*Egypt. J. Soil. Sci.* 47, No. 1, pp.1- 8 (2007)

# Response of Potato to Potassium and Magnesium Fertilizers in Sandy Soils

**A.A. Abd El-Kader, A.M. Shafei and R.A. Youssef**
*Soils and Water Use Department, National Research Centre, Cairo, Egypt.*

A COMPLETELY randomized field experiment with three replication were conducted during two successive seasons ( 2005-2006) at El-Saff , Giza Governorate , Egypt to study the effect of K and Mg fertilization on the yield and nutritional status of drip irrigated potato (*Solanum tuberosum.* L *cv. Sponta*) . Examined fertilization rates were 0, 48, 72 and 96 kg / fed. $K_2O$ and 0, 6, 12 and 18 kg/ fed for MgO .

Obtained results show that the main values of increments in the yield were 23.6 % and 219.9 % for Mg and K levels, respectively. In general, the yield increases as the rate of applied K increases up to 96 kg / fed. The data also indicate the superiority of the combination rates of K fertilizer with 18 kg MgO / fed on the dry mass of the leaves of potato plants, tuber yield and their content of nutrients, *i.e.*, N, P , K , Ca and Mg . The highest value of K /Ca+Mg in the leaves ($\approx$ 6) was considered sufficient. At that ratio, the maximum total yield was obtained. Exchangeable K and Mg were increased linearly with the application rates of both nutrients. Similar to that of K/Ca+Mg, the higher the exchangeable K and Mg in the soil is, the higher is the obtained yield.

The results confirmed the necessity of recommended K fertilization program to be applied together with suitable rate of magnesium fertilizer to obtain better growth and high yield of potatoes rich in nutrients from sandy soils.

**Keywords:** Sand soils, Potassium and Magnesium fertilization, Potato yield.

Nutrient application should be made in the basis of plant demand. Plant demand is a function of growth rate, climatic conditions and cultivar. The amounts of nutrients required by potato crop are also related to a realistic yield potential for the selected cultivar and land farmed. Thus, the amount of fertilizer applied to potato crop should depend on the supplying power of the soil, the potential for nutrients loss and the growth potential of the cultivar (Dean, 1994). The potato crop requires high levels of fertilizers particularly K (Perrenoud, 1993). It is needed for sugar translocation, starch synthesis (Reis Jr & Fontes, 1996) and to promote high potato tuber yield (Westermann *et al.*, 1994b) of good quality (Westermann *et al.*, 1994a). Although the need of K fertilizer could be high, the elevated input of this nutrient can cause some problems, as undesirable nutrients

interactions. For example, when $K^+$ supply is abundant, "luxury consumption" often occurs, which affects plant composition and interferes with the uptake and physiological availability of $Ca^{2+}$ and $Mg^{2+}$ (Marschner, 1995). Interactions between the two mineral nutrients are important when the levels of both are near the deficiency range, because increasing the supply of only one mineral nutrient stimulates growth, which in turn can induce a deficiency of the other by the dilution effect (Marschner, 1995).

The importance of K application in the potato crop and problems associated to high fertilizer inputs demand that K fertilizer should be used in an efficient way. Therefore, the objective of this study was to determine the effect of K and Mg application to sandy soils on: (i) growth and tuber yield of potato (ii) uptake of K and Mg by potato plants (*Solanum tuberosum* L .) grown on such soils.

## Material and Methods

A two successive years field experiment was conducted on a sandy soil at El-Saff, Giza Governorate. Some chemical and physical properties of the studied soil and irrigation water were determined according to Page *et al.* (1982); Cottenie *et al.* (1982) and Klute (1986). Table 1a completely randomized design was followed with three replicates. Each experimental plot contains 16 plants.

Drip irrigation system was used. The distance between drippers was 0.33 m. Super phosphate (15.5 % $P_2O_5$) was broadcasted at rate of 45 kg $P_2O_5$ / fed in two equal doses, *i.e.,* before planting and with the third dose of N, respectively. Nitrogen was added to soil in three equal doses as ammonium nitrate (33.5 % N) at the rate of 90 kg /fed. The first dose was after complete planting while the second and the third were after two weeks and one month later. Potassium was applied as potassium sulphate (48 % $K_2O$) at the rates of 0, 48, 72 and 96 kg/ fed. Magnesium was also applied as magnesium sulphate (15 % MgO) at the rates of 0, 6, 12 and 18 kg MgO /fed. Potatoes (*Solanum tuberosum* L. *cv.sponta*) have been cultivated for two successive winter seasons (2005 and 2006). After 120 days from planting,the plants were harvested.

