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EFFECT OF POTASH APPLICATION ON YIELD AND QUALITY OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL.)

M. EHSAN AKHTAR[1], M. ZAMEER KHAN[1], M. TAHIR RASHID[1], ZAHIR AHSAN[2] AND SAGHEER AHMAD[3]

[1]*Land Resources Research Institute, National Agricultural Research Centre, Islamabad-45500, Pakistan*
[2]*Oilseed Research Lab, National Agricultural Research Centre, Islamabad-45500, Pakistan*
[3]*Sugarcrops Research Program, National Agricultural Research Centre, Islamabad-45500, Pakistan.*

Abstract

A field experiment was conducted to evaluate comparative effects of sulphate and muriate of potash (SOP and MOP) application on yield, chemical composition and quality of tomato (*Lycopersicon esculentum,* M. cultivar Roma) at National Agricultural Research Centre Islamabad, Pakistan. Potassium from two sources i.e., MOP and SOP was applied @ 0, 100 and 200 kg K ha^{-1} with constant dose of 200 kg N ha^{-1} and 65 kg P ha^{-1}. A significant increase in tomato yield with K application was observed. Potassium applied @ 100 kg K ha^{-1} as MOP produced significantly higher marketable tomatoes as compared to SOP and control. Levels and sources of potassium showed no effect on acidity of tomato fruits. Potash application decreased sugar content of tomato fruits as compared to control. This effect of K on reducing sugar content was more pronounced in K treated fruits as SOP than those of MOP. Vitamin C contents in tomato fruits increased with K application in the form of MOP. The K use as MOP significantly reduced incidence of leaf blight disease and insect pest attack in tomato plant as compared to SOP and control treatments.

Introduction

In Pakistan, tomatoes are grown over about 53.1 thousand hectares with an average yield of about 10.1 tons ha^{-1} (Anon., 2008). However, much higher tomato yield has been reported in other countries of the world e.g., 73.87 t ha^{-1} in USA, 63.55 t ha^{-1} in Spain, 88.91 t ha^{-1} in California and 146 t ha^{-1} in the Netherlands (Tomato News 2004). Higher production of tomato depends upon adoption of high yielding varieties, appropriate crop management techniques including precise and balanced fertilization, timely irrigation, control of diseases and insect pests. In Pakistan, the tomato yields are far below than average yield being achieved in many other countries of the world. One of the reasons of low yield in Pakistan is imbalanced fertilizer use; nitrogen 250 kg N and phosphorus 125 kg P_2O_5 ha^{-1} are being used commonly (Anon., 2008), while the use of potash and micronutrient are negligible. Potash use in Pakistan is only about 2 kg ha^{-1} (Anon., 2009). Tomato is a heavy feeder of nutrients, especially potash as compared to cereals (Ehsan *et al.,* 2003a). On an average, a tomato crop producing 30 t ha^{-1} would require approximately 280 kg N, 55 kg P_2O_5 and 540 kg K_2O ha^{-1}, (Anon., 1992; Ehsan *et al.,* 2003b). Traditionally SOP and MOP are being used as source of potash all over the world, however MOP is considered a relatively cheaper source of K. Both the K sources have similar effects on a number of crops tested (Akhtar *et al.,* 1998). Thus the study was planned to evaluate the sources of K_2O for tomato, not only for their effects on yield, but also on the quality of tomato, resistance against disease incidence and insect pest attack.

Material and Methods

The study was conducted at NARC experimental area and tomato variety Roma was used as the test crop. Nursery was raised and 15 days old plants were transplanted on beds. Nitrogen and P @ 200 and P @ 65 kg ha^{-1} was applied. Three levels of K viz. 0, 100 and 200 kg ha^{-1} were applied from two sources i.e., MOP and SOP. All P and one third of N and K fertilizers were applied at the time of transplanting as side dressing and the remaining N and K fertilizers were applied at flower initiation and fruit setting stages. The experiment was laid out in a randomized complete design with four replications. Data regarding growth, yield and yield components i.e. weight and number of fruits and incidence of disease (leaf blight; S*eptoria*) and (white fly; *Bemisia tabbacci*) and fruit borer (*Heliothus armigrah*) attack were recorded on the basis of number per plant and fruits damaged. Then Diethene M-45 was sprayed twice after 10 day intervals at flowering stage to control the disease and Nogas and Melathian at fruiting stage to control insect pest attack. Number and weight of healthy and damaged tomato fruits were counted and weighed separately.

