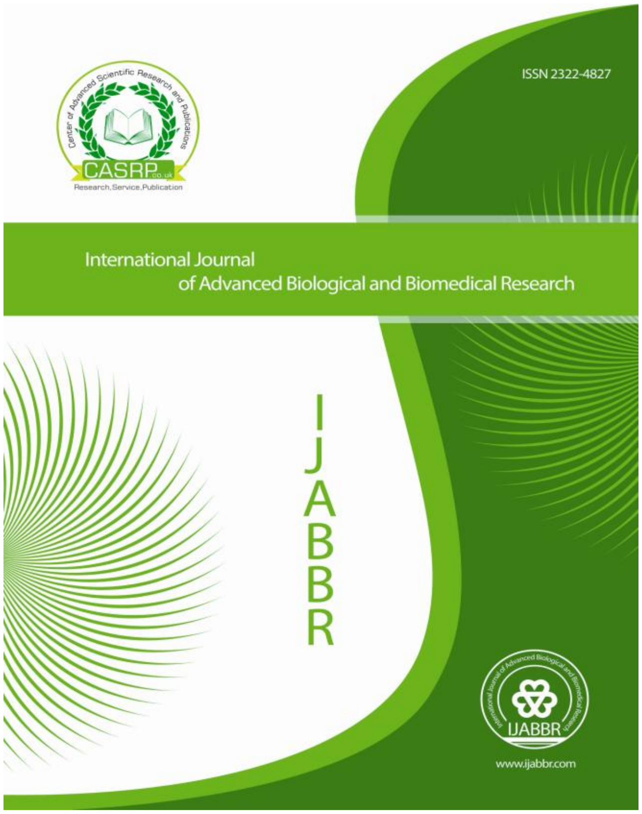
ISSN 2322-4827
CASRP co.uk
Research, Service, Publication
International Journal
of Advanced Biological and Biomedical Research
IJABBR
IJABBR
www.ijabbr.com

Available online at www.casrp.co.uk/journals

CASRP PUBLISHER

International journal of Advanced Biological and Biomedical Research 4(2) (2016) 170–178

doi: 10.18869/IJABBR.2016.170

Original Article **Open Access**

Influence of KSB, PSB and NFB on fruit quality and potassium contents in tomato

Peyman Sheikhalipour[1],*, Saheb Ali Bolandndnazar[2], Jaber Panahandeh[2]

[1]*M.Sc. Student of Horticultural Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.*
[2]*Department of Horticultural Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.*

Abstract

To evaluate the inoculation effect of potassium releasing, phosphate solubilizing and nitrogen fixing bacteria on the fruit quality of tomato, an experiment based on randomized complete block design with 9 treatments and 3 replications has been conducted. In this experiment, tomato (super chief cv.) seedlings of the in the treasury cultivation with single and combined treatments of the potassium releasing bacteria (KSB: *Pseudomonas* sp. S19-1, *Pseudomonas* sp. S14-3), phosphate solubilizing (PSB: *P. putida* Tabriz, *P. fluorescens* Tabriz) and nitrogen fixing (NFB: *Azospirillum* sp. Acu9, *Azotobacter* sp.), in the nursery cultivation. In addition, a control treatment without inoculation of bacteria (negative control) and a complete fertilized treatment based on the soil test analysis (positive control) were included to compare the results. The results showed that inoculation with bacteria had significant effect on average fruit weight, fruit length, number of total fruits, the percentage of marketable fruit, and the percentage of BER incidence and Potassium content of fruit. The highest number of total fruits was obtained in the PSB treatment. The highest average fruit weight, Potassium content of fruit, the percentage of marketable fruit, fruit length were observed in KSB treatment with values of 54/11g, 4.7 mg/g, 56.71 percent and 51 cm respectively. The lowest percentage of BER incidence was observed in KSB with values of 6.24 percent.

Keywords: Fruit quality, Pseudomonas, Azotobacter, Azosprillum, Tomato.

***Corresponding author:** M.Sc. Student of Horticultural Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.

Received 19 March 2016 | Accepted 18 April 2016 | Available online 25 April 2016
iThenticate screening 22 March 2016 | English editing 15 April 2016 | Quality control 21 April 2016

1. Introduction

By population growth in the planet, the need for food, particularly agricultural products increases. Increasing agricultural productions to meet human food needs is possible through increasing area under cultivation and production per unit area. In order to increase agricultural productivity per unit area, most producers have been using chemical fertilizers, but a long-term use of chemical fertilizers destroys the physicochemical properties of soil and expansion of plant roots exposes trouble by reducing the permeability of the soil, and ultimately reduces yield which decreases the quality of agricultural productions and causes environmental problems and groundwater pollution as well (Wu et al., 2004). In recent years, the World Food and Agriculture Organization has proposed the synthetic use of organic and chemical fertilizers for developing countries (Griffe et al., 2003). According to research, a combination of chemical fertilizers with organic and biological resources has an increasing effect on yield of agricultural productions which will be a step toward sustainable agriculture (Karla, 2003).

Bio-fertilizer refers to fertilizer materials which contain enough number of one or more species of beneficial soil organisms that are provided through suitable preservers. These fertilizers are microorganisms that can alter nutrients from unusable to usable forms, and this conversion is done through a biological process. Hegde et al (1999) studied the effect of phosphorus bio-fertilizer on maize and observed that the use of the bio-fertilizer increased the biological yield of maize which was related to a better uptake of nutrients and hence a better plant growth. Kumar and Singh (2001) showed that pea inoculation with *Pseudomonas* increased biological yield and plant height. In different surveys researchers have reported the use of plant growth promoting bacteria increased plant growth by increasing the absorption of nitrogen and phosphorus (Cakmaci et al., 2005; Cavaglieri et al., 2004; Han et al., 2004) in addition to reducing the consumption of chemical fertilizers and increasing the efficiency of them (Pan et al., 1999). According to Zodape (2001) increase of productions due to the use of bio-fertilizers yields is because of providing micronutrients and growth regulators owing to such fertilizers.

2. Materials and methods

The experiment was conducted in Khalatpoushan Research Station Agriculture College of Tabriz University in 2014. Table 1 shows the results of soil analysis. A field experiment was implemented in a randomized completely block design with 9 treatments and 3 replications. The treatments were as follow:

1- KSB: Pseudomonas sp. S19-1, Pseudomonas sp. S14-3 (to supply the potassium) (K)
2- PSB: Pseudomonas putida Tabriz, P. fluorescence Tabriz (to supply the phosphorus) (P)
3- NFB: Azospirillum sp. Acu9, Azotobacter sp. (to supply nitrogen) (N)
4- KSB + PSB
5- KSB + NFB
6- PSB + NFB
7- KSB + PSB + NFB
8- A control treatment without the inoculation of bacteria and use of any chemical fertilizers, (negative control) (B)
9- A completer fertilized treatment (by meeting the required K, P, N demand through providing the fertilizer according to the soil test), (positive control) (A)

Prepared tomato seedlings have been cultivated in furrows with a length of 2 meters and a width of 70 cm. In each farrow 6 plants were planted and the distance between plants on the farrow was 30 centimeters. Tomato (super chief cv.) seeds were planted in a sandy leam soil after disinfecting with 0.01 sodium hypochlorite for ten minutes, in late March and in planting trays. When planting, seeds were inseminated by a bacterial inoculum, for each cultivating tray 10 grams of CFU/g 2.4×10^8 bacterial inoculum was used. Bacteria were prepared from the Department of Soil Science University of Tabriz. Tomato seedlings were transferred to field once they had reached to the required size and in the favorable weather and soil conditions in 2014. Tomatoes were irrigated once a week, and irrigation was done completely accurate by using tape irrigation. According to the soil analysis test and recommended fertilizers based on the table of fertilizers, the required fertilizer need was 72 kg urea per 1 hectare which was consumed in three time intervals. Potassium and phosphate were not used because there was sufficient amount of these nutrients in the soil. The manual soiling of the plants have been done after a month of planting on the farm. The first harvest was conducted in early July and after the first harvesting; other fruits were gradually harvested at 1 week intervals. Harvesting continued until late September.

Measuring potassium was conducted by flame photometer (Waling et al., 1989), respectively. The Statistical analysis of data was performed by MSTATC software. The mean comparison was carried out using of multiple range test of Duncan test for the one and five percent probability levels. In order to draw figures, Excel Microsoft Office 2010 has been employed.

Table 1
Physical and chemical characteristics of the soil.

Saturation (%)	EC ($dS.m^{-1}$)	pH	Organic carbon (%)	Nitrogen ($mg.kg^{-1}$)	Phosphorus ($mg.kg^{-1}$)	Potassium ($mg.kg^{-1}$)	Sand (%)	Silt (%)	Clay (%)
37	2.25	8.5	1.5	0.15	46	570	69	13	18

3. Results

3.1. The number of total fruits

The number of total fruits were significantly ($p<0.01$) affected by treatments. The highest amount of the number of total fruits was observed in the PSB bacterial treatment. The lowest amount of the number of total fruits was belong of the NFB+PSB treatment which showed no significant different from the negative control treatment (Figure 1). PSB treatment increased the number of total fruits 27.85 and 43.85 percent compared to the positive control and negative control treatments, respectively.