The following parameters were taken for evaluation :

1- Dry mass, K,Ca and Mg content in the mature leaves (Cotteni *et al.*, 1982).
2- Tuber yield (ton/fed) .
3- Nitrogen, P, K, Ca and Mg content in the tubers (Cotteni *et al.*, 1982).
4- Exchangeable K and Mg in the soil (Page *et al.*, 1982).

Obtained results were statistically analyzed using the methods described by Snedecor & Cochran (1981).

**TABLE 1. Some chemical and physical properties of the experimental soil as well as water used for irrigation.**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Soil | Particle size distribution (%) | | | | | | | | | |
| | Sand | | Silt | | Clay | | texture | | | |
| | 90.3 | | 5.0 | | 4.7 | | sandy | | | |
| | chemical properties | | | | | | | | | |
| | EC (1:5) dS/m | | pH ( 1:2.5 susp.) | | CEC cmol/kg | | O.M % | | $CaCO_3$ % | |
| | 2.1 | | 7.6 | | 4.84 | | 0.06 | | 11.95 | |
| | Available macronutrients (ppm) | | | | | | | | | |
| | N | | P | | K | | Ca | | Mg | |
| | 32 | | 6 | | 63 | | 300 | | 108 | |
| Water wel | pH | EC dS/m | Soluble cations meq/l | | | | Soluble anions meq/l | | | |
| | | | Na | K | Ca | Mg | CO3 | HCO3 | Cl | SO4 |
| | 7.68 | 1.23 | 5.78 | 0.23 | 6.47 | 4.74 | 0.05 | 2.41 | 0.98 | 13.67 |

*Adj.SAR = 5.06

## Results and Discussion

As the obtained results of both successive seasons were not significantly different, their average was taken into consideration.

Data given in Table 2 reveal that treating the soil with the different application rates of both K and Mg fertilizers generally increased the tuber yield of potato and its nutritional status, compared to that of the control treatment (untreated one). In most cases the increments in tuber yield were proportional to the increase in the individual application rate of either K or Mg fertilizer. The mean values of the increment in the tuber yield due to the addition of different rates of either Mg or K were 23.6 % or 219.9 %. The data also demonstrate the superiority of the different rates of K when combined with 18 kg MgO / fed, for increasing the tubers yield and the nutrient content in the tubers. With this respect, the relative increase due to the combination of both K at the rate of 96 kg $k_2O$/ fed and Mg at the rate of 18 kg MgO / fed were 306 % for the tubers yield. For the same treatment, N, P, K, Ca and Mg in the tubers reached their maximum to be 10.9, 20.1, 9.2, 21.4 and 16.4 times that of the control treatment, in sequence.

The positive effect of increasing both K and Mg levels on yield may be due to that potassium increase the efficiency of utilizable nitrogen taken by plant as well as other metabolic processes in the plant (Putrskii,1971). Moreover the obtained results were in agreement with those of Fontes *et al.* (1996) and Singh (1999). They reported that increase in total yield and the yield of large tubers caused by K fertilization may be due to the stimulating effect of potassium on photosynthesis, phyloem loading and translocation, as well as synthesis of large molecular weight substances within storage organs, contributing to the rapid bulking of the tubers.

