Impact of Potassium Fertilization Rates and Bacillus circulans on the Growth, Yield and Color of processed Potato (Solanum tuberosum L.) Tubers Chips

Said A. Z. Elhakim1, Dina, S. El-Mesirry 2 and Mona, M. Yousry 3

ABSTRACT

Two field experiments were conducted during the winter seasons of 2014/2015 and 2015/2016 at El-Nobaraya Region 71km, Alex-Cairo desert road, at Chipsy Company farm in Beheira Governorate. This investigation aimed to study the effect of Bacillus circulans (potassium bio fertilizers) in combination with different rates of mineral potassium on the growth, yield and quality characters. Potassium fertilizer at levels 80 and 100 kg/fed. with application of bio- fertilizer gave the highest mean number of branches. It was also equivalent to the application of K fertilizer only at 120 kg/fed, or with application of bio-fertilizer but potassium application at 100 kg/fed, gave the best results of plant height equivalent to the application of K fertilizer only at 120 kg/fed, or with application of bio-fertilizer while. The application of K fertilizer only at 120 kg/fed, or with application of bio-fertilizer gave the highest mean value of total chlorophyll. Moreover, potassium application at level 100 kg/fed gave the highest mean value of tuber weight (ton)/fed, average tuber weight (kg) dry matter, specific gravity and accepted potato yield for processing equivalent to the application of K fertilizer only at 120 kg/fed, or with application of bio-fertilizer. The application of K fertilizer only at 60 kg/fed, or with application of bio-fertilizer gave the highest mean number of tuber. Addition of K fertilizer only at 60 kg/fed, gave the highest mean value of nitrogen concentration in leaves and roots. Application of K fertilizer only at 120 kg/fed, or with application of biofertilizer gave the highest mean value of K concentration in leaves and tuber. Potassium application at 100 kg/fed, gave the highest mean value of starch content equivalent to the application of K fertilizer only at 120 kg/fed, or with application of bio-fertilizer. Application of K fertilizer only at 60 kg/fed, gave the highest mean value of total sugar and reducing sugar. The lowest level of chips defects was also found at the level 120 kg K/fed, only or with application of bio-fertilizer. Potassium at 100 kg/fed, with application of bio-fertilizer gave the same effect in the two seasons.

Key words: potatoes; potassium fertilization; Bacillus circulans.

INTRODUCTION

One of the most important solanaceous vegetable crops grown in Egypt is potato (Solanum tuberosum L.). Its tubers are rich in carbohydrates and contain considerable amounts of proteins, vitamins and minerals. Potato is fourth most important world crop, after rice, wheat and maize (Spooner and Bamberg, 1994). It is a major source of inexpensive energy. It contains high levels of carbohydrates and significant amount of vitamin Band C and other minerals, each 100g of edible portion of the tuber contains 79.89g water, 76 calories, 2.1 protein, 0.19g lipids, 17.19g carbohydrates, 0.5g fibers, 0.9mg ashes, 7mg calcium, 53mg phosphorus, 0.6mg iron, 3mg sodium, 407mg potassium, 22mg magnesium, traces of vitamin A, 0.1mg thiamin, 0.4mg riboflavin, 1.5mg niacin, 20mg ascorbic acid (Watt and Merrill 1963). Moreover, potato is used in many industries, such as French fries, chips starch and alcohol production (Abdel-Aal, et al., 1977). Now in Egypt, a great part of potato crop directed to chips production to supply the Egyptian and foreign market throughout the year. The chipping companies complain about the discoloration of the product due to the high reducing sugars even after a considerable storage time after harvesting. Potato has a high potassium requirement that could be attributed to: poorly developed root system (Abdel salam and Shams 2012). Saurbeck and Helal (1990) declared that potassium is necessary for many plant functions such as carbohydrate metabolism enzyme activation, N uptake, protein synthesis, photosynthesis and translocation of assimilates.

Potassium is usually applied in forms of chemical fertilizers mainly sulphate chloride and nitrate. In Egypt, K is added as sulphate. Recently, addition of these fertilizers has been criticized due to a suspicion of having an adverse effect on environment (Abdel salam and Shams 2012).

