A Comparison between the Effects of Fertigation and Soil Application of Potassium Chloride and Soluble SOP on the Yield and Quality of Tomato in Borazjan Region of Boushehr

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ABSTRACT

A completely randomized block experiment with three replications was carried out to compare the effects of fertigation and soil application methods of the different rates of potassium chloride and soluble SOP on the yield and quality of tomatoes in Borazjan region of Boushehr in 2002. A total of 12 treatments, including two methods of application, two sources of potassium and three rates of potassium namely the control (no potassium), a rate based on the soil test (K_1) and twice the soil test (K_2) were used.

The experimental soil had a sandy loam texture with an exchangeable potassium level of 140 mg/kg. More specifically, T_1=NP (surface irrigation), T_2=NP + Micronutrients (surface irrigation),
T_3= T_2+K_1 (MOP, fertigation), T_4= T_2+K_1 (Soluble SOP, fertigation), T_5= T_2 + K_2 (MOP, fertigation), T_6= T_2+K_2 (Soluble SOP, fertigation), T_7= T_2+K_1 (MOP, soil application), T_8= T_2+K_1 (Soluble SOP, soil application), T_9= T_2+K_2 (MOP, soil application), T_{10}= T_2+K_2 (Soluble SOP, soil application), T_{11}= T_1+K_1 (Soluble SOP, fertigation), and T_{12}= T_1+K_1 (Soluble SOP, soil application). K_1 is based on soil test, K_2 is based on two times of K_1, where K_1 and K_2 were 200 and 400 kg per hectare based on K_2O from SOP or MOP sources, respectively.

The treatments significantly affected the yield at 1% level. The highest yield of 39.27 tons/ha was obtained with fertigation of potassium chloride at the rate based on soil test plus micronutrients which exceeded the control by 10.44 tons/ha. The fertigation method of application proved superior to soil application in statistical terms. There was a significant yield difference between potassium chloride and soluble SOP treatment. There were also significant yield differences due to potassium rates of various treatments even though the rate at twice the soil test level did not improve the yield significantly. There were no significant differences in the leaf potassium concentration or chloride accumulations due to the nutrient treatments.

KEYWORDS: MOP; Soluble SOP; Fertigation; Tomato yield.

1. Introduction

Out of 164 million ha of total area (of which 60 million ha agricultural land and 14 million ha of arable land), field crops cover 5.5 million ha; horticultural crops cover 1.8 million ha. The irrigated area is about 7.5 million ha of which 0.313 million ha of mechanized/pressurized irrigation. **S**urface irrigation systems, which are not highly efficient for water application in arid zones, can be suited for fertigation to increase the fertilizer use efficiency. In traditional cropping systems, K deficiency causes yield losses; particularly in light soils. Application methods such as fertigation with high soluble sources can enhance the uptake of high demanded nutrients. Regarding techniques such as fertigation, the suitable rates and times of application of K are the key to success. Fertigation can increase fertilizer efficiency resulting in lower rates of fertilizer requirements and maximize water use efficiency for the best results

