seasons of 2017/2018 and 2018/2019 at the experimental Station of National Research Centre in NubariaRegion, Behira Governorate, North of Egypt. This study was carried out to investigate the response of cassava (Indonesian cultivar) to different potassium fertilizer sources on growth, yield and its chemical contents. The soil texture was sandy, where the sand, silt and clay values were 78.6, 13.9 and 7.5% respectively. The soil pH was 7.5 and soil salinity or EC recorded 2.2 dS m^{-1}. Six different potassium fertilizer sources treatments as follows:

1. Non-adding potassium fertilizer (control).
2. Mineral fertilizer as potassium sulphate (48% K_2O) at rate of 96 kg K_2O/fed. was applied through a drip irrigation system.
3. Bio-fertilizer as *Bacillus circulans* bacteria at a concentration of ($5X10^{-1}$cfu) plus applied potassium feldspar (10.6% K_2O).Concerning feldspar as a natural local potassium rock powder was produced by Al-Ahram for mining Co., Ltd., Egypt. It was added during soil preparation, while, bio-fertilizer maundered with the unit of bio-fertilizer, Fac. Agric., Ain Shams University and it was applied during the cultivation seasonat the root absorption zone of plants.The chemical properties of the used feldspar rock according to Soltanpour *et al.* (1996) are presented in Table 1.

Table 1. Some chemical constitution of feldspar used in the experiment during two growth seasons.

Components		Components		Components	
Al_2O_2	15.12%	Fe_2O_2	0.08%	TiO_2	0.01%
K_2O	10.6%	P_2O_2	0.05%	MnO_2	0.02%
MgO	7.03%	CaO	0.36%	$CaCO_3$	0.42%
Na_2O	1.91%	Cl	0.03%	SiO_2	64.37%
pH	8.21	EC (dS m^{-1})	0.55		

4- Compound K at concentration 30% K_2O at rate 2.5ml/ L. was foliar sprayed during the cultivation season on vegetative growth.
5- Natural fertilizer as Aloe extract at rate 100cm/ L was foliar sprayed the same way as mentioned above. It was prepared as described by Wilfred *et al*. (1990) where the plant tissues were crushed using a porcelain mortar and pestle, aloe extract presence of distilled water at equal rate (1/1by volume), then filtered. The obtained extract was used for foliar spray at 100% by adding distilled water.Determination of minerals contents in the Aloe vera leaves extract were performed according toRawe (1966).

Table 2. Determination of minerals in *Aloe vera*extract.

Minerals	**(mg/100ml F.W)**
Nitrogen (N)	80.65
Phosphorus (P)	6.95
Potassium (K)	60.14
Iron (Fe)	0.229
Zinc (Zn)	0.028
Manganese (Mn)	0.0266
Calcium (Ca)	40.00
Copper (Cu)	0.0042
Magnesium (Mg)	14.44
Sodium (Na)	51.12

Organic fertilizer as Humic acidat 0.5% rate, was applied to the soil during the cultivation seasonat the root absorption zone of plants, Humic acid was produced from Soil, Water and Environment Res. Institute., ARC.Egypt.All treatments were applied four times during the cultivation season, the first was after two months from planting and then at one and half month intervals.

Cassava was planted on 23rdApril during the two growing seasons. Cassava stalks of similar thickness of approximately 2.5 – 3.0 cm in diameter were cut into stalk cuttings of 25 – 30 cm in length and planted vertically by burring two-thirds of the cuttings into the soil and keeping one third of them over ground, then irrigated directly after planting. The size of each plot was 10 m^2 and consisted of one row; one meter width and 10 meters length. Stalk cuttings were planted at a distance of 1 m apart between plants within the rows. So, each plot contained 10 plants.Theother agricultural practices were carried out uniformly in all treatment plots as recommended.

Data recorded

Vegetative growth parameters

Representative random samples of 5 plants were labeled in each replicate for every treatment after 180 days from planting and the following parameters were recorded: plant height, leaves number per plant, main stems number per plant, main stem diameter, leaves dry matter,total chlorophyll content andleaf area. The total chlorophyll content in cassava leaves was measured using portable photosynthesis system (Li-Cor Inc. USA).

Tuber root yield and yield components

Harvesting was done 10 months after planting to recordtotal yield per fed., and then ten uniform tuber roots were randomly chosen from each treatment to measure: average tuber roots number, average tuber roots diameter, average tuber roots length,average tuber roots weight and tuber roots dry matter.