Some microorganisms play important roles in the weathering processes of silicate minerals through solubilizing nutrients (Deka and Dutta 2000; Lallitha et al., 2000; Ahmed 1994 and Marschner 1997). They added microorganisms which are commonly known as potassium solubilizing bacteria (KSP) or potassium dissolving bacteria (KDP) or silicate dissolving bacteria (SDP) solubilize K-bearing minerals to free K for plants.
The present investigation was initiated to study the effect of *Bacillus Circulans* as potassium bio-fertilizers in combination with different rates of mineral potassium on the growth, yield and quality character of potato.

**MATERIALS AND METHODS**

Two field experiments were conducted at EL-Nobaraya Region of 71 km, Alex-Cairo desert road, Chipsy Company farm in Beheira Governorate, during the winter potato growing seasons of 2014/2015 and 2015/2016. Some of the chemical properties of the experimental soil were determined before planting according to the methods outlined by Jackson (1973) and are shown in Table (1).

### Source of potato seedtubers and planting

Local produced certified potato seed tubers of Karozo cultivar were tested. Planting took place in the first of October of both seasons in a wet soil, using whole seed tubers. One hundred whole locally produced seed tubers were planted in two rows, 0.90 m wide, 12.5 m long and 0.25 m apart between hills, making an area of 22.5 m² for each experimental plot. The experiments were laid out in a split plot design with three replicates.

### Field experiment

Phosphorus fertilizer was applied at the rate of 46.5 kg P₂O₅/fed. in the form of superphosphate (15.5% P₂O₅), added once in the opened row at planting time to all of the experimental plots. Nitrogen fertilizer was added at the rate of 150 kg N/fed., in four equal doses, the first one was added at soil preparation, the second, the third and the fourth doses were added at 30, 45 and 60 days after planting in the form of ammonium nitrate (33.5%). Four potassium levels were tested in this experiment 60, 80, 100 and 120 kg (as a control) K₂O/fed., which were added on three equal doses, the first one was during soil preparation and the 2nd and 3rd at 45 and 60 days after planting in the form of potassium sulphate (48% K₂O). Potato seeds were inoculated just before sowing with bio fertilizer (*Bacillus Circulans*) which is a commercial product obtained from Hanover, Germany, and it was added at the rate of 100 ml/plant (200 g powder/100 l water as recommended).

### Frying experiment

Random potato tuber samples were taken from each treatment either from cold storage or from nawalla in 15 days interval for chemical analysis. The first sample was taken at harvesting time, and then at 15, 30, 45, 60 and 75 days after harvesting from both storage facilities. Potato tuber were washed and cleaned by running water, peeled using carbarundum mechanical potato peeler model No 20 fimar Co., Italy, with size 14 lbs., grit size 1-1.5 mm for 1.5 to 2 minutes. Washed peeled potatoes were trimmed by hand using stainless steel knives, mechanically sliced into slices, 1.3 to 1.5 millimeters thickness by Lama 220 slicer model Shed Co, Italy. The resulted slices were washed to remove the released starch formed during slicing. The weight of washed slices was 300 gm. before frying. The slices were immersed in palm olein vegetable oil at 185°C until fried, using pilot fryer, 8 liter capacity, model Bartlett D11E30, Italy. When the oil in the fryer heated to 185 °C, power to the fryer was immediately switched off then the basket containing potato slices was immersed in the oil. The basket was moved out rigorously after 3 minutes from frying in the oil to prevent the sticking of slices together. The weight of fried sample was recorded to calculate the chips yield. Samples of chips were inspected for defects according to the standards of Frito Lay Company (1999).

### The Recorded data, Foliage measurements

Number of main stems/hill was determined using the average number of main stems per hill after planting. Plant height (cm) was determined using the average height of the main stem of 10 plants at 75 days after planting. Total leaf chlorophyll content (mg/100g FW) was determined in the fourth top leaves at 75 days after planting according to (Moran and Porath, 1980) method.

### Yield and its component

Total tuber yield: The tuber yield of each plot was weighed in kilogram and then converted into tons/fed. The suitable tubers for processing per plot were selected, weighted and converted into tons/fed. The number of tubers/10 kg was determined by taking a random sample of 10 kg of tubers from the yield of each treatment and then counted. The accepted category is that count 72 – 112 tubers in such treatment (Frito Lay Company 1999). Average tuber weight was determined by dividing the tubers yield/plant by tuber’s number as an average of 10 plants, at harvesting time.