Potassium is one of the constituents of soils and plants. Some plants absorb potassium up to 8% of their dry weights. The level of soil potassium depends on the type of parent material, the degree of weathering, the amount of potassium fertilizer added, the rate of absorption by plants and losses due to erosion and leaching. The potassium supplying power of a soil in meeting a crop demand during the growing season would depend on the quantity and intensity factors on the one hand, and on the other hand on the rate of release of potassium from none exchangeable sources to exchangeable and soluble forms. Therefore, it would not be enough to depend only on exchangeable potassium rather all the other factors that affect available soil potassium should be taken into account in evaluating the status of soil potassium (Tisdale *et al.*, 1993). Potassium is usually absorbed as a single charge cation by an active mechanism. This element is quite mobile and can translocate along electrochemical potential gradient. It has become clear that potassium activates some 60 plant enzyme systems involved in controlling many of the plant activities (Rao *et al.*, 1976; Aparna, 2001). Potassium is an essential element for all the living organisms and is considered to be the most important cation not only from the viewpoint of its relative amounts but also from the viewpoint of its physiological and chemical functions. The contents of surface soil potassium vary from a few hundred kg/ha in sandy soils up to 50,000 kg/ha for clay soils that are rich in mica and layered silicates of 2:1 type. The most important function of potassium would be to activate plant enzymes. Due to high concentrations of potassium in cytosole and chloroplasts, it acts as a counter ion to organic as well as mineral anions maintaining the pH between 7 and 8 favorable for most enzymatic reactions. Potassium moves from the soil solution to the root surface mostly through diffusion. Its diffusion coefficient in water at 25^{o}C is reported to be 1.98 x 10^{-5} cm^2/sec. Potassium absorption takes place by an active mechanism against an electrochemical potential gradient and is quite selective depending on the metabolic activity of the plant (Marschner, 1995). The daily rate of potassium absorption by corn and wheat in midseason at peak value is measured to be 2 kg/ha. Despite the high demands of fruit trees for potassium, the agricultural specialists have not made the necessary considerations for this important fact and the consequent negligence in the use of potassium fertilizers along with continuous cultivation practices have lead to potassium depletion. According to the Soil and Water Research Institutes findings, the soil potassium has severely depleted in places like the Caspian sea littoral, north Khuzestan province, Zayandeh rood River alluvia's and the Jiroft orchards (Malakouti, 1999).

Considering the fact that the soils of Iran mostly contain mica and illite, it is thought that these minerals would release enough potassium for crops without the necessity of using chemical fertilizers, but some research results indicate that the available potassium is on the decline for many farming areas due to intensive farming, excessive rates of removal of soil potassium by crops and limited practice of leaving farmlands fallow; therefore, it seems essential to have to review and reconsider our notions and practices with regard to the application of potassium fertilizers. Considering the fact that the soils of Iran mostly contain mica and illite, it is thought that these minerals would release enough potassium for crops without the necessity of using chemical fertilizers, but some research results indicate that the available potassium is on the decline in many farming areas due to intensive farming, excessive rates of removal of soil potassium by crops and limited practice of leaving farmlands fallow; therefore, it seems essential to have to review and reconsider our notions and practices with regard to the application of potassium fertilizers.

Radina (1990) stated that vegetable crops demand more potassium than agronomic crops. Potassium, in a sense facilitates plants metabolic activities and potassium deficient tomatoes, for example, would yield too soft and irregularly shaped fruits. Malakouti (2000) reports that potassium deficient tomatoes are small and lighter than normal ones besides having an irregular shape and less acidity; their sugar content and yield are also lower than normal (Marchand and Bourrie 1999).

2. Materials and methods

In order to evaluate the tomato crop response to K-fertilizers in different agro-ecological zones of the country, the experiments were conducted on the major field and horticultural conditions during 2001-2002 growing seasons. The yield and quality of tomatoes were measured .The experiment was carried out in completely randomized block design with three replications. 12 fertilizer treatments were used for the Borazjan climatic zones namely; T_1=NP (surface irrigation), T_2=NP + Micronutrients (surface irrigation), T_3= T_2+K_1 (MOP, fertigation), T_4=T_2+K_1 (Soluble SOP, fertigation), T_5= T_2 + K_2 (MOP, fertigation), T_6= T_2+K_2 (Soluble SOP, fertigation), T_7= T_2+K_1 (MOP, soil application), T_8= T_2+K_1 (Soluble SOP, soil application), T_9= T_2+K_2 (MOP, soil application), T_{10}= T_2+ K_2 (Soluble SOP, soil application), T_{11}= T_1+ K_1 (Soluble SOP, fertigation), and T_{12}= T_1+ K_1 (Soluble SOP, soil application). K_1 is based on soil test, K_2 is based on two times of K_1, where K_1 and K_2 were 200 and 400 kg per hectare based on K_2O from SOP or MOP sources, respectively. N and P were applied based on the farmer's conventional rates (N=180 kg/ha from urea and 90 kg/ha P_2O_5 from triple super phosphate) in the region and micronutrients were applied based on soil test results ($FeSO_4.xH_2O$=100, $ZnSO_4.xH_2O$ =60, $MnSO_4.xH_2O$ =30 and Cu $SO_4.xH_2O$ =20 kg/ha). The K-fertilizer was applied in soil and with fertigation.

3. Results and discussion

Some physicochemical properties of the experimental soil are given in table 1. The data indicate no salinity problem but high levels of calcium carbonate (61.2%), a sandy loam texture and poor levels of nutrient contents (all the soil nutrients are at concentrations below the critical levels). The data in table 2 on the well water indicate that it is fit for tomato irrigation. The water was classed as C_2S_1; it has a salinity level of 3.7 dS/m and Cl^- concentration is measured to be 8.5 meq/l.

Table 1. Some of the experiment soils physicochemical properties, sampled before planting

Soil depth	*SP*	*EC*	*pH*	*T.N.V.*	*O.C.*	*Ca*	*Mg*	*P*	*K*	*Mn*	*Cu*	*Zn*	*Fe*	*Clay (%)*	*Texture*
(cm)	*(%)*	*(dS/m)*		*(%)*	*(%)*	*(mg/kg)*									
0-30	*30.0*	*3.4*	*7.6*	*61.2*	*0.39*	*580*	*276*	*9.1*	*140.0*	*7.1*	*0.7*	*0.7*	*2.8*	*12.0*	*S.L*

Table 2. Some chemical data on the tomato irrigation water for the experiment year

Sample description	*EC (dS/m)*	*Acidity*	*Cl^-*	*$Ca^{++}+Mg^{++}$*	*HCO_3^-*	*Na^+*	*SAR*
		(meq/l)					
Bushehr Agr. Res. Station	*3.7*	*7.6*	*8.5*	*37.0*	*4.5*	*12.0*	*2.8*

Table 3. The effect of potassium rates, sources and application methods on the yield of tomato*

Treat. No.	**Treatments**	**Yield average, (kg/ha)**
T_1	NP (surface irrigation)	28,830 C
T_2	NP+ Micronutrients (surface irrigation)	33,670 B
T_3	T_2+K_1(MOP, fertigation)	39,270 A
T_4	T_2+K_1 (Soluble SOP, fertigation)	34,430 B
T_5	T_2+K_2(MOP, fertigation)	28,070 C
T_6	T_2+K_2 (Soluble SOP, fertigation)	32,270 BC
T_7	T_2+K_1 (MOP) (Soil application)	34,900 B
T_8	T_2+K_1 (Soluble SOP, soil application)	28,570 C
T_9	T_2+K_2(MOP) (Soil application)	32,200 BC
T_{10}	T_2+ K_2 (Soluble SOP, soil application)	28,730 C
T_{11}	T_1+K_1(Soluble SOP, fertigation)	19,270 C
T_{12}	T_1+ K_1 (Soluble SOP, soil application)	27,930 C

The values, which are shown with the same letters, are statistically in the same group at α=0.05.

As can be seen from table 3 and figure 1, the yield grouping indicates that the treatment 3 or the application of potassium chloride and micronutrients by fertigation ($N_{180}P_{190}K_{200}$) produced the highest yield. Most of the fertilizer treatments with moderate rates of nutrients improved the yields as compared with those that included only nitrogen and phosphorus or with those that excluded micronutrients.

Table 4. The effect of potassium rates, sources and its application methods on vitamin C of tomato

Treat. No.	**Treatments**	**Average of vitamin C (mg/100gr)**
T_1	NP (surface irrigation)	37 AB
T_2	NP+ Micronutrients (surface irrigation)	32 CD
T_3	T_2+K_1(MOP) (Fertigation)	35 AB
T_4	T_2+K_1 (Soluble SOP) (Fertigation)	38 A
T_5	T_2+K_2(MOP) (Fertigation)	32 BC
T_6	T_2+K_2 (Soluble SOP) (Fertigation)	35 AB
T_7	T_2+K_1 (MOP) (Soil application)	35 AB
T_8	T_2+K_1 (Soluble SOP) (Soil application)	28 CD
T_9	T_2+K_2(MOP) (Soil application)	33 ABC
T_{10}	T_2+ K_2 (Soluble SOP) (Soil application)	31 BCD
T_{11}	T_1+K_1(Soluble SOP) (Fertigation)	35 AB
T_{12}	T_1+ K_1 (Soluble SOP) (Soil application)	26 D

*** The potassium sulfate was applied from the Soluble SOP source.**
The values, which are shown with the same letters, are statistically in the same group at α=0.05.