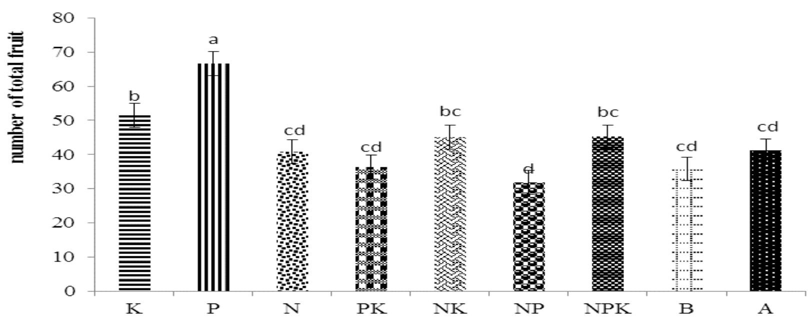

Fig. 1. Comparison of the average effect of treatments with bio-fertilizers on the number of total fruits of tomato (multi-amplitude Duncan test $p<0.01$).

(K: Pseudomonas sp. S19-1, Pseudomonas sp. S14-3, P: Pseudomonas putida Tabriz, P. fluorescence Tabriz, N: Azospirillum sp. Acu9, Azotobacter sp., B: control treatment without microbial insemination and use of any fertilizer (negative control), A: complete fertilized treatment (by providing required K, P, N through fertilizers based on the soil test) (positive control)

3.2. Percentage marketable fruit

The marketable fruit implies the total large and medium fruits. The Percentage of marketable and non-marketable Fruit is depicted in (Figure 2). Perusal of data showed that Percentage of marketable Fruit was significantly ($p<0.01$) affected by treatments. The highest percent of marketable fruit was observed in the KSB bacterial treatment. The lowest amount of marketable fruit was belonging of the negative control treatment (Figure 2). KSB treatment increased marketable fruit 41.68 and 59.06 percent compared to the positive control and negative control treatments, respectively.

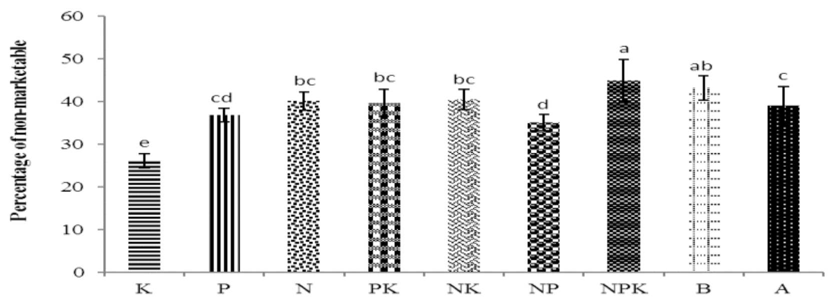

Fig. 2. Comparison of the average effect of treatments with bio-fertilizers on Percentage of marketable of tomato (multi-amplitude Duncan test p<0.01).

3.3. Percentage non-marketable Fruit

The non-marketable fruits are the total small and BER incidence fruits. The Percentage of non-marketable Fruit is depicted in (Figure 3). Perusal of data showed that Percentage of non-marketable Fruit was significantly ($p<0.01$) affected by treatments. The lowest percent of non-marketable fruit is of the KSB bacterial treatment. The highest percent of non-marketable fruit is of KSB+NFB+PSB treatment with no significant different from the negative control treatment (Figure 3).

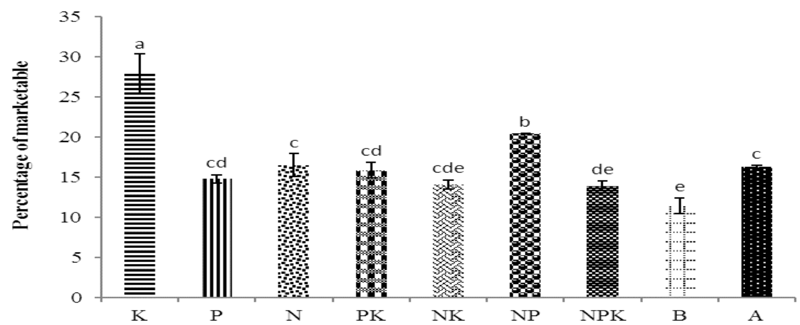

Fig. 3. Comparison of the average effect of treatments with bio-fertilizers on non-Percentage of marketable of tomato (multi-amplitude Duncan test p<0.01).