**TABLE 2. Tubers yield of potato and nutrients content as affected by K and Mg applications.**

| Applied rates kg/fed | | Yield ton/fed | Macronutrient content kg/fed | | | | |
|---|---|---|---|---|---|---|---|
| $K_2O$ | MgO | | N | P | K | Ca | Mg |
| 0 | 0 | 3.52 | 19.6 | 1.4 | 28.1 | 7 | 5 |
| | 6 | 3.83 | 22.7 | 1.8 | 34.1 | 8 | 31 |
| | 12 | 4.13 | 26.3 | 2.1 | 37.7 | 11 | 40 |
| | 18 | 4.83 | 29.9 | 2.7 | 44.0 | 12 | 52 |
| 48 | 0 | 6.96 | 107.1 | 9.8 | 104.3 | 55 | 22 |
| | 6 | 7.63 | 115.7 | 10.8 | 110.7 | 75 | 45 |
| | 12 | 8.24 | 143.7 | 15.8 | 126.1 | 87 | 58 |
| | 18 | 8.83 | 163.7 | 18.1 | 154.3 | 93 | 72 |
| 72 | 0 | 9.63 | 118.1 | 12.6 | 128.0 | 68 | 29 |
| | 6 | 10.06 | 133.3 | 14.2 | 163.0 | 86 | 53 |
| | 12 | 11.09 | 156.7 | 15.6 | 168.7 | 106 | 75 |
| | 18 | 11.83 | 181.3 | 18.6 | 218.7 | 120 | 79 |
| 96 | 0 | 12.09 | 125.6 | 14.7 | 164.8 | 79 | 38 |
| | 6 | 12.74 | 156.5 | 19.6 | 209.9 | 104 | 58 |
| | 12 | 13.08 | 190.4 | 22.9 | 236.5 | 122 | 76 |
| | 18 | 14.29 | 213.1 | 28.2 | 257.9 | 150 | 82 |
| LSD at 0.05 | | 1.15 | 3.2 | 1.8 | 9.1 | 9 | 18 |

*Mean of two seasons

Data presented in Table 3 pointed out that the high rates of both K and Mg combined with each other gave the highest values of leaves dry weight. The relative increase of dry weight of the leaves was 228.6% compared to that of control treatment (untreated). Moreover, the dry weight of leaves is mostly close to the yield of the tubers where the highest dry weight of leaves was obtained when 96 kg $K_2O$ / fed was combined with 18 kg MgO / fed where it reached 15.5 times that of the control treatment.

Obtained results were confirmed by those of Omran *et al.* (1991) and El-Metwally (2003) who found that the yield of potato tubers was increased as the rate of K fertilization increased up to 96 kg / fed, while in the case of Mg addition, the maximum yield of tubers was obtained at the rate of 18 kg MgO / fed when Mg was added to the soil separately or combined with K fertilizer.

Data in Table 3 show that the K/Ca +Mg ratio was increasing by increasing the rate of both K and Mg application to reach ≈ 6 by applying 96 units of $K_2O$ and 18 units of MgO / fed. Moreover, the soil exchangeable K and Mg were increased linearly with the application rates of both nutrients. Fig. 1 illustrate potato yield in relation to soil exchangeable K and Mg. Similar to that of K/ Ca+Mg, the higher the exchangeable K or Mg in the soil is , the higher is the obtained yield .

**TABLE 3. K/Ca+ Mg in potato leaves as affected by K and Mg levels.**

| Applied rates | | Dry weight of 100 leaves (g) | K g/100g | Ca +Mg g/100g | K/ Ca +Mg | Class* |
|---|---|---|---|---|---|---|
| $K_2O$ Kg/fed | MgO Kg/fed | | | | | |
| 0 | 0 | 69.3 | 1.23 | 0.70 | 1.75 | Low |
| | 6 | 74.7 | 1.30 | 0.72 | 1.81 | Low |
| | 12 | 79.1 | 1.48 | 0.77 | 1.93 | Low |
| | 18 | 84.7 | 1.61 | 0.82 | 1.96 | Low |
| 48 | 0 | 91.3 | 2.10 | 0.44 | 3.14 | Medium |
| | 6 | 101.3 | 2.17 | 0.69 | 4.72 | Medium |
| | 12 | 115.7 | 2.27 | 0.72 | 3.15 | Medium |
| | 18 | 129.1 | 2.33 | 0.75 | 3.11 | Medium |
| 72 | 0 | 136.7 | 2.33 | 0.46 | 5.07 | Medium |
| | 6 | 144.1 | 2.45 | 0.55 | 4.45 | Medium |
| | 12 | 151.7 | 2.46 | 0.61 | 4.33 | Medium |
| | 18 | 161.1 | 2.51 | 0.72 | 3.49 | Medium |
| 96 | 0 | 176.7 | 2.53 | 0.58 | 4.36 | Medium |
| | 6 | 195.3 | 2.63 | 0.56 | 4.70 | Medium |
| | 12 | 210.3 | 2.91 | 0.55 | 5.29 | Medium |
| | 18 | 227.7 | 3.29 | 0.55 | 5.98 | Sufficient |

* Fontes *et al.* (1996).