The highest vitamin C concentration was obtained with treatment 4, i.e. the application of moderate rates of macronutrients and micronutrients with K as SOP applied by fertigation.

Vitamin C concentration range was between 26 to 38 mg/100 g tomato without following a particular trend (Table 4 and Figure 2).

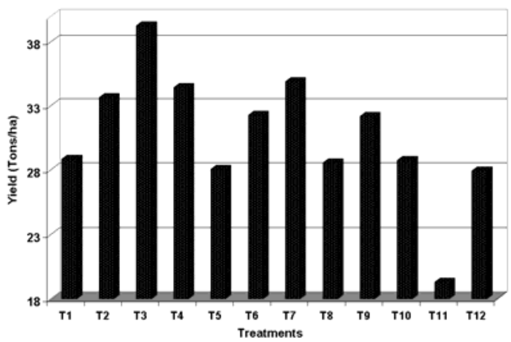

Fig. 1- Effect of potassium rates, sources and application methods on the yield of tomato.

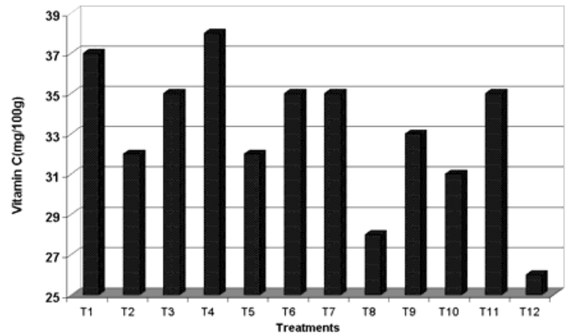

Fig. 2- Effect of potassium rates, sources and its application methods on vitamin C of tomato.

A comparison of fertigation treatments 3, 4, 5, 6 and 11 with the comparative soil treatments 7, 8, 9, 10 and 12, respectively indicates that fertigation is superior to the soil application of fertilizer nutrients. For example, treatment 3 (by fertigation) produced 39270 kg tomatoes/ha, which was significantly higher than the yield of 34900 kg/ha produced with a comparative fertilizer rate that was only soil applied (Treatment 7).

When a comparison is made between treatments 3, 5, 7 and 9 (MOP) with the comparative treatments 4, 6, 8 and 10 (SOP), respectively, it becomes clear that most of the treatments that included MOP performed superior to those with SOP. The only exception was treatment 5 (MOP) which produced lower yields than the comparative treatment 6 (SOP), however the difference was not statistically significant. The experimental results show that with sandy loam soils like that of Borazjan Agr. Res. Station, potassium applications at rates higher than the soil test requirements would not be recommended. Among the quality factors, vitamin C was most affected by the method of fertilizer application; fertigation produced more vitamin C but not significantly. The various rates and sources of potassium performed equally with respect to vitamin C contents of tomatoes (Malakouti and Homaee, 2003). The fruit pH varied from 4.5 to 4.7. However, it did not show a definite trend with respect to the treatments. The overall fruit density was measured to be 1.013. The T.S.S. content varied between 4.067 and 5.267%. The lowest level of 4.046% was obtained with the control (NP). The effects of various treatments on acidity or the prevalent acid were significant. Treatment 12, i.e. the soil application of SOP at K_1 rates produced most acidity. In general, MOP based on soil tests increased the levels of prevalent acid in the tomatoes. The potassium contents of the leaves ranged between 1.4 and 1.8%. However, the differences were not significant. The lowest potassium contents belonged to the control samples and the highest level was obtained with treatment 10.

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