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Dr. Márton László
RISSAC, Budapest, Hungary, laszlo.marton@gmail.com, +35 1 3558491

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DR. MÁRTON L. PhD
RISSAC-HAS, Agrochemistry, Budapest, Hungary (marton@rissac.hu, +36 1 3558491)

Abstract

Nowadays potato (Solanum tuberosum L.) is a more important throughout the world between field crops. As potato is such a potassium demanding crop, it is particularly important that the potassium fertilizers used should be correctly balanced. Applying the adequate quantity of balanced K- fertilizer is the first requirement for achieving optimum yield and doing so will result in potatoes of acceptable quality. Potato potassium nutrition has been studied at the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (RISSAC-HAS)- Experiment Station, Nagyhörcsök (chernozem soil) in a long term field experiment designed to determine NPK- nutrient requirements. The method of the experiment was 43 mixed factorial design with 64 treatments in 2 repetitions with 128 plots. The residual effects of K- levels brought about by build- up fertilization were studied. Potato were planted in 1978. The experimental dates were estimated by multivariate analysis of variance (MANOVA). On the basis of foliar analysis at early flowering about 4.5 to 5.0% K in dry matter proved to be satisfactory for obtaining maximum yield (32.6 t/ha). The yields increased by 22%, 34%, and 38% at 124-140, 141-168 and 169-208 ppm soil AL- K2O rates, respectively. The tubers concentrated much N 19% and less P 81% than potassium. Results for tuber maximum uptake of potassium reached a maximum about 130 days after planting. The improvement of the K supply of the soil increased yield and induced low concentrations of numerous microelements on leaves considered to be important.

Key words: Potato (Solanum tuberosum L.), chernozem soil, potassium, yield

Introduction

Potato is an important food crop, more particularly in the temperate zone, especially in Europe and Asia. Between 1981 and 1995, in spite of an 18% decrease in cultivated area production increased by 13% because the average yield increased from 11.0 to 15.1 t/ha. Potato is a soil nutrients demanding crop and has a particularly high requirement for potassium. Tubers remove 1.5 times more potassium than nitrogen and 4 or 5 times the amount of phosphate. The quantity of nutrients taken up by a crop is not necessarily an indication of responsiveness to fertilizers but potato, because its root system is relativly poorly developed in relation to yield is extremly responsive to all nutrients (Márton 1984). As potato is such a demanding crop, it is particularly important that the potassium fertilizers used should be correctly balanced (Burton 1966). Applying the adequate quantity of balanced K- fertilizer is the first requirement for achieving optimum yield and doing so will result in potatoes of acceptable

quality (Márton 2000). It is not the objective of present publication to give recommendations K- fertilizers which vary greatly according to local conditions. We intend to discuss various aspects of potassium effects on the basis of our research results.

The importance of potatoes

In terms of area planted, potato is the twelfth most important crop in all the world (18.48 million hectares) by FAO in 1995. In terms of total production it occupies the 5th position with 280 million t, between maize (515 mio) and sugar beet (266 mio). It is a high yielding crop. The world average being 15.1 t/ha, the third highest yielding crop on the bases of fresh matter following sugar cane (62.6 t/ha) and sugar beet (33.9 t/ha).

Area planted, production and yield (1981 and 1995)

Between 1981 and 1995 the total world area planted declined by 18%. While the importance of the crop declined more or less markedly in Europe, and in N. and C. America, there has been an increase in S. America (Márton 1999). The area planted in Asia has more than doubled and in Africa tripled. Despite of the reduction in area, world production has actually increased by 13% in the same period. This increase in production is due to a general 37% growth in yield from 11 to 15.1 t/ha. The potential yields of varieties, estimated at 85-100 t/ha for potato, 75-85 t/ha for beet and 12-15 t/ha for wheat (Evans 1977). These are far higher than the yields commonly obtained in practice. World average yields were only 1/6th of the potential for potato, 1/6th for wheat and 2/5th for sugar beet in 1995.

Utilization of the crop

The major part of potato production is usually used for human consumption. Human consumption of potatoes however has declined in the industrialised countries as the standard of living has increased. In these countries an increasing proportion of the crop is used for manufacturing products such as crisp, oven-ready chips, dehydrated potato powder. Thus, in Hungary the consumption of potatoes per person decreased from 110 kg in 1951/1960 to 60 kg in 1995, whereas the consumption of processed potatoes increased from 1 to 15 kg/person during this period.

Uptake of potassium

Potassium is the nutrient taken up by potato in the greatest quantity, it also takes up much nitrogen and appreciable amounts of phosphorus, calcium, magnesium and sulphur (Perrenoud 1993). Maximum uptakes by different varieties in Japan range between 140 and 267 K2O (Kali Kenkyu Kai 1980). In England, potatoes grown on the „ blueprint" system and giving the very high yield of 77.7 t/ha took up 450 kg/ha K2O (Anderson and Hewgill 1978). Brazílian experiments with 6 varieties showed the following uptakes (kg/ha): potassium 207-367 (Motta 1976).

