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EFFECT OF CHOPPED RICE STRAW AND FOLIAR APPLICATION OF POTASSIUM AND PHOSPHORUS ON GROWTH, YIELD AND TUBEROUS ROOT QUALITY OF SWEET POTATO (*Ipomoea batatas* L.) GROWING AT LATE SUMMER SEASONS UNDER CLAY SOIL CONDITIONS

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ABSTRACT

Two field experiments were carried out at the experimental Farm, Faculty of Technology and Development(Ghazala farm), Zagazig university El Sharkia Governorate, Egypt during the summer season of 2017 and 2018 to investigate the effect of chopped rice straw and foliar spray with potassium and phosphorus fertilizers sweet potato cv. Minufiya 6 growing at summer seasons in clay soil, on growth, yield and quality.

The experiment was set out in a randomized complete blocks design where including seven treatments, which were chopped, rice straw at 2kg/ridge only and in combinatory with potassium and phosphorus at 2 and 4 mll^{-1}as well as control.

The results indicated that application of chopped rice straw at the rate of 4kg/ridge with foliar spray of potassium and phosphorus at 4mll-1 was the most effective treatment for increasing the morphological trail of plants and its chemical composition. Also, this treatment recorded the highest values of total and marketable tuber root yield, as well as the best tuber physical characters(fresh weight, length and diameter) and maximum concentration of nutritive values, i.e. N, P, K, protein and starch percentage , besides the root content of carotene.

Conclusively, *it could be concluded that the obtained results, it can be recommended that the treatment of 4 kg/ridge of chopped rice straw and foliar application of potassium and phosphorus at the concentration of 4 mll^{-1} for improving the properties of clay soil and to access the vigorous plant growth, maximum production with the best tuber quality of sweet potato.*

Keywords: Sweet potato, rice straw, potassium, phosphorus

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a starchy tuberous crop related to family *Convolvulaceae*. It is considered as one of the most important vegetable crops in most parts of tropical and sub-tropical regions of the world and ranked the seventh among the world's major food crops (FAO,2004). The importance of sweet potato as food security crop can not be underestimated which covered human food, animal feed and biofuels. Tuber can be eaten fried, roasted or boiled by human where small tubers serve as livestoke feed. Moreover, it used as a raw material for industrial processing such as starch, alchohol and pharmaceutical. Sweet potato has a high nutritive value and considered a good source of energy; some miner varieties contain high Beta- carotene content which become very important in combating vitamin A deficiency, especially in children (Woolfe, 1992).

In recent years, straw resources have been of greater interse and their rational use and influence on agricultural production are key issues. Most crop straw, i.e. rice straw is burned and only of 2%-5% is used as organic fertilizer (Yang *et al*., 2014) caused wasted resources and environmental pollution. Rice straw is an organic material contains numerous essential elements importance for plant growth including nitrogen, phosphorus and potassium (Gaihre *et al*., 2013). Moreover, rice straw also contains bio polymers, such as cellulose (32-37%), hemicellulose (29-37%) and lignin (5-15%). The nutrients are released from these compounds to the soil and available for crop growth (Byous *et al*., 2004).

Rice straw has been reported as materials improving the soil physical and chemical characters and decomposition as a result to improving soil fertility by promoting soil organic matter and soil moisture content, as well as inducing the living organism activities (Ruensuk *et al*., 2008).

Foliar spray of fertilizers are widely used in vegetable crops as a supplemental nutrition with macro and micro nutrients which are more environmentally friendly and may be increase growth, productivity, as well as quality of yield (Haytova, 2013). There are many advantages of foliar fertilizer application, *i.e.* fast acting where it absorbed in leaves(the green factories where the photosynthesis process produce the compounds that needed to plant growth), lower cost, easy of application (Jasim *et al*., 2013). Therefore, foliar fertilization has become an important management in crop production to increase the yield and quality (Romheld and El-Fouly, 1999).

Potassium supply plays an important role in increasing carbohydrates, proteins, translocation of photosynthetic assimilates, enhances water uptake, beside its role in increasing water use efficiency (Marschner, 2012). Moreover, foliar spray of potassium can improve the growth, yield and tuber quality, especially under the conditions of heavy soil or sandy soil, where potassium

insufficient available for the plant (Marchand and Bourrie, 1999). Potassium appears to be the very efficient nutrient in the production of sweet potato through its effect on the number, size, weight and quality of the tuberous root, consequently reflected on yield (Abd- All *et al*., 2017).