Chemical composition of tuber roots

Starch percentage was determined as described by Smith and Zeeman (2006). Potassium percentage was determined using flame photometer according to the method of Page *et al*. (1982).

Statistical analysis

Data were subjected to analysis of variance method according to Snedecor andCochran (1980). The comparisons of treatment means were done with Duncan Multiple Range Test (Duncan, 1955). All data analyses were performed using the *STATISTIX* version 8.0 software.

Results And Discussion

1-Vegetative growth parameters

Different sources of potassium fertilizer had positive effect on vegetative growth parameters of cassava plant as shown in Tables3 and 4.The highest values of vegetative growth parameters (plant height, leaves number/ plant, main stems number/ plant,main stems diameter/ plant, leaves dry matter, and leaf chlorophyll contentand leaf areawere recorded by mineral potassium fertilizer (potassium sulphate) followed bynatural fertilizer (Aloe extract) and organic fertilizer (Humic acid) with no significant differences between them. On the contrary, the lowest values of vegetative growth parameters of cassava plants were found with control (no adding potassium fertilizer) preceded by biofertilizerin both growing seasons. This resul tmay be due to that potassium playsvital role in photosynthesis by direct increasing in growth and leaf area index and hence CO_2 assimilation and increasing the outward translocation of photosynthates. Also, aloe extract and humic acid are rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds and growth regulating hormones like zeatin (Nagar *et al.,* 2006) that reflected on an increase in growth parameters of cassava plants.

These results are in harmony with these obtained by Hamad *et al.* (2017), on dill plant,they mentioned that using mineral fertilizer full NPK dose gave the best results of vegvtitave growth as well as Aloe extract at 40g/ L comperded with zero and half NPK doses as well as Aloe extract at 20g/ L. Also, Shadia, Ahmad *etal.* (2014) stated that the best treatment of aloe at 100% concentration increased plant height, number of branches, dry weight of herb (basil plant) for other aloe treatments (concentrations 25, 50 and 75%).Abou El-Khair and Mohsen (2016) on Jerusalem Artichoke as well as Shams and Fekry (2014) on sweet potato stasted that using 100% potassium sulphate alone recorded the high values of vegetative growth compared to feldspar rock + inoculation with bactria.

Table 3. Effect of different sources of potassium fertilizers on cassava vegetative growth at 180 days after planting in 2017/2018 and 2018/2019 seasons.

Treatments	Plant height		Leaves number/ plant		Main stems number/ plant		Main stems diameter/ plant	
	Season 1	Season2	Season 1	Season2	Season1	Season2	Season1	Season2
Control	142.0C	136.6E	98.3E	108.3D	1.66A	2.00B	2.10D	1.90D
Mineral fert.*	185.6A	187.6A	163.3A	177.6A	2.66A	2.66A	2.83A	2.76A
Bio-fert.	149.0C	145.0D	120.0D	137.6C	2.33A	2.00B	2.33C	2.13C
Comp. K**	177.3B	155.3C	123.3CD	142.6BC	2.33A	2.00B	2.46BC	2.20C
Natural fert.	180.6AB	172.0B	150.6B	156.0B	2.33A	2.66A	2.60B	2.50B
Organic fert.	178.6AB	169.3B	135.0C	152.6BC	2.33A	2.33AB	2.50BC	2.46B

Values within the same column followed by the same letter (s) are not significantly different at 5% according to Duncan's Multiple Range Test.
*fert: fertilization, ** comp. K: compound potassium.

Table 4. Effect of different sources of potassium fertilizers on cassava vegetative growth at 180 days after planting in 2017/2018 and 2018/2019 seasons.

Treatments	Leaves dry matter		Leaf chlorophyll content		Leaf area	
	Season 1	Season2	Season 1	Season2	Season 1	Season2
Control	56.9 C	54.8 C	29.6 C	18.3 D	195.0 D	181.0 C
Mineral fert.*	71.2 A	72.2 A	51.3 A	43.0 A	229.3 A	217.3 A
Bio-fert.	61.9 B	57.1 BC	33.6 C	31.6 C	206.3 C	188.3 BC
Comp. K**	58.4 BC	57.0 BC	33.0 C	24.0 D	206.4 C	188.6 BC
Natural fert.	70.0 A	71.0 A	48.3 AB	39.3 AB	218.6 B	210.0 A
Organic fert.	69.3 A	64.1 AB	44.6 B	34.3 BC	217.0 B	195.3 B

Values within the same column followed by the same letter (s) are not significantly different at 5% to Duncan's Multiple Range Test..
*fert: fertilization, ** comp. K: compound potassium.