### Table 1. The main chemical analysis of the experimental soil

<table>
<thead>
<tr>
<th>PH</th>
<th>EC (ds/m)</th>
<th>Soluble cations (meq/l)</th>
<th>Soluble anions (meq/l)</th>
<th>Available nutrients (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Na⁺⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻‥</td>
<td></td>
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</tbody>
</table>
Dry matter (%) was determined by drying the tuber sample slices at 70 °C for 24 hrs until a constant weight by dividing the dry weight/the fresh x100 (Haase, 2003). Specific gravity was determined using the method described by Dinesh et al., (2005)

Chemical composition of potato

75 days after planting the forth top leaves of 10 random plants per plot were carefully detached, packed in paper bags. The collected samples were washed with tap water, distilled water, oven dried at 65 °C for 72 hrs, then grounded in a mill and stored for the elemental analysis. Powder of leaf material was wet digested with H2SO4 -H2O2 digest (Lowther, 1980) for the following determinations. Leaf total N content was determined colorimetrically, 75 days after planting using the Nessler’s method (Chapman and Pratt, 1978). Leaf total K content was determined photometrically, 75 days after planting using the flame photometer method (Jackson, 1973). Tuber total N content was determined using standard methods described by Ryan et al., (2001). Tuber total K content was determined using standard methods described by Ryan et al., (2001).

Quality character

Starch content (%) was determined using the method described in A.O.A.C (1980) on dry matter basis. Total sugars contents (%) was determined using method outlined by Dubbois, et al., (1956) fresh weight bases. Reducing sugars content (%) was determined using Dubbois et al., (1956) method on fresh weight basis. Chips defect evaluation was calculated by showing the size limits (1/2 cm) for sugar browning and defects using chip–check chart method to determine the size limits (1/2 cm) for sugar browning and defects. The collected data were tabulated and statistically analyzed using the analyses of variance method as reported by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Potato Vegetative Characters

Table (2) showed that vegetative growth characters of potato number of branches/plant, plant height and total chlorophyll content were improved significantly as K fertilizer rate increased in both seasons. These results indicated that application of K at level 120 kg/fed, with bio-fertilizer gave the highest mean values of number of branches at first season but addition of bio-fertilizer with K mineral fertilizer at 80 or 100 kg K/feddan was equivalent to the application of K fertilizer only at 120 kg/fed, or with application of bio fertilizer at second season. Application of potassium at 100 kg/fed, in combination with bio-fertilizer gave the same effect of the application of K fertilizer at 120 kg/fed. only or with application of bio fertilizer at first season. Also, K level at 120 kg/fed. Addition of bio-fertilizer gave the highest mean value of plant height at second season. The highest mean value of chlorophyll content was recorded at 120 kgK/fed. only or with application of bio-fertilizer at first season, but the highest value was recorded at 120 kgK/fed. with application of bio-fertilizer second season. These results are in agreement with those found by Ahmed et al., (2009) who reported that application of potassium improved plant growth characters compared with untreated plants. AbdEl-Mouty et al., (2001) reported that Bio-fertilizers application affected plant growth of potatoes. Moreover Fawzy et al., (2012) reported that bio-fertilizer has beneficial return to increase population of soil microorganisms especially in the surface layer of root rhizosphere that create substances which stimulate plant growth.

Potato yield, its component characters and accepted potato yield for processing %

Table (3) cleared that application of potassium fertilizer only at 120 kg/fed, or with bio-fertilizer gave the highest mean value of tuber weight and average of tuber weight, and also, gave the same effect of K.
Table 2. The effect of biofertilizer and potassium fertilization treatments on potato vegetative characters.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>K level (mg/kg dry weight)</th>
<th>K level (mg/kg dry weight)</th>
<th>K level (mg/kg dry weight)</th>
<th>Character</th>
<th>Plan High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-fertilizer</td>
<td>0.92</td>
<td>0.93</td>
<td>0.94</td>
<td>0.95</td>
<td>0.96</td>
</tr>
<tr>
<td>Bio-fertilizer</td>
<td>0.98</td>
<td>0.99</td>
<td>1.00</td>
<td>1.01</td>
<td>1.02</td>
</tr>
</tbody>
</table>

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Table 3. Effect of bio-fertilizer and potassium fertilizer treatments on potato yield, its component characters and accepted potato yield for processing %