Phosphorus is an important macronutrient for crop growth and ensure high yield with good quality. It plays a key role in biochemical processes in plants through its contribution in energy transformation. Furthermore, phosphorus enhances different plant physiological process, such as photosynthesis and nitrogen fixation.

In addition, is an essential constituent of many organic compounds which can affect on the development and growth of root (Marschner, 2012). Fixation of phosphate when applied to the soil considered one of the main problems of phosphate fertilizer, the recovery with crop uptake is about 15-30%, while 60% of phosphorus fertilizer was adsorbed or fixed by the soil, and this due to reduce the efficiency of phosphorus uptake from fertilizers (Olusola, 2009 and Marschner, 2012). Therefore, foliar application of phosphorus fertilizer caused a significantly increased of plant growth, number of tubers, total and marketable yield, as well as the quality of tubers (Ekelof, 2007 and Jasim *et al*., 2013).

Therefore, the purpose of the present study was to investigate the effect of chopped rice straw in the clay soil ridges as soil amendment for making sufficient aerial spaces in the soil and foliar spray with the two nutrients of potassium and phosphorus on growth, tuber yield performance as well as tuberous root quality of sweet potato, cv. Monyfiya-6 growing at late summer seasons in clay soil.

MATERIALS AND METHODS

Two field experiment were carried out during the successive summer seasons of 2017 and 2018 at the Experimental Farm, Faculty of Technology and Development,(Ghazala, Farm), Zagazig University El-Sharkia Governorate, Egypt to improve sweet potato (*Ipomoea batates* L.) cv. Minufiya 6 growing at late summer seasons growth, productivity, as well as chemical constituents of plants and tuber roots, by using the chopped rice straw and spraying with as commercial compound named Extra Top Green Leaf which contains (55% K_2O and 45%$P_2O_{5)}$ potassium and phosphorus(KP) under clay soil conditions. Characteristics of the experimental soil and rice straw are presented in Tables (1 and 2), and the analysis were performed according the methods described by Black(1982) and A.O.A.C. (2005), respectively.

Table (1): The characteristics of the experimental soil**.**

Analysis	2017-2018
Particle size distribution (g.kg^{-1})	
Coarse sand	22
Fine sand	10
Silt	24
Clay	44
Textural class	Clay
Bulk density (g.cm^{-3})	1.32
EC (dS.m^{-1}) in soil paste extract	2.76
pH (in 1 soil:2.5 water suspension)	8.2
Organic Matter (%)	1.66
Plant nutrients –available (mg.kg^{-1})	
N	27.18
P	18.23
K	177.12
Si	27.02

EC = Electric conductivity

Table (2): The characteristics of chopped rice straw of the experiment

C/N ratio	N %	P %	K %	Si %	Cellulose %	Lingin %
60.11	0.75	0.63	0.55	5.6	32.0	15.0

The experiments were set out in a randomized complete blocks design with three replications. The experiment included 7 treatments as follows:

1- Control (without any addition)
2- Chopped rice straw at 2 kg/ridge
3- Chopped rice straw at4 kg/ ridge
4- Chopped rice straw at 2 kg/ ridge +KP at 2mll^{-1}
5- Chopped rice straw at 4 kg/ ridge + KP at 2mll^{-1}
6- Chopped rice straw at 2 kg/ ridge)+ KP at 4mll^{-1}
7- Chopped rice straw at 4 kg/ ridge + KP at 4mll^{-1}

Rice straw was chopped into pieces about 30mm long with a cutting machine. Rice straw was placed into a furrow inside the ridge where the transplants were cultivated according to the dose treatment and thin layer of soil took placed on top of the rice straw. Foliar spray with potassium and phosphorus (KP) were applied with the compound of Extra Top Green Leaf which contains 55% K_2O and 45%P_2O_5. Potassium and phosphorus (KP) treatments were sprayed at 30, 60 and 90 days after transplanting. Each

experimental plot was 9 m^2 included three ridges (75 cm wide and 4 m long). Vine cutting (25 cm long) were planted at 1st June in the two growing seasons on one side of the ridge (where the rice straw was exist) at a distance of 25 cm apart. All treatments were fertilized with ammonium sulphate (20.5% N), calcium superphosphate (15.5% P_2O_5) at 150 Kg/fed., and 100 kg of Potassium sulphate (48% K_2O) per feddan. Were added during the soil preparation. The rest of nitrogen and potassium fertilizers were applied at two equal portions after one, and two months of cutting cultivation, respectively. The other agricultural practices of growing sweet potato plants were carried out as commonly followed in the district.