Initial soil physical and chemical characteristics of experimental field like soil texture, pH, EC_e, N, P and K were determined using proper analytical techniques (Richards, 1954; Soltanpour, 1977). Sugar, acidity and vitamin C in tomato fruits were determined by methods given by AOAC (Anon., 1990). Plant available NO_3-N, P and K was determined by the standard procedures given by Winkleman *et al*., (1990). The data collected from the experiment regarding different parameters were subjected to analysis of variance to test the significance of treatments and treatment means were compared using least significant difference (LSD) (Steel *et al*., 1997). Further, statistical analysis was also done to compare different treatment combination using orthogonal contrasts and their coefficients (Peterson, 1977).

Results and Discussion

Soil analysis: Soil was loam in texture and belonged to Nabipur soil series (coarse-loamy, mixed, hyperthermic, Udic Utocrept). The soil was normal having pH 7.73, EC_e, 0.59 dS m^{-1}, AB-DTPA extractable NO_3-N 30, P 9.7 and K was 214 mg kg^{-1} soil (Table 1). The surface soil contained relatively larger amounts of nutrients as compared to the lower layers because soil was under vegetable production and there had been regular addition of farm yard manure and fertilizers.

Tomato yield: The yield of tomatoes increased significantly with K application (Table 2). Maximum yield of 24.9 t ha^{-1} was obtained with application of 100 kg K ha^{-1} as MOP and it was significantly higher than control (12.6 t ha^{-1}) and the same level of K from SOP produced 15.4 t ha^{-1}. The yield increase was more pronounced with K applied as MOP compared to SOP (Table 3). The orthogonal contrast analysis clearly indicated that tomato yield harvested from control plot significantly differed from the yield obtained from K treated plots on overall basis. The difference between K sources also differed significantly. The response of tomato in terms of increase in tomato yield with applied K at 100 kg ha^{-1} as MOP was higher than that of applied K at 200 kg ha^{-1}. Whereas in case of K application as SOP, tomato yield gradually increased with increasing K rates. This indicates the preference of the tomato variety for K source (Table 2). The results of the study are in line with those reported by Kaviani *et al*., (2004). They reported that MOP treated tomato plants gave higher yield than that of SOP under field conditions. The findings of the study are in contrary to the work reported by Loch & Petho, (1992). They compared the response of tomato to SOP and MOP and reported a higher response of tomato to SOP than that of MOP. The difference regarding preferential response of tomato to K sources could be due to nature of tomato variety tested, soil and climatic condition etc. The experimental site in the present study is situated in high rainfall area and low levels of soluble salts. It appears that variety had preference for relatively higher levels of chloride.

Table 1. Chemical characteristics of soil of the experimental site.

Depth (cm)	OM	Sand	Silt	Clay	pH	EC_e (dS m^{-1})	NO_3-N	P	K	S	Cl me L^{-1}
	(%)						----------- (mg kg^{-1}) --------------				
0-15	0.85	20	29	51	7.73	0.59	30.57	9.70	214	18.4	3.02
15-30	0.63	22	31	47	7.81	0.44	21.30	9.80	198	8.0	1.98
30-60	0.56	25	32	43	7.80	0.40	19.00	8.00	112	8.8	2.01

Table 2. Effects of potash on yield and damage by fruit borer infestation of tomato.

K_2O applied (kg ha^{-1})	Total yield (t. ha^{-1})	Marketable (t. ha^{-1})	Damaged (kg ha^{-1})
Control	12.6 c	11.6 c	943 a
100 MOP	24.9 a	24.0 a	847 ab
100 SOP	15.4 bc	14.6 bc	783 ab
200 MOP	19.2 ab	18.4 ab	951 ab
200 SOP	16.5 bc	15.8 bc	624 b
LSD	6.25	6.28	238

Note: Means followed by the similar letter(s) do not differ significantly at $p \leq 0.05$.

Table 3. Orthogonal contrast comparison of yield and fruit borer infestation infestation of tomato.