<table>
<thead>
<tr>
<th>Character Treatment</th>
<th>Total yield (ton/fed) K level (kgK₂O/fed.)</th>
<th>No. of tuber/10kg K level (kgK₂O/fed.)</th>
<th>Average of tuber weight (kg) K level (K₂O/fed./kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Bio- fertilizer</td>
<td>9.33c</td>
<td>10.25c</td>
<td>11.83a</td>
</tr>
<tr>
<td>Without</td>
<td>9.0f</td>
<td>9.76d</td>
<td>10.96b</td>
</tr>
<tr>
<td>Bio- fertilizer</td>
<td>9.06c</td>
<td>10.3b</td>
<td>11.3a</td>
</tr>
<tr>
<td>Without</td>
<td>8.73f</td>
<td>9.4d</td>
<td>9.9c</td>
</tr>
<tr>
<td>Character Treatment</td>
<td>Dry matter (%) potato accepted yield for processing (%)</td>
<td>Specific gravity</td>
<td></td>
</tr>
<tr>
<td>Bio- fertilizer</td>
<td>18.16c</td>
<td>20.33b</td>
<td>22.33a</td>
</tr>
<tr>
<td>Without</td>
<td>17.33c</td>
<td>19.0c</td>
<td>20.5b</td>
</tr>
<tr>
<td>Bio- fertilizer</td>
<td>16.16c</td>
<td>20b</td>
<td>23.6a</td>
</tr>
<tr>
<td>Without</td>
<td>15.16c</td>
<td>17.16c</td>
<td>19.5b</td>
</tr>
</tbody>
</table>
fertilizer at 100 kg/fed. with application of biofertilizer at two seasons. Application of K fertilizer at 60 kg/fed. only or with biofertilizer produced highest number of tuber/10 kg. The highest value of dry matter at level 120 kg K/fed. only or with application of bio-fertilizer. The same effect of the application of K fertilizer at 100 kg K/fed. with application of bio-fertilizer at the two seasons. The highest mean value of specific gravity at level 120 kg K/fed. with application of biofertilizer was recorded at first season but at second season 100 and 80 kg K/fed with application of biofertilizer gave the same effect of the application of K at 120 kg K/fed, only or with application of bio-fertilizer. These results agree with those found by Arafa et al. (2012) who indicated that tuber yield measured as tubers yield (kg) per plant and total yield (kg) per plant and total yield (ton/fed.) were significantly increased with increasing potassium fertilizer rate. Bio-fertilization exerted positive effects in this respect. An addition of effective microorganisms in both seasons significantly increased tuber yield per plant and tuber yield per fed. An increase in potato yield as indicated in the present investigation due to applying potassium was reported by Radwan et al. (2011) who indicated that potassium fertilization in potato resulted in significant increase in tuber yield. The role of potassium in increasing the yield and its components might be attributed to its function in plants which includes energy metabolism and enzyme activation on exchange rate and nitrogen activity as well as enhanced carbohydrates application enhanced the stomatal resistance coupled with reduced transpiration rate and increased relative water content, thus, may improve water storage capacity of the cells and providing favorable conditions for better yields (Umar and Bansal 1995). Concerning the effect of effective microorganisms, Lin (1991) indicated that soils treated with microorganisms become more friable, less compact and better drained. This provides a more favorable environment for crop, growth and tuber production. The enhancing effect of microorganisms on yield and its component may be attributed to one or more of the following factors: improving root growth and functions and enhancing mineral uptake in the plant (Stancheva et al., 1995), production the phytohormones indole- 3-acetic acid, gibberellins and cytokinin, also reduced of abscic acid. These phytohormones, particularly IAA, play an essential role in plant growth stimulation (Kawther et al., 2002) and producing amino acids as well as phenolic compounds (El-Morsi et al., 2000). The increase of tuber numbers and tuber dry weight (g) per plant may be due to microorganisms application stimulated plant roots, absorption of nutrients and photosynthesis process which led to produce vigorous plants, numerous tubers, bigger tuber size and total tuber yield (Hammad and Abdel-Ati 1998).

