English Version

Evaluation of NPK 8-30-20 with gypsum addition compared to fertilization employed in the region for the production of potato (*Solanum tuberosum* L.)

Sidnei Osmar Jadoski[1]; Marcio Furlan Maggi[1]; Adenilsom dos Santos Lima[1]; Douglas Jobim Vieira[2]; Rafael Wazne[2]

Abstract

Different forms of fertilizer management are employed by potato farmers, and from time to time, it appears a receipt to fertilize the crop. However, one should pay special attention to nutrition and fertilization of the potato as the relative demand of fertilizer per unit area in culture is high. The objective was to evaluate the use of NPK 8-30-20 with the addition of gypsum compared to NPK 4-14-8 (regional standard treatment) in the production of potato. The study was conducted at the Research Unit in Potato Production and Microclimate on Agriculture, *Campus* CEDETEG at UNICENTRO in Guarapuava - PR. The treatments were: T1 - 3.5 t ha^{-1} NPK 4-14-8, T2 - 3.5 t ha^{-1} NPK 4-14-8 over the application of 3 t ha^{-1} gypsum; T3 - 1.75 t ha^{-1} NPK 8-30-20, T4 - 1.75 t ha^{-1} NPK 8-30-20 plus the application of 3 t ha^{-1} gypsum, T5 - 1.75 t ha^{-1} NPK 8-30-20 plus the application of plaster to make up the difference between fertilizer. The cultivation of potato was held on December 23, 2008 and the cultivar used was Agatha. The seed used was Generation 01 and tubers of class II. The density used was 50.000 tubers per hectare. The experimental design was completely randomized design with five treatments and four replications. It was evaluated the productivity and classification of tubers of the size and incidence and severity of common scab (*Streptomyces* spp.) and silver scurf (*Helminthosporium solani* Dur. And Mont.) in the tubers. Statistical analysis was performed by ANOVA test and mean comparison by Tukey test (5%). Classification of the tubers was performed according to the diameter classes of the Ordinance No. 69 MAP of February 21, 2005. The use of manure at 5 t ha^{-1} NPK 4-14-8 over the application of 3 t ha^{-1} gypsum and 1.75 t ha^{-1} of 8-30-20 NPK plus the application of 3 t ha^{-1} gypsum causes the best results of yield of potato tubers and better classification. The application of gypsum was important to reduce the incidence of common scab independent of the formulation and application of NPK without addition of gypsum predisposes the crop to a higher incidence of scabies.

Keywords: fertilization on potato; gypsum; common scabies; silver scurf

Introduction

Potato, *Solanum tuberosum* L.(Solanaceae) is an important source of food in all world. Their main consumers are the Americans and Europeans, with an emphasis to Germans and Russians, whose consumption per capita/year is the highest (SOUZA and REIS, 1999). In Europe and America, except Brazil, potato is a basic food to various social classes (FILGUEIRA, 1987). Brazil is considered the main cucurbit crop, either in cultivated area or in food preference (LOPES and BUSO, 1997).

The Brazilian potato cultivation does not adopt technical-scientific criteria concerning soil amendment and mineral nutrition of the plant (VIEIRA and SUGIMOTO, 2002). This fact may compromise productivity and affect significantly the cost of production since, according to Embrapa (1999), the cost with fertilizers on the potato crop represents approximately 15% of the total cost.

Different forms of fertilization management are employed by potato farmers, since it occasionally appears a receipt to fertilize the crop. However, one should be aware of the fertilization and the nutrition of potato because the relative demand of fertilizers per area unit in the crop is high, occupying the first place on the "ranking" among the main plantations, i.e., cotton, coffee, soybean, maize and beans (VIEIRA and SUGIMOTO, 2002).

With the application of gypsum it is possible to obtain the saturation of Aluminum in the deepest

1 Professor Adjunto do departamento de Agronomia da Universidade Estadual do Centro-Oeste - UNICENTRO, Guarapuava - Pr

2 Academico do Curso de Agronomia da Universidade Estadual do Centro-Oeste - UNICENTRO, Guarapuava - Pr

layers of the soil. Thus, this process creates conditions to the root system of the plants to go deeper and, consequently, minimize the effect of the *veranicos*[1]. However, gypsum does not neutralize the soil acidity (EMBRAPA, 2004). Gypsum is a byproduct on the production of phosphoric acid, and it is widely available in many parts of the world. Only in Brazil, approximately 3.3 millions of tonnes are produced annually (FREITAS, 1992). Chemically, gypsum is constituted of Calcium sulfate dihydrate ($CaSO_4.2H_2O$), composed of at least 16% of Ca and 13% of S (SOUSA e LOBATO, 2004). The application of gypsum on the surface, followed by leaching to acid soils, results in better growth and larger water and nutrient absorption by plant roots (CARVALHO e RAIJ, 1997).

The movement rate of Ca and Mg on the profile therefore depends on the existence of other anions on the soil solution, especially nitrates, chlorides and sulfates, mainly from the mineralization of the organic matter and in quantities which can explain, at least partially, the differential mobility of the effects of limestone in different soils (PEARSON et al., 1962; GONZALEZ-ERICO et al., 1979).

The pH and Al values changed a little in depth due to the low solubility of agricultural limestone acidity and to the high reactivity of their anions with acids present in the soil layer in which limestone is incorporated. The low Ca and Mg mobility, by contrast, happens due to the low permanency of the anions added by limestone in the soil solution. Thus, almost all Ca and Mg added goes to the negative charges created by an increase on the pH, or to the charges that were occupied by Al, and only a small part stays on the soil solution.

Some soil intrinsic characteristics, mainly those related to the buffering, also affect the depth of acting of these reactions, which in some cases can reach layers to 40-60 cm of depth. (QUAGGIO et al., 1982; MORELLI et al., 1992). Gypsum ($CaSO_4.2H_2O$), by contrast, has been used in acid soils as a product complementary to limestone, aiming to reduce the toxicity of Al and increase the concentration in depth. The great vertical mobility of cations caused by gypsum (ERNANI, 1986; CAIRES et al., 1998) is due to the better solubility of this product in relation to the limestone, the lack of change of electronic charges and the permanence of the sulfate anion almost completely on the soil solution (ERNANI, 1986; ERNANI e BARBER, 1993; DIAS et al., 1994).

Guaggio et al. (1993) verified that gypsum accelerated the movement of Ca and Mg on the soil profile, however its effect lasted a short period, and eighteen months after the gypsum application, almost all Ca and S-SO_4 applied were leached to layers inferior to 40-60 cm. In the upper layers, it remained only partial substitution of Mg by Ca.

In the potato crop, liming is performed mainly to provide Ca, since the content of this nutrient on the soil is positively related to yield and to the tubercle quality (MIRANDA FILHO et al., 1990). Thus, the recommendation in state of São Paulo aims to increase the base saturation at 60% and the content of Mg to a minimum of 8 $mmol_c\ dm^{-3}$. To cultivars more exigent in Ca, it is recommended complementation with more soluble sources (LORENZI et al., 1997).

In this contest, the present study aimed to evaluate the use of NPK 8-30-20 with addiction of gypsum compared to the fertilization NPK 4-14-8 (regional standard treatment) in potato crop yield.

Material and Methods

The experiment was developed on the Unit of Research in Potato Production and Microclimate on Agriculture, Cedeteg *Campus* of the Universidade Estadual do Centro-Oeste – Unicentro in Guarapuava – PR, supported by the Potato Producers Group of the city. The soil of the experimental area is classified as Latossolo Bruno Distroférrico[2]. It was performed a chemical analysis of the soil on the layer 0-20 cm. Treatments applied were: T1 - 3,5 t ha^{-1} of NPK 4-14-8; T2 - 3,5 t ha^{-1} of NPK 4-14-8 more the application of 3 t ha^{-1} of gypsum; T3 - 1,75 t ha^{-1} of NPK 8-30-20; T4 - 1,75 t ha^{-1} of NPK 8-30-20 more the application of 3 t ha^{-1} of gypsum; T5 - 1,75 t ha^{-1} of NPK 8-30-20 more the application of gypsum to supplement the difference between fertilizers.

Potato sowing was performed on December

1 'