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Evaluation of Potassium Sources and Rates on the Yield and Quality of Fertigated Potato Grown in Sandy Soil

S.T. Abou zeid and Amal L. Abd El-Latif
Soil Science Dept. Fac. of Agriculture, Cairo University, Giza, Egypt

A FIELD experiment was conducted in sandy soil at El-Sadat city Menoufiea Governorate, Egypt for two consuctive seasons (2012 and 2013) to investigate the effect of different sources and rates of potassium fertilizers on total yield and tuber quality of potato (*Solanum tuberosum* L.). Cv. Diamante grown on sandy soil. The experiment was conducted under drip irrigation system in split-split design with three replicates. Four sources of potassium were used, *i.e.* potassium sulphate (K_2SO_4), potassium chloride (KCl), potassium carbonate (K_2CO_3) and potassium hydroxide (KOH) with three rates, 80, 100 and 120 kgK_2O/fed applied through irrigation water.

As regards to sources and rates of potassium fertilizers, results showed significant differences among the sources and rates of potassium fertilizers on total yield, tuber weight, tuber diameter, specific gravity and starch content of tuber. The data revealed that K_2SO_4 was the best among other sources. Data also showed that yield and quality of tuber increased with increasing potassium rates up to 120 kg K_2O/fed. except KCl treatment. In both seasons, the highest tuber yield was 14.85 ton/fed. with potassium sulphate at 120 kg K_2O/fed.

Keywords: Potato, Potassium fertilizers, Fertigation, Tuber quality.

Introduction

in Egypt, potato (*Solanum tuberosum L.*) could be considered as one of the cash crops and its economic importance arises from the fact that large amount of this crop is exported yearly (Eleiwa *et al*., 2012).

One of the major production factors of potato is fertilization. Potato plants require much more potassium than many other vegetable crops (Al-Moshileh and Errebi, 2004).

Potassium is an essential plant nutrient that plays a very important role in plant growth and development. Its role is well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthetic, enabling their ability to resist, pests and diseases. Also, potassium is considered as a major osmotically active cation of plant cell (Mehdi *et al*., 2007), where it enhances water uptake and root permeability and acts as a guard cell controller, beside its role in increasing water use efficiency (Zekri and Obreze, 2009).

Horticultural crops absorp potassium in large quantities, especially at fruit filing stages. Potassium fertilizer can be applied in several ways by banding, fertigation or by spraying liquid fertilizers on the leaves. Various sources of K salts are used such as potassium chloride (KCl), potassium sulphate (K_2SO_4), potassium nitrate (KNO_3) and mono-potassium phosphate (KH_2PO_4)(Magen, 2004). Most previous studies took place on K-fertilization used potassium sulphate source, but studies for experimenting potassium chloride as a cheaper fertilizer source, are still limited expect for some vegetable crops grown on sandy and loamy soils (Gunadi, 2009).

The present investigation was, therefore carried out to study the effects of source and rate of potassium fertilizers on tuber yield and tuber quality of potatoes grown in a sandy soil under fertigation system.

Materials & Methods

A field experiment was established at El-Sadat City, Menoufia Governorate, Egypt during the two successive Fall (nili) seasons 2012 and 2013. Potato (*Solanum tuberosum* L.). Cv. Diamante

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was chosen as indicator plant in this study. The experiment design was split split plot design with three replicates under drip irrigation system. The plot area was 17.5 m^2 (3.5 m x 5m). Some physical and chemical properties characteristics of initial soil under investigation were shown in Table (1)

TABLE .1 Particles size distribution and chemical analysis of soil sample from the experimental site

Particle size distribution (g/kg)		Chemical analysis	
Clay	47	pH (1:2.5)	8.0
Silt	50	EC dSm^{-1}	0.32
Fine sand	228	$CaCO_3$ (g/kg)	36
Coarse sand	675	O.M (g/kg)	0.6
Texture class	sandy	Available nutrients (mg kg^{-1})	N 34 P 4.8 K 63

The sources of potassium :
T_1:Potassium sulphate (50 % K_2O)
T_2:Potassium chloride (62 % K_2O)
T_3:Potassium carbonate (70 % K_2O)
T_4:Potassium hydroxide (80 % K_2O)

Three rates of potassium were used 80,100 and 120kg K_2O/Fed,assigned as R_1,R_2andR_3,respectively.Both nitrogen and phosphorus were applied according to the recommendation of Ministry of Agriculture and Land Reclamation.

Whole seed tubers were planted in row 0.70 m apart and 0.25 m within the row on October 15^{th} .