While, the percentage of accepted tubers from processing increased gradually and significantly as potassium level was increased in both seasons. Adding K at the rate of 120 kg K/fed. only or with application of bio-fertilizer gave the highest accepted percentage of tubers for processing. Also, 100 kg K/fed. with application of bio-fertilizer gave equal effect. These results may be accepted on the basis that K resulted in a sturdy plant and in turn, sturdy tubers, which can tolerate miss handling bouses and cracks during harvesting. In addition, it increased the tuber content of soled and specially starch and handling the crop in the field. It was recorded by Khan et al. (2010) that K enhanced potato tuber yield and also improved the quality of the produced potato compared with the low potassium rate, the higher K rate increased the yield of medium (82-60mm) and oversized (<60mm) tubers by approximately 15 and 40%, respectively and both categories of tuber sizeses are accepted for processing (Tawfik, 2001). Similarly Mc Dole (1978) and Satyanarayana and Arora (1985) reported that insufficient K results in reduced yield and smaller tubers which are rejected from processing.

**Chemical Composition of Potato Showed**

Table (4) that Potassium fertilizer levels only or with biofertilizer had highest significant effect for leaves and tuber elements. Potassium level at 60 kg/fed. only gave the highest mean value of N concentrations in leaves and roots at two seasons. On the other hand, potassium only at 120 kg/fed. or with application of bio-fertilizer gave the highest mean value of K concentration in leaves in both seasons. Addition of potassium at 100 kg/fed. with application of bio-fertilizer gave the same effect and highest mean value of K concentration in leaves at first season, while potassium level at 120 kg K/fed. with application of bio-fertilizer gave the highest mean value of potassium concentration in tuber at first season but at second season potassium fertilizer only at 120 kg K/fed. only or with application of bio-fertilizer gave the highest mean value of K concentration in tuber. Arafa et al., (2012) reported that inoculation potato plants with effective microorganisms significantly increased the percentage of nitrogen and insignificantly increased potassium percentage in potato tuber as compared with untreated plants. Afify and Bayoumy (2001) reported that the increase in tubers potassium content might be possibly due to the role of microorganisms in supplying great amounts of both water-soluble and amorphous potassium which was reflected in plant up take.
<table>
<thead>
<tr>
<th>Table 4</th>
<th>Effect of Bio Fertilizer and Potassium Fertilizer treatments on Elemental Composition of Potato</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K (mg/kg)</td>
</tr>
<tr>
<td>Control</td>
<td>180.2</td>
</tr>
<tr>
<td>K (200mg/kg)</td>
<td>192.3</td>
</tr>
<tr>
<td>K (400mg/kg)</td>
<td>198.4</td>
</tr>
<tr>
<td>Potassium Fertilizer</td>
<td>188.5</td>
</tr>
<tr>
<td>Potassium Fertilizer + Bio Fertilizer</td>
<td>194.6</td>
</tr>
</tbody>
</table>
Table 5: Effect of bio-fertilizers and potassium fertilizers treatments on root quality character and chip defect of polalo

<table>
<thead>
<tr>
<th>Treatment</th>
<th>K (KCl) + K2O (kg/ha)</th>
<th>Root (cm)</th>
<th>Root Hair</th>
<th>Root Chip Defect (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% K</td>
<td>0</td>
<td>120</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>100% K2O</td>
<td>0</td>
<td>100</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>50% K + 50% K2O</td>
<td>0</td>
<td>120</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>50% K + 50% K2O</td>
<td>0</td>
<td>100</td>
<td>80</td>
<td>0</td>
</tr>
</tbody>
</table>

Table continues...
On the other hand, Ahmed et al., (2009) reported that there was no significant interaction between K- addition and biofertilization on N and K uptake by shoots. The highest K content in tubers was recorded with the highest level of potassium sulphat.

Tuber quality character and chip defect of potato

Table (5) showed that Potassium fertilizer only or with application of bio fertilizer had highly significant effects on most studied characters with only exception reducing sugar content in the two seasons. The highest mean value of starch content in tuber was recorded at 120 kg kg/fed. only or with application of bio-fertilizer. Potassium rate at 100 kg/fed., with application of bio-fertilizer gave the equal effect in two seasons. Potassium fertilizer only at 60 kg K/fed., gave the highest mean value of total sugar content in tuber at two seasons, while, potassium fertilizer only at 60 kg/fed., or with bio-fertilizer application gave the highest mean value of reducing sugar content in two seasons.