Data recorded

Vegetative growth:

Three plants were randomly chosen from each experimental unit at 120 days after transplanting to measure the plant growth and its chemical constituents.

1- Growth parameters :Vine length (cm) , both of number of leaves and branches /plant and vine fresh and dry weight(branches+ leaves) /plant (g)

2- Plant chemical analyses: The concentration of nitrogen, phosphorus and potassium were determined in the dry weight of vine according to the methods described by A.O.A.C. (1995). Protein content was calculating by multiplying the percentage of total nitrogen by 6.25 as described by Pregl (1945).

3. *Tuber yield and its components:*

At harvest time (150 days after transplanting approximately), all tuber roots of plants in each plot were counted and weighted (Kg) to calculate the average of tuber root weight, number of tuber roots yield /plant, root tuber yield per plant (Kg) and marketable(ton/fed.). Where the marketable root yield feddan (ton/fed) are characterized by length about 20 cm, diameter 5-6 cm and weight from 100-250g.

4. *Tuber root quality:*

Ten roots tubers were randomly taken from each treatment for measuring the physical characters, i.e. average tuber root weight(g), length diameter(cm), and the chemical tuber root quality (the nutritive value) by dried and ground the tuber to determine the content of total nitrogen, phosphorus, potassium and protein according to the methods previously described in plant chemical analyses. The percentage of starch according to A.O.A.C. (1995). Carotene content was determined in the tuber fresh weight method as described by A.O.A.C. (1995).

Statistical analysis

All the data were subjected to statistical analysis of variance according to the methods described by Snedecor and Cochran,1991.The means between the treatments were done by Duncan multiple range test (Duncan, 1955) of probability with SAS software (SAS Institute, 2001).

RESULTS AND DISCUSSION

Vegetative growth characters:

All studied growth parameters of sweet potato plants were influenced by chopped rice straw and foliar spray with potassium and phosphorus treatments as presented in Table (3). The results showed that all the tested treatments had different significant effect on the plant growth characters of sweet potato, i.e. vine length, number of both leaves and branches as well as vine fresh and dry weight per plant. The treatment amended with 4 kg/ridge of chopped rice straw and foliar spray with potassium and phosphorus (KP) at 4 mll^{-1} had a highest significant values of all studied features in both growing seasons. Recorded compared to the control treatment.

The increment effect of chopped rice straw on vegetative trails may due to the rice straw act through providing nutrition of elements (Gaihre *et al*., 2013) and soil aeration. Insufficient soil aeration considered a serious problem for plant growth where poor soil aeration inhibits water and nutrients absorption by plants (Russel, 1977 and Islam *et al*., 1997). The inhibition partly attributed to suppression of root respiration as a result of low oxygen and high carbon dioxide concentration in soil (Kitaya *et al*., 1992), consequently affected on the promotive effect in vegetative growth by spraying potassium may be due to the role of potassium on plant meristematic growth, plant nutrition, enhancing protein synthesis and translocation of photosynthesis assimilate, as well as potassium is essential to the performance of plant enzyme function (Marschner, 2012). Furthermore, the positive growth response to applied potassium is attributed to it's role in cell multiplication and photosynthesis which increased the size and length of leaves and stems (Uwah *et al*., 2013). As for phosphorus effect, it is the second important macronutrient next to nitrogen in limiting crop growth, this nutrient is involved in different processes, such as photosynthesis, energy transformations, and as integral component of sweet

potato plant structures, *i.e*. phospholipids, and for cell division and development of meristem tissues(Bidwell, 1979 and Vance *et al*., 2003).

The revealed results are in agreement with those obtained by Byous *et al*., 2004, Saothongnoi *et al*.,(2014) and Ahmed *et al*., (2015), who confirmed the beneficial effect of rice straw in growing media and a soil

amendment which improve the physical and chemical properties of soil, consequently led to higher root zone than untreated plants and encourag vegetative growth. As for the role of potassium, El- Sawy (2011), Abou-El-Nasr and Ibrahim (2011), Jasim *et al*. (2013), and Bista and Bhandari (2019) stated the essential importance of potassium for plant growth and development. Moreover, Barel(1975), Ekelof (2007) and Jasim *et al*. (2013) emphasized the vegetative parameters of plants.