3.4. Length fruit

Data in Table (2) show the length fruit of tomato. Inoculation with KSB significantly increased length of fruit than other treatments ($p<0.01$). The lowest amount of fruit length is of the PSB+KSB treatment (Table 2). KSB treatment increased fruit length 7.58 and 14.05 percent compared to the positive control and negative control treatments, respectively.

3.5. Diameter fruit

The influence of diameter of fruit with treatment was no significant; however the highest amount of fruit diameter was of the KSB bacterial treatments. The lowest amount of fruit length is of the PSB+KSB treatment (Table 2).

3.6. Percentage of BER incidence

Analysis of variance showed that the effect of treatments on the percent of BER incidence was significant ($p<0.01$). The highest amount of BER incidence was observed in the KSB+NFB+PSB bacterial treatments. The lowest amount of BER incidence was of the KSB treatment (table 2).

3.7. Average fruit weight

Data illustrated in Table 2 show that application of potassium releasing microorganisms significantly increased average fruit weight compared with the other treatments. The highest amount of average fruit weight was of the KSB bacterial treatment. The lowest amount of average fruit weight fruit was of the KSB+NFB+PSB treatment (Table 2).

3.8. Potassium concentration of fruit

Analysis of variance showed that the effect of treatments on the amount of Potassium concentration of fruit was significant (p<0.01). The highest amount of Potassium concentration of fruit was observed in the KSB bacterial treatments. Negative control treatment had the lowest Potassium concentration of fruit (Figure 5). KSB treatment increased Potassium concentration of fruit of 17.87 and 29.14 percent compared to the positive control and negative control treatments, respectively.

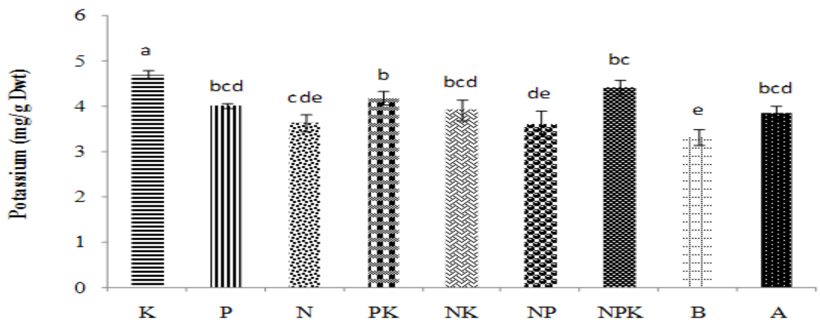

Fig. 5. Comparison of mean effect of treatments with bio-fertilizers on Potassium concentration of fruit in tomato (Duncan's multiple range test p<0.01).

4. Discussion

4.1. The number of total fruits

Oskooei et al. (2005) reported that Phosphorus effects positively on increasing the number of fruits per plants of tomato.

4.2. Percentage of marketable and non-marketable fruit

The highest fruit potassium was observed in the KSB treatment. Providing enough potassium to develop large and high quality fruits is necessary (Chapagain, and Wiesman, 2004). These results are in accordance with the results obtained by Bryson and Barker (2002). Also they showed that by increasing the amount of potassium, the quality of tomato fruit increases and the number of non-saleable fruits decreases. Achieving these results may be due to the role of potassium in fruit quality, because potassium is known as food quality element owing to an important effect on fruit quality parameters (Imas and Bansal, 2006). (Fawzy et al., 2005) for pepper plants, (Fawzy et al., 2007) for eggplant and (Al-Karaki, 2000) and (Gupta and Sengar, 2000) for tomato reported results similar to the results of this study. They reported that by increasing the use of potassium fertilizer, plant yield and fruit quality increases. In this study, the KSB treatment had the highest yield and fruit quality through increasing available potassium for plants. Fruit quality is directly affected by the feeding of potassium (Zhao et al., 2001; Lester et al., 2005). Increasing fruit quality due to feeding of potassium may be due to increase of asimalite material formation in photosynthesis, transferring these materials from leaves to fruits and increasing enzyme activities. Bernard et al. (2006) reported that by increasing the use of potassium in tomato, the fruitage ratio increases. They suggested that increased K uptake by plant roots probably accelerate the metabolism in younger tissues, resulting in an increase of fruitage ratio in the plant.

4.3. The length and diameter of fruit

It is reported that yield and quality of eggplant (diameter, fruit length and average fruit weight) may enhance by increasing the amount of soil application of potassium fertilizers in plants (Fawzy et al., 2007). Increased yield and fruit quality parameters such as the length and diameter of fruit, vitamin C and sugar content have been reported in sweet pepper plants through sprayed potassium (El-Bassiony et al., 2010). Development and enlargement of the cell during plant growth is affected by the amount of potassium in the plant. In this case, even a very close relationship exists between potassium and growth effecting hormones (Marschner, 1995; Taiz and Zeiger, 2002). Several studies show that soil application and foliar leaf of potassium increased vegetative growth, yield, fruit quality and chemical compositions of various products including vegetables such as peppers (Nassar et al., 2001; Fawzy et al., 2005), tomatoes (Al-Karaki, 2000; Gupta and Sengar, 2000), eggplant (Fawzy et al., 2007) and melon (Lester et al., 2006). This is mainly due to potassium's role in the physiology of plant growth and development, especially increasing the efficiency of photosynthesis and the synthesis and transport of hydrocarbons in plants (Tisdale et al., 1985).

4.4. Percentage of BER incidence

Potassium is one of the most important elements for tomato. Potassium affects positively the sugar, vitamin E, carotene and lycopene of fruit, but when too much potassium is absorbed by the plant, it impacts negatively on the absorption of magnesium, calcium and Bor (Gent, 2004; Caretto et al., 2008; Ramirez et al., 2012). For a long time BER incidence was interpreted due to low calcium levels in the root zone, but in recent years by studying anatomical, genetic and environmental factors, it was found that the main cause of BER incidence is a lack of coordination between transmission of assimilates by flumes and transmission of calcium by xylems in fast cell enlargement procedure in the tissues near the ends of the fruit. Barker and Ready (1994), Franco et al (1999), Murray et al. (1972), Saure (2001) and Spurr (1959) emphasized that no significant differences exist between the tissue calcium of a BER incidence and of a healthy fruit. This illustrates the fact that finding a certain relationship between the amount of calcium in the fruit and BER incidence of the fruit is difficult. As we know vascular bundles reduce from stem to the end of fruit. During two weeks after pollination, fruit grows quickly, but ratio of vascular bundles reduces. In such cases, when the calcium entrance in tomato fruit is limited by external factors such as relative humidity, enough calcium is not provided.

4.5. Average fruit weight

Kloepper et al. (2004) suggested that the use of *Pseudomonas sp.* can even increase the yield of crops up to 144 percent. Igual et al. (2002), based on an experiment, reported that using the phosphorus solubilizing bacteria increased the solubility of insoluble phosphate and a significant increase in grain yields of barley and peas. Veresoglou and Menexes (2010) during their investigation showed that for wheat treatments inoculation with *Azospirillum* bacteria the grain yield increased as much as 9.8 percent. PGPR also affected plant growth by increasing synthesis of growth promoting compounds. Patidar (2001) and Egamberberdiyeva and Hoflich (2003) interpreted the seed yield mainly due to producing growth promoting materials by *Pseudomonas* bacteria in wheat and sorghum. Plant growth promoting bacteria such as *Azotobacter* improves the growth through nitrogen fixing and producing growth promoting materials (Brown, 1974).

Researchers have stated that using bacterial inoculation of *Pseudomonas* and *Bacillus* species can promote the growth and increase yield of tomato and pepper (Kotan et al., 1999; Sahin et al., 2000), sugar been (Cakmakci et al., 2006), spring barley (Salantur et al., 2005), apricots (Esitken et al., 2003), blackberry (Orhan et al., 2006) and apple (Aslantaş et al., 2007). Previous studies by scientists indicate that potassium provides an essential role in fruit weight, fruit color, dry matter and the ultimate yield of tomato (Anac et al., 1994). Hariprakasha and Subramanian (1991) observed that the yield increases by increasing the potassium levels in tomatoes. Padem and Ocal (1999) reported that an increase in potassium levels led to significantly increased fruit weight. Potassium plays a major role in the transfer of made materials in photosynthesis procedure and growth of healthy fruits by increasing fruit weight.

4.6. Potassium concentration

Han et al. (2006) reported that inoculation soil with potassium releaser bacteria, the nutrient significantly increases in pepper and zucchini. Increasing the concentration of potassium in the shoots and roots due to inoculation with potassium releaser bacteria has been reported by different researchers (Badr, 2006). The researchers reported that the bacteria are able to produce indole acetic acid (IAA) and siderophore which the produced siderophore can complex with the elements in the mineralogy level and effect the liberation elements such as phosphorous, potassium and iron (Heinrich et al., 2004). So potassic mineral weathering and the release of potassium due to this mechanism or other mechanisms can be effective in increasing the available potassium in the soil, as well produced as IAA by these bacteria can act as an organic compound stimulating plant growth. Many researchers reported that root dry weight, shoot and absorbed K by plants significantly increased owing to the inoculation with potassium releaser bacteria compared to without bacteria control treatment (Chakraborty et al., 2006).

Table 2
Effects of inoculation with PGPR on tomato fruit size, average fruit weight and BER incidence.