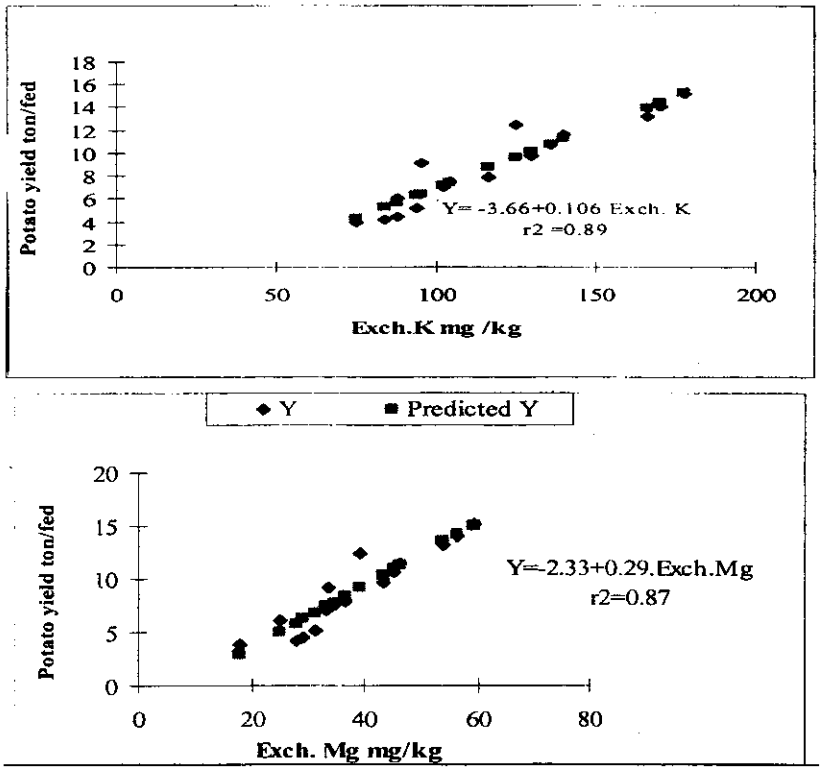


**Fig .1. Potato yield in relation to soil exchangeable K and Mg.**

According to Fontes *et al.* (1996) this ratio is considered sufficient. It is worthy to note that at this ratio , the highest yield of potato tubers was obtained. Moreover, the soil exchangeable K and Mg were increased linearly with the application rates of both nutrients. The aforementioned results confirmed the necessity of recommended NPK fertilization program to be applied together with the suitable rate of Mg fertilizer to obtain better growth and high yield of potatoes rich in plant nutrients from sandy soils

## References

**Cottenie, A.; Verloo, M.; Kekens, L.; Velghe, G. and Camberlynck, R. (1982)** *"Chemical Analysis of Plants and Soils"*. Lab. Agroch., pp. 15 -19, State Univ. Ghent.

**Dean, B.B. (1994)** Cultivation, fertilization, and irrigation. In: *"Managing the Potato Production System"*, pp. 69–83, Haworth Press, Inc. New York .

**El-Metwally, M.E. (2003)** Fertigation of drip irrigated potato (*Solanum tuberosum*, L.) *Ph. D. Thesis;* Mansoura Univ., Fac. Agric., Soil Sci. Dept.

**Fontes, P.C.R.; Reisjr, R.A. and Pereira, P.R.G. (1996)** Critical potassium concentration and potassium/calcium plus magnesium ratio in potato petioles associated with maximum tuber yields. *Journal of Plant Nutrition* **19**: 657- 667.

**Klute, A.A. (1986)** *"Methods of Soil analysis"*, Part I , 2nd ed., Physical and Mineralogical Properties., Amer. Soc. Agron. Madison, Wisconsin, USA.

**Marschner, H. (1995)** *"Mineral Nutrition of Higher Plants."*, 2nd ed., 889p., London, Academic Press .

**Omran, M.S.; Tayser, M.; Waly, M.; El-Shinnawi, M. and El-Sayed, M.M. (1991)** Effect of macro – and micro – nutrients application on yield and nutrients contents of potatoes. *Egypt. J. Soil Sci.* **31** (1): 27-42.

**Page, A.L.; Miller, R.H. and Keeney, D.R. (1982)** *"Methods of Soil Analysis"*, Part 2, 2nd ed. Chemical and micro- biological properties, Amer. Soc. Agron., Madison, W.I., USA.