Plant foliage chemical constituents:

Data in Table (4) indicated that the chopped rice straw and foliar application of potassium and phosphorus (KP) at 4 kg/ridge significantly increased the total nitrogen, phosphorus, potassium and protein contents of sweet potato foliage (leaves+ branches), compared to the other treatment and the control. Such increments may be attributed to exist chopped rice straw in the soil ridges through improves soil structure, *i.e.* decrease soil bulk density, causes the soil to be light, increased organic matter content, enhanced water holding capacity and soil cation exchange where due to high soil nutrients (Gaihre *et al*., 2013, Saothongnoi *et al*., 2014 and Zhao *et al*., 2019). As for the effect of foliar application of nutrients, El-Fouly and El-Sayed (1997) reported that foliar feeding of nutrients enhance the root absorption of the same nutrient or other nutrients through promoting root growth and movement of nutrients from terminal leaves to depth roots.

These results are in accordance with those obtained by Ibrahim *et al*., (2011) and Farag *et al*.,(2015) on the effect of rice straw, Abou El-Nasr and Ibrahim(2011)and Thummanatsakum and Yamprach (2018) of potassium, as well as, Prummel and Sijthoff (1984), and Rosen and Bierman (2008) of phosphorus.

Tuber root yield and its component

Data presented in Table (5) showed that chopped rice straw at 4 kg/ridge and foliar application of KP(potassium and phosphorus) at $4ml l^{-1}$ recorded a maximum value of tuber root number/ plant, tuber root yield/ plant, total tuber root yield/ fed and marketable tuber root yield/ fed in both season. The increase in total tuber root yield and its components may be owing to the positive effect of these treatments on vegetative growth parameters as shown in Table (3) and

its chemical constituents Table (4), which consequently reflected on tuber yield. In this concern, the exist of rice straw provide a better environment for the formation of tuberous root and the soil to be light and easily penetrated by roots, while the insufficient aerial spaces in the soil ridges as shown in the control treatment in Table (4) due to the decrease tuber formation. Moreover, the application of chopped rice straw as soil amendment may be due to increase the organic matter where it had an improving action on the soil physical, chemical and biological properties, as well as the nutrients status in the soil that

affected on plant growth, the number and weight of tubers per plant. (Ruensuk *et al*., 2008, El-Gizawy, 2013 and Ginting, 2019).

Respecting the stimulative effect of potassium, it is an important plant nutrient for growth and physiological functions, i.e. enzyme activation, protein synthesis, enhanced photosynthetic activity and increases the translocation of photosynthates to the tuberous roots (Marschner, 2012, Wang *et al*., 2013 and Howeler, 2014). In addition, the enhancement of spraying phosphorus may be due to that phosphorus considered as essential components of various organic compounds needed for metabolic processes, i.e. photosynthesis, nitrogen fixan, nucleic acid biosynthesis, energy generation. Furthermore, it encouraged root growth and development (Marschner, 2012 and Kareem, 2013).

Such results were confirmed by those obtained by Islam *et al*., (1997) and EL- Gizawy *et al*., (2013)who studied the influences of rice straw on the yield, Marschner and Bourrie (1999), El-Sawy (2011), Jasim *et al*., (2013) and Abd-All *et el*.,(2017)who working on potassium and Allison *et al*., (2001)and Jasim *et al*., (2013) who emphasized the importance of phosphorus foliar spray on yield.

Tuber root quality

a- Physical characters

Data in Table (6) revealed that there were a significant differences between chopped rice straw and KP foliar spray treatments on the physical characters of sweet potato tubers. Chopped rice straw at 4kg/ridge and foliar spray with KP at 4 mll^{-1} gained the highest values of all studied physical of sweet potato tuber root characters, i.e. fresh weight, length and diameter.