Orthogonal contrast	Total yield		Marketable		Damaged	
	F. Value	Prob.	F. Value	Prob.	F. Value	Prob.
Control vs K	7.95	0.05*	8.367	0.014*	4.889	0.047*
SOP vs MOP	8.819	0.012*	8.481	0.013*	1.501	0.244 NS
SOP (K_{100} vs K_{200})	0.128	0.089 NS	0.170	0.240 NS	2.101	0.173 NS
MOP (K_{100} vs K_{200})	3.86	0.073 NS	3.702	0.078 NS	54.75	0.768 NS

Note: * Significant at alpha 5%; NS = Non-significant

Tomato is a high K requiring crop and K application increased the yield though soil had relatively high plant available K. This indicates that despite being adequate K levels in soil, the crop K requirements for attaining higher yield could not be met from native source, thus addition of K through fertilizers was required (Ehsan *et al*., 2003b). Hariprakasa & Subramanian (1991) studied the effect of different sources and levels of K on vegetables and reported that the higher yield of tomato was obtained with 100 kg K_2O ha^{-1} application under field conditions. They also reported non-significant difference between the K sources in terms of yield. However, Nandel *et al*., (1993) reported that the maximum tomato yield was obtained with 80 kg K_2O ha^{-1}. Potassium application also affected the marketable yield as higher marketable tomato yield was obtained from K treatments compared to control. Effect of K on increased marketable yield of tomato is in conformity with the findings of Usherwood, (1985). Khan *et al*., (2005) conducted an experiment to study the effect of NPK on yield of sugar at NIA Tando Jam, Pakistan and reported a significant increase in sugar with K application at 150 kg ha^{-1}.

Pattern of tomato production: Though there is a significant response of tomato to K application, however the pattern of production remained unaffected with K treatments i.e., K sources and their levels (Fig. 1). The figure shows that the production of fruits started from 56 day after transplanting (DAT) and last till 110 DAT. Maximum fruit production was obtained from 79 to 94 DAT. The difference between different treatments became more pronounced at this growth stage.

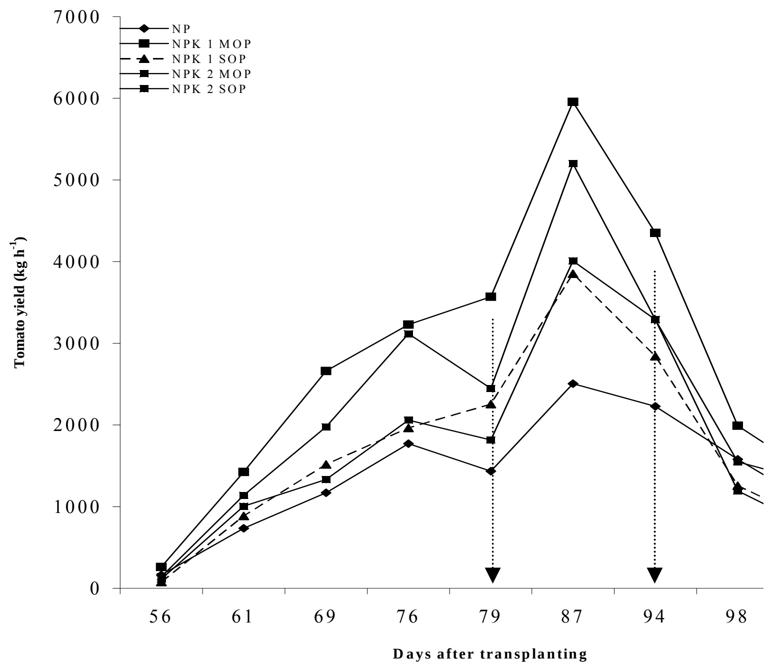

Fig. 1. Comparative effect of sources and levels of K application on tomato production.

Table 4. Comparative effects of potash on chemical composition of tomato fruit.