Removal of potassium by tubers

23 experimental crops in France (Loué 1977), -with a mean yield of 37.3 t/ha tubers removed: 196 kg K2O, respectively. It is equal to 5.3 kg K2O per 1 tonne tuber. Motta Macedo (1976) reports the following removals in kg/ha for 6 varieties grown in Brazíl: K2O: 118-192. In 14 experiments in India (Grewal and Singh 1979) a mean yield of 28.8 t/ha tuber was obtained which removed an average of 91 kg/ha K2O. At very high yield level, nutrient removal in tuber is very high. Anderson and Hewgill (1978) report a yield of 90 t/ha, obtained at Stockbridge House in 1973 which contained 487 kg K2O in the tubers.

The effects of potassium fertilizer on yield

The averages of 1267 experimental results (607 from 8 developed countries and 660 from 10 developing countries) were estimated. Yields increased by 14, 10 and 11% for 1-100, 101-200 and 201-300 kg/ha K2O rates, respectively. The greater average effect of potassium on yield at the 1-100 kg/ha K2O rate as compared to higher doses was due to the strong effect of this nutrient in experiments. 1 kg K2O produces 32, 16 and 13 kg tubers when 1-100, 101-200 and 201-300 kg/ha K2O are applied. An example of the effect of potassium on yield is in the Siebold (1971) reports that heavy potash dressing had spectacular effects on yield on a soil which fixed potassium strongly.

Nutrient interactions

In 17 years of a long- term experiment at Aspach (France) (Loué 1977) positive interactions between N and K

were recorded in 15 years and negative in 2. Yadav and Tripathi (1973) recorded an NxK interaction amounting to 4.44 t/ha tubers in India.

Materials and Methods

The NPK fertilization field trial was set up at the Nagyhörcsök Experiment Station of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences by Imre Kádár in the autumn of 1973. The method of the experiment was 43 design of the mixed factorial with 64 treatments, in 2 repetitions with 128 plots. The gross and net size of the plots were 6 x 6 = 36 m2 and 24.5 m2 respectivly. N fertilization was repeated yearly. As regards P and K residual effects of nutrient levels brought about by build-up fertilization in autumn 1973, were recorded. The experiment was carried out in South-East Hungary on a calcareous chernozem soil. The clay fraction (0.002 mm) content of the soil was 20 % and silt fraction (0.02 mm) 40 %. The 0.05-0.02 mm fraction was 35-50 %. The main characteristics of the soil (plough layer) are as follows: CaCO3 5 %, humus 3 %, pH(KCl) = 7.4-7.8, AL-P2O5 = 50-80 ppm, AL-K2O = 120-140 ppm, Mg(KCl) = 120-150 ppm, EDTA-Mn = 100-150 ppm, EDTA-Zn = 1-2 ppm, EDTA-Cu = 2-4 ppm. The initial nutrient supply of the soil was poor in P and medium in K. After build-up fertilization (1973) the easily soluble phosphorus and potassium contents of the soil rapidly decreased without yearly maintenance fertilization. In the first four years of the experiment winter wheat-winter wheat-maize-maize were grown. Potatoes (variety: Desirée) were planted by hand in 1978. Plant sampling was carried out by averaging 20 subsamples per plot. The experimental data were estimated by multivariate analysis of variance, MANOVA. In this paper We would like to present the potassium effects on potato yield.

Results and Discussion

Uptake of potassium

Under the experimental conditions of 1978, on the basis of foliar analysis at early flowering, in dry matter about 4.5 to 5.0% K proved to be satisfactory for obtaining maximum yield (32.6 t/ha).

Effects of K- fertilizers on yield

Potato yields increased by 22%, 34% and 38% at 124-140, 141-168 and 169-208 ppm soil AL- K2O rates, respectively. That the average effect of potassium on yield was greater at 208 ppm K2O than at higher rates is due to the strong effect of this nutrient in experiments. 1 ppm K2O produced 268, 232 and 185 kg tubers when 124-140, 141-168 and 169-208 ppm K2O were applied. These results are very similar to those reported by Siebold (1971), he found that heavy dressing of potash had spectacular effects on the yield on a soil with strong potassium-fixing ability.

Removal of potassium and other nutrients in tuber

The tubers removed much nitrogen, 0.1 times more than potassium and 6 times as much as phosphorus. Removal of calcium and magnesium were much lower but still significant. In experiment- giving a mean yield of 32.6 t/ha tubers on K- effects on average of NP removed 454 kg N, 76 kg P2O5, 488 kg K2O, 81 kg CaO, 26 kg MgO and 14 kg/t N, 2 kg/t P2O5, 15 kg/t K2O, 3 kg/t CaO and 0.8 kg per tonne MgO, respectivly. We found that 32.6 t/ha crop removed 1.8 kg sodium, 1.6 kg iron, 400 g zinc and 100 g manganese.

Pattern of potassium and other nutrient uptake

The uptake of nutrients during potato growth were studied. Results for tuber average uptake of nitrogen (472 kg/ha), phosphorus (77 kg/ha) and potassium (426 kg/ha) reached a maximum about 130 days after planting. It was observed that crop took up about 3.6 kg N, 0.5 kg P and 3.0 kg K per ha per day.

Nutrient interaction

Improving K- supply of the soil was found to increase yield and induce low concentration of numerous elements on leaves considered as important. K- fertilization had a negative effect mainly on the Mg and Ca contents. Thus

e.g. K/Mg ratio increased from 3 to 11 at yearly flowering as an effect of K fertilization, that however, should not be considered an unfavourable ratio as yet and on these plots K fertilization still remained effective.

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