Treatment	Diameter of fruit (cm)	Length of fruit (cm)	Average fruit weight (g)	BER incidence (%)
K	46/33	51a	54/11a	6/24e
P	38/85	42/85bc	31/40cd	14/76d
N	44/07	44/79bc	42/33abc	23/19b
KP	38/94	41/23c	42/71abc	20/05bc
NK	39/13	45/66abc	32/72bcd	16/60cd
PN	42/68	48/12ab	45/27ab	19/95bc
NPK	38/39	41/46c	28/32d	27/35a
B	41/39	43/83bc	41/01abcd	16/74cd
A	45/16	47/14abc	43/68abc	19/22bc

K: Pseudomonas sp. S19-1, Pseudomonas sp. S14-3, P: Pseudomonas putida Tabriz, P. fluorescence Tabriz, N: Azospirillum sp. Acu9, Azotobacter sp., B: control treatment without microbial insemination and use of any fertilizer (negative control), A: complete fertilized treatment (by providing required K, P, N through fertilizers based on the soil test) (positive control).

5. Conclusion

It is concluded that the usage of PGPR can increase average fruit weight, fruit length, number of total fruits, the percentage of marketable fruit and Potassium content of fruit of tomato plant, and when KSB added to the PGPR these factors will be higher, than the compared to the positive control and negative control treatments.

References

Al-Karaki, G.N., 2000. Growth, sodium, and potassium uptake and translocation in salt stressed tomato. J. Plant. Nutr., 23(3), 369-379.

Anac, D., Eryuce, N., Kilinc, R., 1994. Effect of N, P, K fertilizer levels on yield and quality properties of processing tomatoes in Turkey. Acta. Hort., 376, 243–250.

Aslantaş, R., Çakmakçi, R., Sahin, F., 2007. Effect of plant growth promoting rhizobacteria on young apple tree growth and fruit yield under orchard conditions. Sci. Hort., 111, 371-377.

Badr, M.A., 2006. Efficiency of K-feldspar combined with organic materials and silicate dissolving bacteria on tomato yield. J. Appl. Sci. Res., 2, 1191-1198.

Barker, A.V., Ready, K.M., 1994. Ethylene evolution by tomatoes stressed by ammonium nutrition. J. Am. Soc. Hort. Sci., 119, 706-710.

Bernard, J.Z., Kocialkowski, W., Grzebisz, W., 2006. Evaluation of potassium quantity intensity parameter of selected polish agriculture soils. J. Polish. Agr. Univ. Agron., 9(40), 67-72.

Brown, M.E., 1974. Seed and root bacterization. Ann. Rev. Phytopatliol., 12, 181-197.

Bryson, G.M., Barker, A.V., 2002. Determination of optimal fertilizer concentration range for tomatoes. Soil. Sci. Plant. Anal., 33, 759-777.

Cakmaci, R., Akmakc, I.A., Figen, B., Adil, A., Fikrettin, S., Ahin, B.C., 2005. Growth promotion of plants by plant growth-promoting rhizobacteria under greenhouse and two different field soil conditions. Biochem., 38, 1482-1487.

Cakmakci, R., Donmez, F., Aydın, A., Sahin, F., 2006. Growth promoting of plants by plant growth-promoting rhizobacteria under greenhouse and two different field soil conditions. Soil. Biol. Biochem., 38, 1482-1487.

Caretto, S., Parente, A., Serio, F., Santamaria, P., 2008. Influence of potassium and genotype on vitamin E content and reducing sugar of tomato fruits. Hort. Sci., 43(7), 2048–2051.

Cavaglieri, L.R., Passone, A., Etcheverry, M.G., 2004. Correlation between screening procedures to select root endophytes for biological control of Fusarium verticillioides in Zea mays. Biol. Contr., 31, 259-262.

Chakraborty, U., Chakraborty, B., Basnet, M., 2006. Plant growth promotion and induction of resistance in Camellia sinensis by Bacillus megaterium. Journal of Basic Microbiology (JBM) cyclic nucleotids. J. Plant. Physiol., 127, 1617-1625.

Chapagain, B.P., Wiesman, Z., 2004. Effect of potassium magnesium chloride in the fertigation solution as partial source of potassium on growth, yield and quality of greenhouse tomato. Sci. Hort., 99, 279-288.

Egamberberdiyeva, D., Hoflich, G., 2003. Influence of growth- promoting bacteria on the growth of wheat in different soils and temperatures. Soil. Biol. Biochem., 35, 973-978.

El-Bassiony, A.M., Fawzy, Z.F., Abd El-Samad, E.H., Riad, G.S., 2010. Growth, yield and fruit quality of sweet pepper plants (Capsicum annuum L.) as affected by potassium fertilization. J. Am. Sci., 6(12).

Esitken, A., Karlidag, H., Ercisli, S., Turan, M., Sahin, F., 2003. The effect of spraying a growth promoting bacterium on the yield, growth and nutrient element composition of leaves of apricot (Prunus armeniaca L. cv. Hacihaliloglu). Aust. J. Agr. Res., 54, 377-380.

Fawzy, Z.F., Behairy, A.G., Shehata, S.A., 2005. Effect of potassium fertilizer on growth and yield of sweet pepper plants (Capsicum annuum, L.). Egypt. J. Agr. Res., 2(2), 599-610.

Fawzy, Z.F., El-Nemr, M.A., Saleh, S.A., 2007. Influence of levels and methods of potassium fertilizer application on growth and yield of eggplant. J. Appl. Sci. Res., 3(1), 42-49.

Franco, J.A., Perez-Saura, P.J., Fernandez, J.A., Parra, M., Garcia, A.L., 1999. Effect of two irrigation rates on yield, incidence of blossom-end rot, mineral content and free amino acid levels in tomato cultivated under drip irrigation using saline water. J. Hort. Sci. Biotechnol., 74, 430-435.

Gent, P.P.N., 2004. Effect of nitrogen and potassium supply on yield and tissue composition of greenhouse tomato. Acta. Hort., 644, 369–375.

Griffe, P., Metha, S., Shankar, D., 2003. Organic production of medicinal, aromatic and dye yielding plants (MADPs): forward, preface and introduction. Food. Agr. Organ., 2, 52-63.

Gupta, C.R., Sengar, S.S., 2000. Response of tomato (Lycopersicon esculentum Mill.) to nitrogen and potassium fertilization in acidic soil of Bastar. Veg. Sci., 27(1), 94-95.

Han, H.S., Supanjani, K., Lee, D., 2004. Effect of co-inoculation with phosphate and potassium solubilizing bacteria on mineral uptake and growth of pepper and cucumber. Agron. J., 24, 169-176.

Han, H.S., Supanjani, Lee, K.D., 2006. Effect of co-inoculation with phosphate and potassium solubilizing bacteria on mineral uptake and growth of pepper and cucumber. Plant. Soil. Environ., 52, 130-136.

Hariprakasha, R.M., Subramanian, T.R., 1991. Effect of potassium application on the yield and content of K, Ca and Mg in cabbage, okra, tomato and beetroot. J. Potash. Res., 7(3), 190–197.

Hegde, D., Dwived, M., Sudhakara, B.S., 1999. Biofertilizers for cereal production in India-A review. India. J. Agr. Sci., 69, 73-83.

Heinrichs, D.E., Rahn, A., Dale, S.E., Sebulsky, M.T., 2004. Iron transport systems in pathogenic bacteria: Staphylococcus, Streptococcus, and Bacillus. 387-401. In: crosa JH, Mey AR and payne SM, (eds.) Iron Transport in Bacteria. American Society of Agronomy. Wisconsin, DC. Hort., 731, 115-120.

Igual, J.M., Rodriguez-Barrueco, C., 2002. Phosphate solubilizing bacteria as inoculants for agriculture. In: The proceeding of the first international meeting on microbial posphate solubilizing, 16-19 July, Salamanca, Spain.

Imas, P., Bansal, S.K., 1999. Potassium and integrated nutrient management in potato. Presented at the global conference on potato, Dec., 6-11, New Delhi, India.

Karla, A., 2003. Organic cultivation of medicinal and aromatic plants. A hope for sustainability and quality enhancement. J. Organic. Prod. Medicinal Aromatic Dye Yielding Plants (MADPS). FAO.

Kloepper, J.W., Reddy, M.S., Rodríguez-Kabana, R., Kenney, D.S., Kokalis-Burelle, N., Martinez-Ochoa, N., Vavrina, C.S., 2004. Application for rhizobacteria in transplant production and yield enhancement. Acta. Hort., 631, 217–229.

Kotan, R., Sahin, F., Demirci, E., Ozbek, A., Eken, C., Miller, S.A., 1999. Evaluation of antagonistic bacteria for biological control of Fusarium dry rot of potato. Phytopathol., 89, 41.

Kumar, V., Singh, K.P., 2001. Enriching vermicompost by nitrogen fixing and phosphate solubilizing bacteria. Bioresour. Technol., 76(2), 173-175.

Lester, G.E., Jifon, J.L., Makus, D.J., 2006. Supplemental foliar potassium applications with or without a surfactant can enhance netted muskmelon quality. Hort. Sci., 41(3), 741-744.