2- Total yield and tuber root parameters

The measured data of total yield and its quality in relation to application of all treatments are illustrated in Tables (5and 6) andshowed that cassava plants recorded positive significant differences in measured parameters as a result of different soure of potassium fertilizers. Mineral potassium fertilizer (potassium sulphate) gave the highest mean values of tuber root parameters (tuber roots number, tuber root diameter, tuber root length, tuber roots fresh weight, tuber root dry matter and total yield) followed by natural fertilizer (Aloe extract),next organic fertilizer (Humic acid)compared to the other treatments (non adding K fertilizer, compound K and bio fertilizer) in both seasons.However, the difference variation between mineral potassium and Aloe extract treatments was not enough to be significant. This indicated that potassium sulfate and Aloe extract have the highest ability to enhance growth under sandy soil condition than compound K and bio fertilizer which also increase the yield. Aslo, improving K nutrition of low inherent soil fertility can significantly increase cassava tuber root yield (Taufiq*etal.*, 2013).This resultisin agreement withHamad*etal.* (2017) on dill plant who indicated that using full dose of NPK and Aloe extract at 40g/ L concentration gave the best results of yield comperded with zero and half NPK doses as well as Aloe extract at 20g/ L. In addition,Abou El-Khairand Mohsen (2016) on Jerusalem artichoke stated that plant treated with 100 % natural K as potassium feldspar + inoculation with silicate releasing bacteria decreased total yield/ fad.about 0.36 and 7.14 % than plants recieved 100 % mineral K only in 1st and 2ndseasons, respectively.

Table 5. Effect of different sources of potassium fertilizers on tuber rootparameters at harvesting in 2017/2018 and 2018/2019 seasons

Treatments	Average tuber roots number		Average tuber roots diameter (cm)		Average tuber roots length (cm)	
	Season 1	Season2	Season 1	Season2	Season 1	Season2
Control	14.3 C	26.0 E	2.86 D	2.93 D	34.0 E	27.6 E
Mineral fert.*	22.0 A	43.3 A	4.96 A	5.26 A	47.3 A	49.6 A
Bio-fert.	17.6 B	30.3 D	3.37 C	3.56 C	36.3 DE	35.3 D
Comp. K**	17.3 B	31.0 D	3.56 C	3.86 C	38.6 CD	36.0 D
Natural fert.	19.6 AB	38.6 B	4.20 B	4.90 AB	43.6 B	44.3 B
Organic fert.	18.0 B	35.3 C	3.70 C	4.53 B	41.6 BC	41.0 C

Values within the same column followed by the same letter (s) are not significantly different at 5% to Duncan's Multiple Range Test.
*fert: fertilization, ** comp. K: compound potassium.

Table 6. Effect of different sources of potassium fertilizers on cassava total yieldatharvesting in 2017/2018 and 2018/2019 seasons.

Treatments	Average tuber roots fresh weight (g)		Dry matter of tuber root (%)		Total yield (ten/ fed.)	
	Season 1	Season2	Season 1	Season2	Season 1	Season2
Control	202.0 E	266.5 D	32.1 D	29.5 D	5.567 D	6.233 D
Mineral fert.*	375.8 A	566.1 A	39.3 A	40.6 A	10.267 A	12.600 A
Bio-fert.	248.4 D	377.1 C	34.7 BC	32.0 C	6.033 CD	6.967 CD
Comp. K**	231.7 D	401.13 BC	33.1 CD	33.3 C	6.533 C	7.200 C
Natural fert.	328.5 B	527.4 A	37.1 AB	38.2 B	9.533 AB	12.333 A
Organic fert.	296.7 C	484.5 AB	36.8 AB	37.9 B	9.133 B	9.367 B

Values within the same column followed by the same letter (s) are not significantly different at 5% to Duncan's Multiple Range Test.
*fert: fertilization, ** comp. K: compound potassium.