These results are going in line with those obtained by Islam *et al*., (1997) who demonstrated the best morphological parameters of sweet potato tuberous roots by used chopped rice straw in the furrow of ridge. In this respect, Romheld and El Fouly (1999); Abou El-Nasr and Ibrahim (2011); Thummanatsakum and Yamprach (2018) and Bista and Bhandari (2019) on potassium, as well as, Rosen and Bierman (2008) and Allison *et al*., (2001)

on phosphorus who reported that foliar fertilizer either potassium or phosphorus caused an increases in tuber physical characteristics.

b- Tuber root nutritive value:

Data in Table (6) indicated that the chopped rice straw application at 4 kg/ridge and foliar spray with potassium and phosphorus recorded the maximum values nitrogen, phosphorus, potassium, protein, starch percentage and carotene content. The increment in the biochemical composition of the sweet potato tubers may be attributed to the enhanced effect of chopped rice straw at 4 kg/ridge +KP at 4mll^{-1}growth (Table 3)through providing soil aeration and nutrition, that permit for the best

formation and development of tuber roots. As for the effect of phosphorus, Vance *et al*. (2003) illustrated that phosphorus play an important role for plant growth where it can array the biochemical process in plant, i.e. photosynthesis, energy generation and nucleic acid biosynthesis. Moreover, respecting the promotion effect of potassium was mentioned by Wang *et al*.(2013) who concluded that it plays an essential role in the activation of enzymes, photosynthesis, translocation of carbohydrates, protein synthesis. Furthermore, the increase of tuber content of N, P and k may be due to the role of potassium in plant metabolism and many important regulatory processes that increase the minerals uptake by plants (Marschner, 2012).

These results are agreement with those recorded by El-Gizawy *et al*.(2013) on rice straw, Abou El-Nasr and Ibrahim (2011), Abd- All *et al*.(2017) and Thummanatsakum and Yamprach (2018)who working on potassium and Allison *et al*.(2001), Rosen and Bierman(2008) and Fernandes *et al*.(2015) who working on phosphorus.

***Conclusively,* i**t could be concluded that the obtained results, it can be recommended that the treatment of 4 kg/ridge of chopped rice straw and foliar application of potassium and phosphorus at the concentration of 4 mll^{-1} for improving the properties of clay soil and to access the vigorous plant growth, maximum production with the best tuber quality of sweet potato.

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تأثير قش الأرز المفروم والرش بالبوتاسيوم والفوسفور على نمو، محصول وجودة الجذور المتدرنة في البطاطا المزروعة في العروات الصيفية المتأخرة تحت ظروف الأراضي الطينية

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أجريت تجربتان حقليتان في مزرعة التجارب بكلية التكنولوجيا والتنمية جامعة الزقازيق (مزرعة غزالة)، محافظة الشرقية مصر خلال صيفي موسمين 2017و2018 لدراسة تأثير قش الأرز المفروم مع الرش بالبوتاسيوم والفوسفور على نمو، محصول وصفات الجودة لصنف البطاطا منوفية 6 والمزروعة في العروات الصيفية المتأخرة في ارض طينية. تم تصميم التجربة بنظام القطاعات كاملة العشوائية التي شملت على 7 معاملات هي: عبارة عن معدلات 2 و4 كيلوجرام من القش المفروم منفردة وفى توليفات مع الرش بالبوتاسيوم والفوسفور 2و4 ملى/ لتر بجانب معاملة الكنترول. اشارت النتائج الى ان المعاملة 4 كجم/مصطبة من القش المفروم مع الرش من 4 ملليلتر /لتر من البوتاسيوم والفوسفور هي المعاملة الأكثر تأثيرا على زيادة الصفات المورفولوجية للنباتات وتركيبها الكيماوي. اعطت أيضا هذه المعاملة الى الحصول اعلى القيم لمحصول الدرنات الكلى والقابل للتسويق وأفضل صفات الطبيعية للدرنات (الوزن الغض، الطول والقطر) وكذلك أعطت اعلى القيم للقيمة الغذائية متمثلة في النسبة المئوية للنتروجين، الفوسفور، البوتاسيوم، البروتين، والنشا بجانب محتوى الدرنة من الكاروتين.
التوصية: يمكن التوصية بالمعاملة 4كجم/ مصطبة من القش المفروم مع رش النباتات بالبوتاسيوم والفوسفور بتركيز 4 ملليلتر /لتر والتي تؤدى الى تحسين خواص التربة الطينية والحصول على نمو قوى للنباتات واعلى محصول مع أفضل جودة لدرنات البطاطا الحلوة.