Soil analysis

Soil samples (030- cm) were taken from the experimental site at the beginning and the end of the experiment

Soil analysis were performed as follows: texture and total $CaCO_3$, were determined according to Klute (1986). pH, EC, organic matter available N,P and K were determined according to Page *et al*. (1982).

Data recorded of potato:

Each experimental plot was harvested after 120 days of planting and total tuber yield (ton/fed) were recorded. The produced tubers from each plot were graded into three categories according to tuber weight ,*i.e*. small (< 30g), medium (3060-g) and large tubers (> 60 g).

Specific gravity = weight in the air/weight in the air-weight in the water. Starch (%) was determined. Potassium content was determined in the fourth leaf from the top after 75 days from plantig and tubers according to the method described by Page *et al*.(1982). The obtained data were statically analyzed according to Snedecor and Cochran (1990).

Results & Discussion

Yield:

Data in Table 2 indicated that the different sources of potassium were similar in their effect on tuber weight and tuber diameter in both seasons, K_2SO_4 was superior than the other sources of K fertilizers. While K_2CO_3 produced the lowest values.

In both seasons, increasing potassium rate significantly affected tuber weight and tuber diameter. The addition of 100 KgK_2O/fed. significantly increased both tuber weight and tuber diameter. Application of 120 Kg/fed of K produced maximum tuber weight and tuber diameter in all the sources of K fertilizers. However, this increase had no significant effect compared with the rate 100 kg K_2O/fed. This result was in agreement with El-Sirafy *et al*., (2008). This effect may be due to that potassium play an important role in carbohydrate formation, transformation and movement of starch from leaves to tubers (Vander Zaag, 1981).

The weight of tuber at each class category as affected by K fertilizer sources is presented in Tables 3 & 4. The data indicated significant differences between the sources and the rates of K fertilizer in terms of the grades of tuber weight. In both seasons, potatoes under sulphate and chloride treatments had significantly lower weight of small tuber compared to those supplied with other sources. These results were in agreement with Tawfik (2001).

Compared with the low K rate, the higher K rate increased the yield of medium (3060- g) and large-weight (> 60g) tubers. In both seasons, potatoes under (120 K_2O/fed.), sulphate and chloride had significantly lower weight of small tuber compared to those supplied with other sources and the rates of K fertilizer. These results agree with Chapman *et al*. (1992).

TABLE 2. Effect of source and level of K fertilizers on tuber weight and tuber diameter of potato

Sources	Average tuber weight (g)				Tuber diameter (cm)			
	Season 2012							
	Rate of application							
	R1	R2	R3	Mean	R1	R2	R3	Mean
T1	156.26	170.11	174.23	166.87a	6.60	6.72	6.86	6.69a
T2	155.2	168.2	165.3	162.9b	6.5	6.6	6.4	6.5b
T3	152.46	161.93	164.86	159.8b	6.36	6.48	6.54	6.46bc
T4	151.58	157.30	160.13	156.34c	6.24	6.36	6.48	6.36c
Mean	153.88b	164.39a	166.13a		6.4b	6.54a	6.57a	
L S D 0.05	Source	3.19			0.140			
	Rate	2.76			0.087			
Season 2013								
T1	161.33	173.22	176.36	170.30a	6.82	6.95	7.15	6.97a
T2	159.3	165.4	160.2	161.63b	6.6	6.7	6.3	6.54b
T3	154.3	160.5	165.3	160.03bc	6.46	6.55	6.61	6.53b
T4	152.1	159.6	162.8	158.17c	6.35	6.46	6.53	6.45b
Mean	156.76b	164.68a	166.16a		6.56b	6.65a	6.66a	
LSD 0.05	Source	2.55			0.109			
	Rate	2.12			0.086			

TABLE 3. Effect of source and level of K fertilizers on yield (small and medium) of potato

Sources	Yield component (ton/fed)							
	Small				Medium			
	Season 2012							
	Rate of application							
	R1	R2	R3	Mean	R1	R2	R3	Mean
T1	1.14	0.96	0.61	0.90c	8.73	9.09	9.47	9.20a
T2	1.26	1.03	0.80	1.03b	8.54	8.93	8.99	8.82b
T3	1.4	1.12	1.14	1.22a	8.37	8.75	8.87	8.66c
T4	1.5	1.3	1.1	1.3a	8.3	8.64	8.77	8.57c
Mean	1.33 a	1.10 b	0.913c		8.49b	8.93a	9.03a	
LSD 0.05	Source	0.114			0.134			
	Rate	0.026			0.167			
Season 2013								
T1	1.11	0.98	0.62	0.903c	8.76	9.10	9.48	9.11a
T2	1.23	1.06	0.82	1.04b	8.57	8.99	9.0	8.85ab
T3	1.38	1.14	1.16	1.23a	8.39	8.77	8.89	8.68bc
T4	1.47	1.33	1.23	1.34a	8.31	8.67	8.78	8.47c
Mean	1.30a	1.13b	0.96c		8.42c	8.88b	9.04a	
LSD 0.05	Source	0.127			0.274			
	Rate	0.086			0.186			

Data in Table 4 indicated that in both seasons, tuber yield was affected significantly by the K fertilizer sources. Potato under K_2SO_4 had significantly higher tuber yields (14.85 ton/fed) compared to those supplied with that other sources. This result was similar with that reported by Malakouti *et al.* (1995) who showed that in terms of tubers yield, K_2SO_4 was superior than KCl which may be attributed to the specific Cl-ion effect (Perrenoud ,1993) presumably because of S content in K_2SO_4. The yield in potassium hydroxyl and K carbonate were less than the yield of K_2SO_4 and KCl treatments. The effect of source of K treatments on the yield was not significant between treatments of K_2CO_3 and KOH.

The results showed that the increase of the yield was proportionally with the increase of the K rate of application except in one case, where the rate of KCl was 120 Kg K_2O/fed., here the yield was less than the yield of other sources. This may be associated with the sensitivity of potatoes to chloride ions (AL-Zubaidi, 2004).

Potassium content in leaves and tubers

Data in Table 5 indicated that sources and rates of K fertilizer significantly affect K percentage of leaves and tubers at harvest. In both seasons, K percentage in leaves and tubers of potatoes which supplied with K_2SO_4 was significantly higher than that fertilized with other sources. The results found here was similar with those reported by Gunadi (2009).

The data also indicated that increasing potassium rate significantly affect K percentage in leaves and tubers. Similar trend was obtained by Reis-Junior and Monnerat (2001). In this concern, Tawfik (2001) reported that by increasing K-ratees , leaf K-concentration increased.

Tuber quality

The specific gravity is a measure of quality of potato tuber which is related to the dry matter contents in the tuber. The specific gravity is also associated with starch content of potato tubers. This was positively affected with K fertilization (Table 6). The specific gravity of potatoes under 120 kg K_2SO_4 was higher than those supplied with other sources and the rates of K fertilizer treatments. The differences were significant between K_2SO_4 and the other sources in both seasons. However, the differences were insignificant between K-carbonate and K-hydroxide.

TABLE 4. Effect of source and level of K fertilizers on yield (large) and total yield of potato

Sources	Yield component Large (ton/fed)				Total yield (ton/fed)			
	Season 2012							
	Rate of application							
	R1	**R2**	**R3**	**Mean**	**R1**	**R2**	**R3**	**Mean**
T1	4.42	4.92	5.22	4.85a	14.29	14.97	15.30	14.85a
T2	4.2	4.69	4.60	4.50b	14	14.65	14.39	14.35b
T3	3.99	4.23	4.25	4.16c	13.76	14.1	14.26	14.04c
T4	3.8	4.06	4.23	4.03d	13.60	14	14.1	13.9c
Mean	4.10c	4.48b	4.58a		13.91b	14.43a	14.51a	
LSD 0.05	Source	0.104			0.166			
	Rate	0.076			0.095			
Season 2013								
T1	4.51	5.01	5.31	4.94a	14.38	15.09	15.41	14.85a
T2	4.3	4.83	4.7	4.61b	14.1	14.64	14.72	14.45b
T3	4.00	4.41	4.36	4.26c	13.77	14.32	14.41	14.17c
T4	3.9	4.28	4.30	4.16d	13.68	14.28	14.31	14.09c
Mean	4.18b	4.63a	4.67a		13.98b	14.56a	14.63a	
LSD 0.05	Source	0.077			0.286			
	Rate	0.099			0.171			

TABLE 5. Effect of source and level of K fertilizers on potassium (%) of potato leaves and tubers

Sources	Leaves				Tuber			
	Season 2012							
	Rate of application							
	R1	**R2**	**R3**	**Mean**	**R1**	**R2**	**R3**	**Mean**
T1	2.31	2.44	2.50	2.42a	2.12	2.24	2.33	2.23a
T2	2.28	2.34	2.40	2.34ab	2.06	2.18	2.23	2.16ab
T3	2.15	2.23	2.34	2.24b	2.01	2.10	2.21	2.11ab
T4	2.12	2.22	2.31	2.22b	1.99	2.07	2.17	2.08b
Mean	2.22b	2.31ab	2.39a		2.04c	2.15b	2.23a	
L S D 0.05	Source	0.167			0.128			
	Rate	0.131			0.081			
Season 2013								
T1	2.35	2.49	2.58	2.47a	2.15	2.28	2.35	2.26a
T2	2.30	2.37	2.42	2.36ab	2.08	2.22	2.25	2.18b
T3	2.17	2.28	2.38	2.28b	2.04	2.16	2.23	2.14bc
T4	2.15	2.26	2.35	2.25b	2.02	2.11	2.20	2.11c
Mean	2.24b	2.35a	2.43a		2.07c	2.19b	2.26a	
L S D 0.05	Source	0.127			0.054			
	Rate	0.086			0.045			