3- Chemical contents

Data in figers (1 and 2) showed the influence of different sources of potassium fertilizers on potassium percentage and starch percentage in cassava. It is clearly notced that, applying different sources of potassium fertilizers had positive effect on tuber root chemical contents compared to untreated control. The highest chemical contents were recorded with plants that treated by mineral potassium and Aloe extract with no significant differences between them fowolled with humic acid.Thus, Aloe extract and humic acid can be used instead of mineral potassium (in cassava cultivation) as they all have positive effects with no significant differences on different measured characters (vegetative growth(Table 3 and 4), yield (Table 6) and chemical compound of root (Figers 1 and 2).

Whereas, the lowest value was obtained with control treatment (non adding K fertilizer) in the two seasons. These results may be described as K nutrition can improve starch content of cassava (Taufiq*et al*., 2013).This was due to that potassium as mineral, aloe extract and humic acid substances increased the plants ability to absorb nutrients and water from the sandy soils, where the low capacity to retain water and nutrients, also increased water holding capacity and soil cation exchange capacity. These results are inagreement by Weaam, Sakr*et al*., (2018) who indicated that the full recommended dose form NPK as well as aloe gel extract at 75 ml/ Lproduced a positive increasein chemical composition of geranium (total carbohydrates and potassium %comparded to half dose of NPK as well as 25 and 50 ml/ L aloe gel extract.

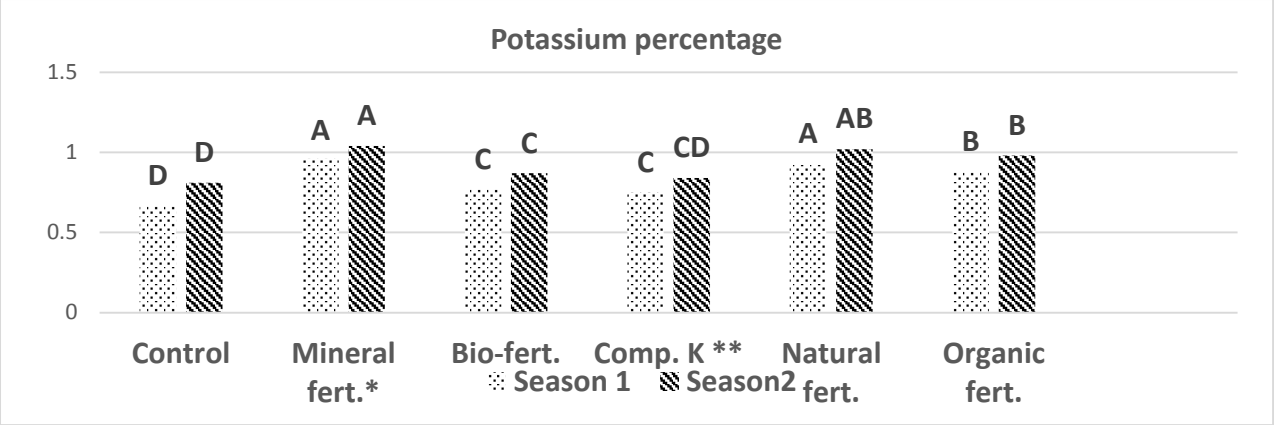

Fig. 1. Effect of different sources of potassium fertilizers on cassava potassium % at harvesting in 2017/2018 and 2018/2019 seasons.

Values within the same column followed by the same letter (s) are not significantly different at 5% to Duncan's Multiple Range Test.
*fert: fertilization, ** comp. K: compound potassium.