K_2O applied (kg ha^{-1})	Acidity	Sugar (%)	Vit C (mg 100^{-1} g)
Control	1.50	4.21 a	23.13 ab
100 MOP	1.30	3.18 ab	25.99 a
100 SOP	1.33	3.15 ab	18.81 b
200 MOP	1.35	3.47 ab	25.24 a
200 SOP	1.29	2.45 b	18.77 b
LSD	NS	1.40*	6.13*

* = Statistically significant; NS = Statistically non-significant

Quality of tomato pulp: Acidity of tomato fruit tended to decrease with K application and it remained unaffected amongst the applied K sources and levels (Table 4). Similar trend was also observed for sugar content in tomato fruits. When K as MOP was applied at 100 kg ha^{-1}, the sugar contents decreased and at higher K levels a slight increase was observed. While in case of SOP, a linear decrease in sugar content was observed with increasing levels of applied K. The maximum value of sugar content (4.2%) was observed in the control and the minimum in treatment where K was applied at 200 kg ha^{-1} as SOP. In general, a decreasing trend of sugar content in tomato fruit was observed with K application as compared to control. This decreasing trend of sugar content may be due to dilution effect, as the yield increased significantly by K application that might have resulted in reduction of sugar contents in tomato fruits with K treatments. The results are in contradiction with those reported by Wuzhong (2002) who reported that K fertilization increased sugar contents in tomato.

High vitamin C contents were observed where K as MOP was applied (Table 4). The difference between K sources was also significant and between K treatments (on overall basis) and control was non significant (Table 5). The effect of K sources on vitamin C content of tomato differed significantly with respect to control on overall basis. These results are in line with those reported by Kaviani *et al*., (2004). They reported a decreasing trend of Vitamin C contents with K application. Anac & Colakogle (1993) in a study on response of some major crops to K fertilization reported a positive effect of K supply on the vitamin C content of tomato fruits. Ibrahim (1996) also reported that sugar and vitamin C content increased with K application regardless of the sources. It was not clear why there was higher content of vitamin C in the tomatoes fruits treated with K as MOP, however, Serg *et al*., (1993) studied the salt tolerance of tomato varieties and reported that with increasing levels of NaCl in solution culture, Cl contents, vitamin C and acidity of tomato fruits increased non significantly. Zubeda *et al*., (2007) also reported similar range of vitamin C content in tomato fruit. Application of K as MOP the Cl contents also increased in tomato fruit (Table 6). Nandal *et al*., (1993) studied the effect of different levels of P and K nutrition on growth, yield and quality of tomato and reported that P and K application increased the acidity and sugar contents of tomato fruit. Hariprakasa & Subramanian (1991) also reported that acidity in tomato increased with K application.

Mineral composition of tomato: Potassium application tended to increase K content in the tomato pulp and effect of K application on K, Na, S and Cl contents in the tomato was non-significant. Higher rates of K from both sources tended to increase K content in tomato pulp but the difference was statistically non-significant (Table 6). Similarly, a slight increase in Cl content of the tomato pulp was observed where MOP fertilizer was applied compared to control and SOP but it was also non-significant (Table 7). Phosphorus content in tomato pulp significantly increased with K application. Higher P concentration was observed in tomato fruits harvested from plots supplied with higher K level from both K sources. The levels of different elements in tomato fruits were found within the normal range for human health (Anon., 1993). The results of the study showed that applied K had positive interaction with other nutrients in the plant system. In a field study Khan *et al*., (2006) also reported a synergistic effect of foliar application of K on N and P concentration in wheat plant.

Diseases and insect pest damage: The incidence of leaf blight *Septoria* was also affected with K application. Relatively lesser number of tomato plants were affected in K treated plots as compared to plants grown without K application on overall basis. The disease incidence was less on the plants treated with K as MOP as compared to control. Plants treated with K as SOP showed less resistance against disease incidence as compared to MOP ones (Table 8). In MOP treated plots, the effect of K on suppressing the disease was more pronounced as compared to SOP treated plots. Muriate of potash seemed to be more effective in suppressing the disease incidence as compared to SOP. Kirali (1976) also reported that K application suppressed damage caused by *Alternaria solani* to tomato.

Insect pest attack was also influenced with K treatments. A decreasing trend of fruit borers (*Heliothus armigrah*) and white fly (*Bemisia tabacci*) attack was observed in K treated plants as compared to control. Damage due to the insect pest attack was reduced with K treatments and at the higher level of applied K, it was further decreased. However, difference among the control and K levels was statistically non-significant. The difference between the K sources was significant as plant treated with K as MOP showed more resistance against pest attack as compared to SOP treated plants.

Table 5. Orthogonal contrast comparison of quality parameters of tomato fruit.