Lester, G.E., Jifon, J.L., Rogers, G., 2005. Impact of potassium nutrition on food quality of fruits and vegetable. J. Am. Soc. Hort. Sci., 130(1), 649- 653.
Marschner, H., 1995. Mineral nutrition of higher plants, 2nd ed. Acedemic Press, London.
Murray, S.A., Spurr, A.R., Paulson, K.N., 1972. Electron probe analysis of Ca, Mg, and K in the fruit of the tomato, Lycopersicon esculentum, with reference to blossom-end rot. Agron. J., 64, 586-588.
Nassar, H.H., Barakat, M.A., El-Masry, T.A., Osman, A.S., 2001. Effect of potassium fertilization and paclobutrazol foliar application on vegetative growth and chemical composition of sweet pepper. Egypt. J. Hort., 28(1), 113-129.
Orhan, E., Esitken, A., Ercisli, S., Turan, M., Sahin, F., 2006. Effects of plant growth promoting rhizobacteria (PGPR) on yield, growth and nutrient contents in organically growing raspberry. Sci. Hort., 111, 38-43.
Oskooei, A.R., Ali-Asgharzadeh, P., Baghban, S., 2005. Influence of mycorrhizal fungi on yield and concentration of vitamin C of tomato in different levels of phosphorous. J. Agr. Natu. Resour. Sci., 82, 849-857.
Padem, H., Ocal, A., 1999. Effects of humic acid applications on yield and some characteristics of processing tomato. Acta. Hort., 487, 159-164.
Pan, B., Bai, Y.M., Leibovitch, S., Smith, D.L., 1999. Plant growth promoting rhizobacteria and kinetin as ways to promote corn growth and yield in a short growing season area. Agron. J., 11, 179-186.
Patidar, M., 2001. Integrated nutrient management in sorghum (Sorghum bicolor) and its residual effect on wheat (Triticum aestivum). India. J. Agr. Sci., 71(9), 587 – 590.
Ramirez, S.L.F., Diaz, S.F.R., Muro, E.J., 2012, Relation between soilless tomato quality and potassium concentration in nutritive solution. Acta. Hort., 947, 215–221.
Sahin, F., Kotan, R., Demirci, E., Miller, S.A., 2000. Domates ve biber bakteriyel leke hastaligi ile biyolojik savasta actigard ve bazi antagonistlerin etkinligi. Ataturk Universitesi Ziraat Fakultesi Dergisi, 31, 11-16.
Salantur, A., Ozturk, A., Akten, S., Sahin, F., Donmez, F., 2005. Effect of inoculation with nonindigenous and indigenous rhizobacteria of Erzurum (Turkey) origin on growth and yield of sipring barley. Plant. Soil., 275, 147-156.
Saure, M.C., 2001. Blossom-end rot of tomato (Lycopersicon esculentum Mill.): calcium- or a stress-related disorder? Sci. Hort., 90, 193-208.
Spurr, A.R., 1959. Anatomical aspects of blossom-end rot in the tomato with special reference to calcium nutrition. Hilgardia., 28, 269-295.
Taiz, L., Zeiger, E., 2002. Plant Physiology, 3rd edition.
Tisdale, S.L., Nelson, W.L., Beaton, J.D., 1985. Soil Fertility and Fertilizers. 4th Ed., Macmillan Pub. Co., NewYork.
Veresoglou, S.D., Menexes, G., 2010. Impact of inoculation with Azospirillum Spp. On growth properties and seed yield of wheat: a meta-analysis in ISI web of science from 1981 to 2008. Plant soil. DOI 10.1007/s1104-010-0543-7.
Waling, I., Vark, W.V., Houba, G., Van der lee, J.J., 1989. Soil and Plant Analysis, a series of syllabi. Part 7. Plant Anal Proced. Wageningen Agriculture University. Netherland.
Wu, S.C., Cao, Z.H., Li, Z.G., Cheung, K.C., Wong, M.H., 2004. Effect of biofertilizer containing Nfixer, P and K solubilizers and AM fungi on maize growth. Geoderma, 125, 155-166.
Zhao, D., Oosterhuis, D.M., Bednarz, C.W., 2001. Influence of potassium deficiency on photosynthesis, chlorophyll content, and chloroplast ultra-structure of cotton plants. Photosynthetica, 39, 103–109.
Zodape, S.T., 2001. Sea weeds as a biofertilizer. J. Sci. India. Res., 60, 378-382.

How to cite this article: Sheikhalipour, P., Bolandndnazar, S.A., Panahandeh, J., 2016. Influence of KSB, PSB and NFB on fruit quality and potassium contents in tomato. International journal of Advanced Biological and Biomedical Research, 4(2), 170-178.