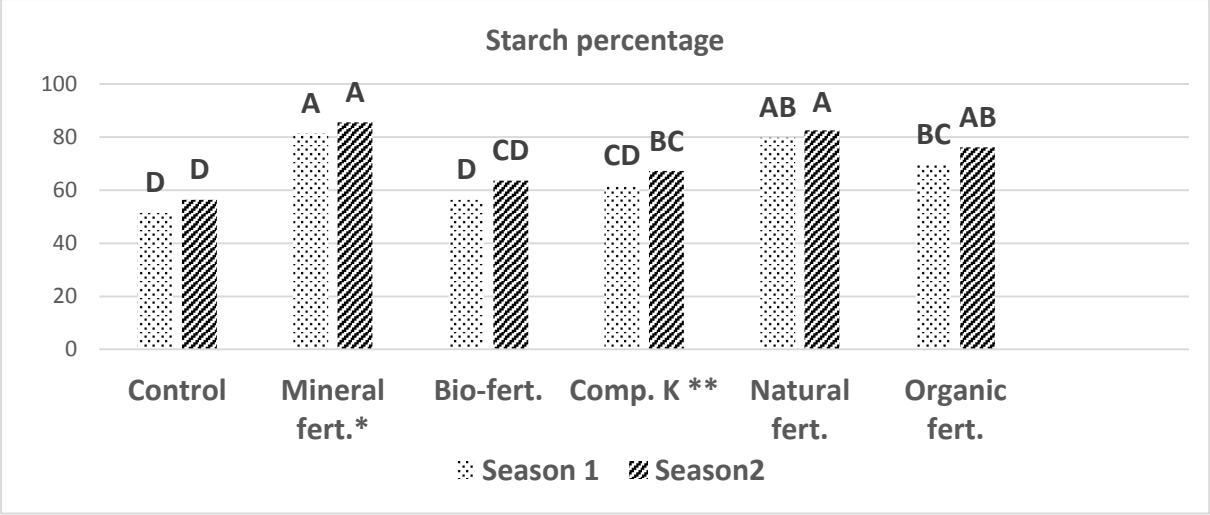

Fig. 2. Effect of different sources of potassium fertilizers on cassava starch %at harvesting in 2017/2018 and 2018/2019 seasons.

Values within the same column followed by the same letter (s) are not significantly different at 5% to Duncan's Multiple Range Test.
*fert: fertilization, ** comp. K: compound potassium.

Conclusion

Under similar conditions to current experiment, it is recommended to fertilize cassava plants with mineral fertilization as potassium sulphate or natural one with Aloe extract to obtain the higest productivity and the best chemical content.

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استجابة محصول الكاسافا المزروع فى الارض الرملية لمصادر مختلفة من الاسمدة البوتاسية

شيماء خميس حنفى حسن[1]، نعمه محمد مرزوق[2]

أقسام بحوث الخضر – معهد بحوث البساتين – مركز البحوث الزراعية. [1]

قسم بحوث الخضر – شعبة البحوث الزراعية والبيولوجية – المركز القومى للبحوث . [2]

أجرى هذا البحث فى ارضحديثه الاستصلاح بمحطة بحوث المركز القومى التابعة لمنطقة النوباريه – محافظة البحيرة شمال مصر، خلال موسمى الزراعه 2018/2017 و2019/2018م.وهذه الدراسه تهدف لتشجيع انتاجيه الكاسافا (الصنف الاندونيسى) باستخدام سته مصادر مختلفة من الاسمدة البوتاسية مثل سلفات البوتاسيوم كسماد معدنى، وصخر الفسبار مع الحيوى كسماد حيوى، والبوتاسيوم المركب، ومستخلص الصبار كسماد طبيعى، وحمض الهيوميك كسماد عضوى، والكنترول بدون اضافه سماد بوتاسى.وقد صممت التجربة بنظامالقطاعات كاملة العشوائية فى اربعة مكررات. وكانت الزيادة فى النمو الخضرى (طول النبات – عدد الاوراق للنبات – عدد السيقان الرئيسيه للنبات – قطر السيقان الرئيسيه للنبات – مساحه الورقة – المادة الجافة لاوراق – محتوى الكلورفيل الكلى) والانتاجية وخصائص الجذور المتدرنه لنبات الكاسافا (طول وعدد وقطر ووزن الجذر المتدرن) والمحتوى الكيماوى (نسبه النشا والبوتاسيوم) سجلت مع التسميد المعدنى يليه التسميد بكلا من مستخلص الصبار وحمض الهيموميك. على الجانب الاخر سجلت معاملة الكنترول (عدم اضافه بوتاسيوم للارض) اقل النتائج لصفات النمو الخضرى والانتاجية والمحصول الكلى وجوده الجذور والمحتوى الكيماوى للجذور المتدرنه فى كلا الموسمين.

الكلمات الدالة: كاسافا، بوتاسيوم معدنى، بوتاسيوم مركب، بوتاسيوم حيوى، بوتاسيوم طبيعى، بوتاسيوم عضوى، مستخلص صبار– حمض الهيوميك، صخر فلسبار.