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

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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 fertilizer application (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 when fertilized plants by mineral potassium, Aloe extract and Humic acid. On the other hand, decrement in vegetative growth and productivity of cassava was observed with non-adding potassium fertilization treatment (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 macronutrient 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 sulphate 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 K2O as compared to 60, 75 and 120 kg K2O 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. DongZhiet 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 cultivated in sandy soil to different sources of potassium fertilizers regarding its growth, productivity and chemical contents.

Materials and Methods

A field experiment was 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 Nubaria Region, 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% K₂O) at rate of 96 kg K₂O/ fed. was applied through a drip irrigation system.
3. Bio-fertilizer as Bacillus circulans bacteria at a concentration of (5x10⁶ cfu) plus applied potassium feldspar (10.6% K₂O). 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 manured with the unit of bio-fertilizer, Fac. Agric., Ain Shams University and it was applied during the cultivation season at 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>
<thead>
<tr>
<th>Components</th>
<th>Components</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al₂O₃</td>
<td>15.12%</td>
<td>Fe₂O₃</td>
</tr>
<tr>
<td>K₂O</td>
<td>10.6%</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>MgO</td>
<td>7.03%</td>
<td>CaO</td>
</tr>
<tr>
<td>Na₂O</td>
<td>1.91%</td>
<td>Cl</td>
</tr>
<tr>
<td>pH</td>
<td>8.21</td>
<td>EC (dS m⁻¹)</td>
</tr>
</tbody>
</table>

4- Compound K at concentration 30% K₂O at rate 2.5ml/ L. was foliar sprayed during the cultivation season on vegetative growth.
5- Natural fertilizer as Aloe extract at rate 100cm³/ 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 (1/1 by 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 to Rawe (1966).

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

Organic fertilizer as Humic acid at 0.5% rate, was applied to the soil during the cultivation season at 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 23rd April 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 m² 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. The other 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 and leaf 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 record total 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 and Cochran (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 Tables 3 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 content) and leaf area were recorded by mineral potassium fertilizer (potassium sulphate) followed by natural 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 biofertilizer in both growing seasons. This result may be due to that potassium plays a vital role in photosynthesis by direct increasing in growth and leaf area index and hence CO₂ 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 those obtained by Hamad et al. (2017), on dill plant, they mentioned that using mineral fertilizer full NPK dose gave the best results of vegetative growth as well as Aloe extract at 40g/L compared with zero and half NPK doses as well as Aloe extract at 20g/L. Also, Shadia, Ahmad et al. (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 stated that using 100% potassium sulphate alone recorded the high values of vegetative growth compared to feldspar rock + inoculation with bacteria.
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.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Leaves number/plant</th>
<th>Main stems number/plant</th>
<th>Main stems diameter/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season 1</td>
<td>Season 2</td>
<td>Season 1</td>
<td>Season 2</td>
</tr>
<tr>
<td>Control</td>
<td>142.0 C</td>
<td>136.6E</td>
<td>98.3 E</td>
<td>108.3D</td>
</tr>
<tr>
<td>Mineral fert.*</td>
<td>185.6A</td>
<td>187.6A</td>
<td>163.3A</td>
<td>177.6A</td>
</tr>
<tr>
<td>Bio-fert.</td>
<td>149.0C</td>
<td>145.0D</td>
<td>120.0D</td>
<td>137.6C</td>
</tr>
<tr>
<td>Comp. K**</td>
<td>177.3B</td>
<td>155.3C</td>
<td>123.3CD</td>
<td>142.6BC</td>
</tr>
<tr>
<td>Natural fert.</td>
<td>180.6AB</td>
<td>172.0B</td>
<td>150.6B</td>
<td>156.0B</td>
</tr>
<tr>
<td>Organic fert.</td>
<td>178.6AB</td>
<td>169.3B</td>
<td>135.0C</td>
<td>152.6BC</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaves dry matter</th>
<th>Leaf chlorophyll content</th>
<th>Leaf area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season 1</td>
<td>Season 2</td>
<td>Season 1</td>
</tr>
<tr>
<td>Control</td>
<td>56.9 C</td>
<td>54.8 C</td>
<td>29.6 C</td>
</tr>
<tr>
<td>Mineral fert.*</td>
<td>71.2 A</td>
<td>72.2 A</td>
<td>51.3 A</td>
</tr>
<tr>
<td>Bio-fert.</td>
<td>61.9 B</td>
<td>57.1 BC</td>
<td>33.6 C</td>
</tr>
<tr>
<td>Comp. K**</td>
<td>58.4 BC</td>
<td>57.0 BC</td>
<td>33.0 C</td>
</tr>
<tr>
<td>Natural fert.</td>
<td>70.0 A</td>
<td>71.0 A</td>
<td>48.3 AB</td>
</tr>
<tr>
<td>Organic fert.</td>
<td>69.3 A</td>
<td>64.1 AB</td>
<td>44.6 B</td>
</tr>
</tbody>
</table>

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 (5 and 6) and showed that cassava plants recorded positive significant differences in measured parameters as a result of different source 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 et al., 2013). This result is in agreement with Hamad et al. (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 compared 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 received 100 % mineral K only in 1st and 2nd seasons, respectively.
increased water holding capacity and indicated 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, Saket et al., (2018) who indicated that the full recommended dose form NPK as well as aloe gel extract at 75 ml/L produced a positive increasein chemical composition of geranium (total carbohydrates and potassium %compared to half dose of NPK as well as 25 and 50 ml/L aloe gel extract.