These results are in agreement with found by Bansal and Trehan (2011) who reported that K application decreased total sugar. Arafa et al., (2012) noted that increase potassium fertilizer rate from 40 to 80 kg K/fed., decrease sugar content in potato tuber. They also, added that inoculation of potato plants with effective microorganisms increase soluble sugars in potato tuber. Rai et al., (2010) indicated that potassium influence reducing sugar content. Mohamed (2007) reported that application of microorganism decreased total carbohydrates content. Abdel Salam and Shams (2012) noted that biofertilization increased starch content. Ahmed et al., (2009) found that starch content in tuber potato showed positive responses to increasing mineral K levels. Bansal and Trehan (2011) found that K fertilizer application decreased total and reducing sugar. On contrary, Rajanna et al., (1987) found that potassium fertilizer increased total and reducing sugar. Rajanne et al., (1987), Sahota et al., (1988), AL- Moshileh (2005) and Bansal and Trehan (2011) reported that K application increased tuber starch content. On the contrary Terman (1950) pointed that there was a consistent decrease in the starch content of potato tuber with increase in the rate of K2O application.

Accumulation of soluble sugars and decrease of starch in potato tubers are the cause of dark colored potato chips which occur under low potassium nutrition level (Perrenoud 1993). Moreover, K application decreased reducing sugars and improve lighten chip color. Anon (2005) and Bansal and Trehan (2011) found that K fertilizer application decreased reducing sugar and improve chips color during procession. In potatoes, reducing sugars are involved in the non-enzymatic browning reaction, known as the Maillard reaction (Ellis, 1959), and thus the amount of reducing sugars (glucose and fructose) determines the processing potential of potatoes in terms of frying colour (Brown et al., 1990; Burton, 1989).

Crisps prepare from potatoes having a higher amount of reducing sugars turn brown and become unacceptable to consumers (Ezekiel et al., 2003). Because of the Maillard reaction occurs between reducing sugars and amino acids during heating, fried potato products acquire a dark color and a bitter taste and become un acceptable to consumers (Burton, 1989).

Kumar et al., (2007) noted that reducing sugars and crisps color are positively correlated.

Over while, increasing K level reduced tuber chips defects in both seasons. The lowest level of chips defects was also found at the level 120 kgK/fed. only or with application of bio-fertilizer. Potassium at 100 kg/fed. with application of bio fertilizer gave the same effect in two seasons.

Kunkle and Holstad (1972) found statistical effect for K level on chip color. Anon., (2005) also, indicated that K application improved chip color score. Bansal and Trehan (2011) reported that K fertilizer improves quality parameters of tuber processing. Crisp quality is a collection of many characters and color is one of the most important. In general, yellowish brown (Burton et al., 1992), uniform light golden (Stevenson et al., 1964), and lighter colored crisps are preferred. Crisps colors between grade 1 (white cream) and grade 3 (dark tan) are commercially acceptable (Amoros et al., 2000). Dark brown crisps may have an undesirable flavor and generally are unattractive to the consumers (Stevenson et al., 1964). Arafa et al., (2012) indicated that the inoculation of potato plants with effective microorganisms improved the potato quality and all tuber quality characteristics. The specific gravity is a measure of quality in potato tuber which is related to the dry matter contents in the tubers. The specific gravity was more in potato tubers harvested from potassium treated plants (Malik 1995). Potatoes with high specific gravity are preferred for preparation of chips and French fries. Mohamed (2007) reported that application of microorganisms increased significantly TSS% but decreased total carbohydrates content.

REFERENCES


Dinesh, K., R. Ezekiel, B. Singh and I. Ahmed. 2005. Conversion Table for specific gravity dry matter and starch content from under water weight of potatoes grown in North India plains. Potato J., 32 (1-2) 79-84.


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I. INTRODUCTION

The impact of potassium fertilization rates and Bacillus circulans on the growth of some promising tomato cultivars was studied. The study was conducted during the period of Mar-Apr 2012 and May-Jun 2012. The treatments included six potassium rates (0, 100, 200, 300, 400, and 600 kg ha⁻¹) and Bacillus circulans treatments at 0, 1, 2, and 4 mL ha⁻¹ applied at the time of transplanting. The results showed that the highest yields and economic returns were observed with the combination of the highest potassium rate and Bacillus circulans treatment. The study concluded that potassium fertilization and Bacillus circulans treatment are effective in improving the yield and economic returns of tomato.