Table 6. Effect of source and level on specific gravity and starch content of potato

Sources	Specific gravity (g/cm^3)				Starch (%)			
	Season 2012							
	Rate of application							
	R1	**R2**	**R3**	**Mean**	**R1**	**R2**	**R3**	**Mean**
T1	1.040	1.049	1.054	1.048a	17.41	18.69	19.35	18.48a
T2	1.038	1.046	1.044	1.043b	16.52	17.5	17.6	17.21b
T3	1.032	1.043	1.046	1.040b	14.33	15.27	16.36	15.32c
T4	1.031	1.041	1.045	1.039b	14.22	15.1	16.3	15.21c
Mean	1.035b	1.044a	1.047a		15.62c	16.64b	17.40a	
L S D 0.05	Source	0.0041			0.127			
	Rate	0.0026			0.086			
Season 2013								
T1	1.043	1.051	1.056	1.05a	17.92	18.98	19.76	18.89a
T2	1.040	1.047	1.045	1.044ab	16.81	17.82	17.92	17.52b
T3	1.035	1.043	1.047	1.042b	15.62	16.33	17.01	16.32c
T4	1.033	1.042	1.046	1.040b	15.61	16.32	17.00	16.31c
Mean	1.038b	1.046a	1.048a		16.49c	17.36b	17.92a	
L S D 0.05	Source	0.007			0.134			
	Rate	0.008			0.071			

These results were in agreement with Khan *et al.*(2010) who reported that potatoes with low specific gravity are preferred for preparation of chips and French fries. Potatoes with low specific gravity are used for canning. However, potatoes with very high specific gravity (1.10) may not suitable for French fries production because they become hard or biscuit like. So purpose of growing potato should be kept in mind.

Data in Table 6 illustrate that starch in potato tuber was significantly affected by application of different forms and added K-levels. Starch content was increased with the use of K_2SO_4 compared with the other sources. The result agrees with Perrenoud, (1993) who showed that SO_4 increasing starch content and this was mainly due to improved translocation of metabolites to the tubers.

Adequate K inputs increased quality, assessed by increasing the starch content. This result was in agreement with Lu-Jianwei *et al*., (2001) who evaluated the effect of K fertilizer on the yield and quality of sweet potato crops.

References

Al-Moshileh, A.M. and Errebi, M.A. (2004) Effect of various potassium sulphate rates on growth, yield and quality of potato grown under sandy soil arid conditions. *Proceedings of the IPI Regional Workshop on Potassium and Fertigation Development in West Asia and North Africa, Rabat,* Nov. 2428-. Morocco, pp. 16-.

Al-Zubaidi, A. (2004) Potassium behavior and response under different methods of irrigation and management. *Proceedings of regional workshop on potassium and fertigation development in west Asia and North Africa; Rabat,* Morocco, 2428- November.

Chapman, K.S.R., Hardman, P.R., Sparrow, L.A. wright, D.N. and Thorp, J.R.A. (1992) Potassium nutrition of Kennebec and Russet Burbank potatoes in Tasmania: effect of soil and fertilizer potassium on yield. Petiole and tuber potassium concentrations, and tuber quality. *Aust. J. Exp. Agric.* **32**, 521527-.

Eleiwa, M.E., Ibrahim, S.A. and Mohamed, M.F. (2012) Combined effect of NPK levels and foliar nutritional compounds on growth and yield parameters of potato plants (*Solanum tuberosum* L.). *African J. Microb. Res.,* **6**, 51005109-.

El-Sirafy, Z.M., Abbady, K.A., El-Ghamry, A.M. and El-Dissoky, R.A. (2008) Potato yield quality, quantity and profitability as affected by soil and foliar potassium application, *Journal of Agriculture and Biological Sciences,* 4 **(6)**, 912922-.

Gunadi, N. (2009) Response of potato to potassium fertilizer sources and application methods in andisols of west Java. *Inonesian J of Agric. Sci.* 10 (2), 6572-.

Khan, M.Z., Akhtar, M.E., Safdar, M.N., Mahmood, M.M., Ahmad, S. and Ahmed, N. (2010) Effect of source and level of potash on yield and quality of potato tuber.*Pak. J. Bot.,* **42** (5), 31373145-.