<table>
<thead>
<tr>
<th>Treatments</th>
<th>Average tuber roots number</th>
<th>Average tuber roots diameter (cm)</th>
<th>Average tuber roots length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season 1</td>
<td>Season2</td>
<td>Season 1</td>
</tr>
<tr>
<td>Control</td>
<td>14.3 C</td>
<td>26.0 E</td>
<td>2.86 D</td>
</tr>
<tr>
<td>Mineral fert.*</td>
<td>22.0 A</td>
<td>43.3 A</td>
<td>4.96 A</td>
</tr>
<tr>
<td>Bio-fert.</td>
<td>17.6 B</td>
<td>30.3 D</td>
<td>3.37 C</td>
</tr>
<tr>
<td>Comp. K**</td>
<td>17.3 B</td>
<td>31.0 D</td>
<td>3.56 C</td>
</tr>
<tr>
<td>Natural fert.</td>
<td>19.6 AB</td>
<td>38.6 B</td>
<td>4.20 B</td>
</tr>
<tr>
<td>Organic fert.</td>
<td>18.0 B</td>
<td>35.3 C</td>
<td>3.70 C</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Treatments</th>
<th>Average tuber roots fresh weight (g)</th>
<th>Dry matter of tuber root (%)</th>
<th>Total yield (ten/ fed.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season 1</td>
<td>Season2</td>
<td>Season 1</td>
</tr>
<tr>
<td>Control</td>
<td>202.0 E</td>
<td>266.5 D</td>
<td>32.1 D</td>
</tr>
<tr>
<td>Mineral fert.*</td>
<td>375.8 A</td>
<td>566.1 A</td>
<td>39.3 A</td>
</tr>
<tr>
<td>Bio-fert.</td>
<td>248.4 D</td>
<td>377.1 C</td>
<td>34.7 BC</td>
</tr>
<tr>
<td>Comp. K**</td>
<td>231.7 D</td>
<td>401.13 BC</td>
<td>33.1 CD</td>
</tr>
<tr>
<td>Natural fert.</td>
<td>328.5 B</td>
<td>527.4 A</td>
<td>37.1 AB</td>
</tr>
<tr>
<td>Organic fert.</td>
<td>296.7 C</td>
<td>484.5 AB</td>
<td>36.8 AB</td>
</tr>
</tbody>
</table>

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 noticed that, applying different sources of potassium fertilizers had positive effect on tuber root chemical contents compared to untreated control.
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 highest productivity and the best chemical content.

References
استجابة محصول الكاسافا المزروع في الأرض الرملية لمصادر مختلفة من الاسمدة البوتانية

شيماء خميس حني حسن، نعمة محمد مرزوق

أقسام بحوث الخضر – بحوث البساتين – مركز بحوث الزراعية.  

قسم بحوث الخضر – شعبة البحوث الزراعية والبيولوجية – المركز القومي للبحوث .

أجرى هذا البحث في اراضي الزراعة في موسم الزراعة 2017/2018 و2019/2020م، يهدف تشجيع انتاج محصول الكاسافا (الصنف الاندونيسي) باستخدام مختلف مصادر الاسمدة البوتانية مثل سمك البوتاسيوم كسماد معدني، وصخر الفوسفور مع الحيوى كسماد حيوي، والبوتاسيوم المركب، ومستخلص الصفصاف كسماد طبيعي، وحمض الهيمومك كسماد عضوي، والكنتروال بدون إضافه سما بوتاسيوم. وقد صمم البحث بنظام بلاطات كاملا للعشائر في اربعة مكررات. وكانت الزائدة في النمو الخضري (طول النبات – عدد الأوراق للنبات – عدد الساقين الرئيسي للنبات – قطر الساق الرئيسي للنبات – ساحة الروقة – المادة الجافة للورقة – محتوى الكروفلوكل (كلي) ) والانتاجية وخصائص الجذور المتدرنة لنبات الكاسافا (طول وعدد وقطر وزن الجذر المتدرن) والمحتوى الكيماوي (نسبة الكحول والبوتاسيوم) سجلت عند التسميد المغذى بكلا من مستخلص الصفصاف وحمض الهيمومك، على الجانب الآخر سجلت متاعبة الخضراع (أعماد إضافه بوتاسيوم لإرض) أقل النتائج لصفصاف الكاسافا وانتاجية وخصائص الجذور المتدرنة. 

الكلمات الدالة: كاسافا، بوتاسيوم معدني، بوتاسيوم مركب، بوتاسيوم حيوي، بوتاسيوم طبيعي، بوتاسيوم عضوي، مستخلص صبار - حمض الهيمومك، صخر الفوسفور.