**Perrenoud, S.(1993)** Potato: fertilizers for yield and quality. Bern: International Potash Institute , 94p.

**Putrskii, N.V. (1971)** Varietal response of potato to fertilizers. Sbornik Nouchnykh Trudov Beloruskol Sel Skokhozyaistvennoi Akademi **72**, 111.

**Reis jr, R.A. and Fontes, P.C.R. (1996)** Qualidade de tubérculos da batateira em função de doses de adubação potássica. *Horticultural Brasileira* **14:** 170-174.

**Singh, J.P. (1999)** Potassium fertilization of potatoes in north India.In: *Proceedings of IPI Workshop on: Essential Role of Potassium in Diverse Cropping Systems,* held at the 16 th World Congress of Soil Science, Montpellier, France, 20-26 August, 1998, pp.123-127, International Potash Institute, Basel, Switzerland.

**Snedecor , G. W. and Cochran, W. G. (1981)** *"Statistical Methods"* , 7 $^{th}$ ed., Iowa State Univ., Iowa, USA.

**Westermann, D.T.; James, D.W.; Tindall, T.A. and Hurst, T.R. L.(1994b)** Nitrogen and potassium fertilization of potatoes: sugars and starch. *American Potato Journal* **71**: 433-454.

**Westermann, D.T.; James, D.W.; Tindall, T.A. and Hurst, T.R. L. (1994a)** Nitrogen and potassium fertilization of potatoes:yield and specific gravity. *American Potato Journal* 71: 417- 432.

(*Received* 8/2006;
*accepted*11/2006)

# استجابة محصول البطاطس للتسميد بالبوتاسيوم والماغنسيوم فى الاراضى الرملية

**عبد القادر عبد الفتاح عبد القادر ، أحمد محمد شافعي و رفعت عبد القوي يوسف**
قسم الأراضي وإستغلال المياه- المركز القومي للبحوث – القاهرة – مصر .

أجريت تجربة حقلية بنظام تام العشوائية ذو ثلاثة مكررات خلال موسمين زراعيين متتاليين (٢٠٠٥ و٢٠٠٦ ) في أرض رملية بمنطقة الصف بمحافظة الجيزة وذلك لدراسة تأثير كل من التسميد البوتاسي والماغنسيومي علي المحصول ومستوي العناصر الغذائية في البطاطس الصنف سبونتا والمزروعة تحت نظام الري بالتنقيط . كانت المستويات المختبرة من السماد البوتاسي صفر، ٤٨ ،٧٢، ٩٦ كجم بو٢ ا / فدان ومن السماد الماغنسيومي صفر ، ٦ ، ١٢ و ١٨ كجم مغ ا/ فدان.

أظهرت النتائج أن متوسط الزيادة في المحصول كانت ٢٣,٦٪ و ٢١٩,٩٪ نتيجة إضافة الأسمدة الماغنسيومية والبوتاسية علي التوالي. ويزداد المحصول بزيادة معدل إضافة السماد البوتاسي حتي ٩٦ كجم بو٢ ا / فدان. كما أظهرت النتائج أيضا تفوق تأثير إضافة السماد البوتاسيوم مع المعدل ١٨ كجم مغ ا/ فدان علي كل من وزن العرش ومحصول الدرنات ومحتواها من العناصر الغذائية . أعتبرت نسبة البوتاسيوم/ الكالسيوم + الماغنسيوم في الأوراق عند المعاملة ٩٦ كجم بو٢ ا / فدان و١٨ كجم مغ ا / فدان كافية (حوالي ٦) والتي عندها تم الحصول علي أعلي محصول للدرنات . ونتيجة لاضافات الأسمدة البوتاسية والماغنسيومية للتربة الرملية فقد ازداد تركيز كل من البوتاسيوم والماغنسيوم المتبادلين فيها ووجدت علاقة طردية بينهما وبين محصول الدرنات.

أوضحت النتائج ضرورة تنفيذ برنامج تسميدي للبطاطس المنزرعة في الأراضي الرملية يشتمل علي معدلات مرتفعة من عنصري البوتاسيوم ( في حدود ٩٦ كجم بو٢ ا / فدان) والماغنسيوم ( من ١٢- ١٨ كجم مغ ا / فدان) للحصول علي نمو أفضل ومحصول أعلي غني بالعناصر الغذائية .