Klute, A. (1986) *Methods of Analysis.* Part I. *Physical and Mineralogical Properties.* 2[nd] ed. Agron. Madison, Wisconsin, U.S.A.

Lu-Jianwei, Chen Fang, Xu Yousheng, Wan Yunfan; Liu-Dong Bi, K.W.Lu, F. Chen; Ys Xu; Yf Wan and Liu D.B. (2001) Sweet potato response to potassium. *Better Crops International.* **15** (1), 1012-.

Magen, H. (2004) Potassium in fertigation systems. International Potash Institute (IPI), 5[th] fertigation Training Coarse Boading, AUH, June.

Malakouti, M.J., Ziaeyan, M.J. Khademi, M.R., Balali, M., Shahabian, M., Bastirat, H., Rezaee, M.H. Davoudi, S., Samavat, S., Manouchehri and Kafi, M. (1995) Effects of rates and sources of potassium on some field and horticultural crops in Iran. http://www.cf.uwe.edu/ces/pubspdf/A2521.pdf. [14 March 2003].

Mehdi, S.M. Sarfaz, M. and Hafeez, M. (2007) Response of rice advance line P.B- 95 to potassium application in saline-sodic soil. *Pak. J. Biol. Sci*., **10**, 29352939-.

Page, A. L., Miller, R. H. and Keeney, D.R. (1982) *Methods of Soil Analysis*, Part 2, 2[nd] ed ,American Society of Agronomy, Madison, WI,USA.

Perrenoud, S. (1993) Fertilizing for higher yield potato. [P] Bull. No. 8 2[nd] ed. International Potash Institute, Berne, Swizrland.

Reis-Junior, R.A. and Monnerat, P.H. (2001) Nutrient removal by potato tuber in response to potassium sulphate applications. *Horticulture Bras. Leira.* **19** (3), 360364-.

Snedecor, G.W. and Cochran, W.G. (1990) *Statistical Methods.* The lowa state Univ. 7[th] ed. pp.507.

Tawfik, A.A. (2001) Potassium and calcium nutrition improves potato production in drip-irrigated sandy soil. *Fifth Triennial Congress of the African potato Association,* 28 May – 2 June 2000. Kampala, Uganda. African crop science Journal. **9** (1): 147155-.

Vander Zaag, P. (1981) Soil fertility requirements for potato production. International potato Center (CIP), Lima-*Peru, Technical Information Bulletin ,* **14**, 120-.

Zekri, M. and Obreza, T.A. (2009) Plant nutrients for citrus trees. SL 200, UF/IFAS Extension service, Institute of Food and Agricultural Science, University of Florida.

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تقييم مصادر ومعدلات الأسمدة البوتاسيةعلي محصول وجودة البطاطس النامية فى الاراضى الرملية تحت نظام الرى التسميدى .

سيد طه أبو زيد و أمل لطفى عبداللطيف
قسم علوم الاراضى- كلية الزراعة- جامعة القاهرة-الجيزة- مصر.

أقيمت تجربة حقلية فى تربة رملية بمدينة السادات –مصر- لموسمين متعاقبين (2012-2013) وذلك لتقييم تأثير مصادر ومعدلات مختلفة من الاسمدة البوتاسية على المحصول الكلى وجودة درنة البطاطس لصنف دايمونت. نفذت التجربة تحت نظام الرى بالتنقيط واستخدم فيها التصميم الاحصائى لنظام القطع المنشقة مرتين فى ثلاث مكررات. استخدم 4 مصادر مختلفة من الأسمدة البوتاسية وهى كبريتات البوتاسيوم و كلوريد البوتاسيوم وكربونات البوتاسيوم و هيدروكسيد البوتاسيوم وذلك بثلاث معدلات وهى 80 ،100 ،120كجم K_2O للفدان تم اضافتهم فى نظام الرى بالتنقيط..

وبمقارنة مصادر ومعدلات أسمدة البوتاسيوم المختلفة، أوضحت النتائج أن هناك اختلافات معنوية بين مصادر ومعدلات الاسمدة البوتاسية على كلا من المحصول الكلى ووزن وقطر الدرنة والكثافة النوعية ومحتوى الدرنة من النشا. وأظهرت النتائج أن استخدام K_2SO_4 كان أفضل مقارنة بباقى المصادر الاخرى.

و أوضحت النتائج أن كلا من المحصول وجودة الدرنة تزيد بزيادة معدلات البوتاسيوم حتى 120 كجم K_2O للفدان ، فيما عدا معاملة (KCl).