Orthogonal contrast	Acidity		Sugar (%)		Vitamin C	
	F. Value	Prob.	F. Value	Prob.	F. Value	Prob.
Control vs K	3.49	0.03*	5.77	0.03*	0.39	0.23 NS
SOP vs MOP	0.05	0.04*	1.71	0.22 NS	15.65	0.00*
SOP (K_{100} vs K_{200})	0.07	1.02 NS	10.89	0.00**	1.22	0.00*
MOP (K_{100} vs K_{200})	0.07	0.13 NS	0.22	0.00 NS	1.22	0.09 NS

Note: * = Statistically significant; NS = Statistically non-significant

Table 6. Effect of MOP and SOP on mineral composition of tomato fruit.

K_2O applied (kg ha^{-1})	K	Na	P	S	Cl
	(mg kg^{-1})				
Control	1680	120	90 B	90	610
100 MOP	1980	140	130 b	110	840
100 SOP	1650	140	140 b	90	640
200 MOP	1930	150	160 a	100	880
200 SOP	1800	140	180 a	110	690
LSD	NS	NS	40	NS	NS

* = Statistically significant; NS = Statistically non-significant

Table 7. Orthogonal comparison of different treatments on mineral composition of tomato pulp.

Orthogonal contrasts	K (%)		Na (%)		P (%)		S (%)		Cl (%)	
	F. Value	Prob.	F. Value	Prob.	F. Value	Prob.	F. Value	Prob.	F. Value	Prob.
Control vs K	1.23	0.29 NS	1.03	0.33 NS	8.43	0.01*	1.43	0.25 NS	0.09	0.00 NS
SOP vs MOP	2.88	0.11 NS	0.00	0.03*	0.00	0.20 NS	0.00	0.03 NS	1.81	0.20 NS
SOP (K_{100} vs K_{200})	0.64	0.00 NS	0.00	0.06 NS	0.46	0.02*	0.00	0.75 NS	0.05	0.00 NS
MOP (K_{100} vs K_{200})	0.01	0.07 NS	0.00	0.11 NS	1.28	0.28 NS	0.00	0.12 NS	0.49	0.00 NS

* = Statistically significant; NS = Statistically non-significant

Table 8. Effect of MOP and SOP on disease and insect pest incidence on tomato.

K_2O applied (kg ha^{-1})	Disease incidence	Insect pest damage
Control	12.0 a	14.0
100 MOP	4.3 b	11.0
100 SOP	7.9 ab	11.0
200 MOP	5.3 b	9.0
200 SOP	8.7 ab	9.0
LSD	6.9	NS

* = Statistically significant; NS = Statistically non-significant

Table 9. Orthogonal comparison of different treatments on disease and insect pest incidence.

Treatments	Insect pest damage		Disease incidence	
	F Value	Prob.	F Value	Prob.
Control vs K treatments	1.325	0.272 NS	5.835	0.033*
SOP vs MOP	0.167	0.044 *	2.440	0.144 NS
SOP (K_{100} vs K_{200})	2.813	0.097 NS	1.596	0.064 NS
MOP (K_{100} vs K_{200})	2.813	0.188 NS	1.596	0.089 NS

* = Statistically significant; NS = Statistically non-significant

Conclusions

Application of K from both the sources of K increased tomato yield, however MOP was more effective im improving yield and quality of tomato. Though, soil K level was in the high range, it couldn't meet the requirements for high yield crop of tomato. Hence, the generalized adequacy range of K in soil needs to be refined for vegetable production, especially for high yield agriculture.

References

Akhtar, M.E., A. Sardar, M. Ashraf, M. Akhtar and M.Z. Khan. 2003b. Effect of potash application on seed cotton yield components of selected cotton varieties-I. *Asian J. of Plant Sci.*, 2(8): 602-604.

Akhtar, M.E., M.T. Saleem and M D. Stauffer 2003a. *Potassium in Pakistan Agriculture*. *PARC, Islamabad, Pakistan*. pp. 80.

Akhtar, M.E., M.T. Saleem and M.D. Stauffer. 1998. Research and development on the use of muriate of potash (MOP) in Pakistan, *a resume of accomplishments*, 1993-98, PARC, Islamabad, Pakistan.

Anac, D. and H. Colakoglu. 1993. Response of some major crops to K fertilization 235-247. In: *Proc. Regional Symp. on K availability of soils in West Asia and North Africa*. June 19-22, 1993, Tehran, Iran.

Anonymous. 1990. *Official methods of analysis of Official Analytical Chemists*. 15th Edition Vol. II AOAC Inc. Arlington, Verginia.22201, USA.

Anonymous. 1992. *World Fertilizer Use Manual. International Fertilizer Industry Association, Paris*. pp 288 and 331.

Anonymous. 1998. *Agricultural Statistics of Pakistan*, *Ministry of Food, Agriculture and Livestock, Islamabad, Pakistan.*

Anonymous. 2008. National Fertilizer Development Centre (NFDC). *Pakistan fertilizer related statistics*, Islamabad, Pakistan.

Anonymous. 2009. National Fertilizer Development Centre (NFDC). *Fertilizer Review Report*, 2007-08.

Hariprakasa, M and T.R. Subramanian. 1991. Effect of potassium application on the yield and content of potassium, calcium and magnesium in cabbage, okra, tomato and beet root. *Potassium Research*, 7: 190-197.

Ibrahim, M. 1996. Research and development project on the use of muriate of potash, (MOP) in Pakistan, *Technical Progress Report of Rabi 1995-96, PARC, Islamabad*, Pakistan.

Khan, A., A.S. Khatri, M.A. Nizamani, S.R. Siddiqui and N. Dabar. 2005. Effect of NPK fertilizer on the growth of sugar cane Clone AEC. 86-347. Developed by NIA Tandojam, Pakistan. *Pak. J. Bot*., 37(2): 355-360.

Khan, M.Z., S. Muhammad, M.A. Naeem, M.E Akhtar and M. Khalid. 2006. Response of some wheat (*Triticum aestivum* L.) varieties to foliar application of N & K under rainfed conditions. *Pak. J. Bot.,* 38(4): 1027-1034.

Kirali, Z. 1976. Plant disease resistance as influenced by biochemical effect of nutrients in fertilizers. P.33-46. *In*: Proc. *Fertilizer use and plant health*, 12th Colloquium of the Potash Institute, Izmir, Turkey.

Kiviani, I., M. Basirat and M.J. Malakouti. 2004. 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. In: *Proc*. *IPI workshop on potassium and fertigation development in West Asia and North Africa, Rabat Morocco*, November, 24-28, 2004.

Loch, J. and F. Petho. 1992. Effect of potassium sulphate on the yield of vegetable: In: *Proc. Potash in Ecosystem,* 23rd Colloquium, Potash Institute, October 12-16, 1992. Prague p. 407-409.

Nandel, J.K., U.C. Pandey, O.P. Yadav and R. Vashistha. 1993. Effect of different levels of phosphorus and potassium nutrition on growth, yield and quality of tomato. p. 100. In: *Int Symposium on a Decade of Potassium Research*, November 18-20, 1993.

Peterson, R.G. 1977. Use and misuse of multiple comparison procedures. *Agron. J*., 69: 205-208.

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soils. *U.S.D.A Hand Book No 60,* U.S. Government Printing Office, Washington D.C.

Serg, S.M.H, R.G. Wyn Jones and F.A. Omar. 1993. Salt tolerance in edkawy tomato. In: *Towards the rational of high salinity tolerant plants* (Vol. 2). (Eds.): H. Lieth and A. Al Masoom. Kluwer Academic Publishers, Netherlands. p. 185-192.

Steel, R.G.D., J.H. Torrie and D.A. Dickie. 1997. *Principles and procedures of statistics, A Biometric Approach.* 3rd Ed. McGraw-Hill, Co. Singapore, pp. 204-227.

Usherwood, N. 1985. The role of potassium in crop quality In: *Potassium in Agriculture* (Swiader, J). pp. 501-502. ASAICSSAISSSA publication, Madison, Wl.

Von., Uexkull. H.R. 1978. Tomato, nutrition and fertilizer requirements in the topics. p. 65-67. *In*: *Proc. The First Int. Symposium on Tropical Tomato*. Asian Vegetable Research and Development Centre, Shanhua, Taiwan, p. 65-77.

Winkleman, E.R. Amin, W.A. Rice and M.B. Tahir. 1990. *Methods Manual Soils Laboratory*. BARD Project, PARC, Islamabad

Wuzhong, N. 2002. Yield and quality of fruits as of solanaceous crops as affected potassium fertilization. *Better Crops International,* 16(1): 6-9.

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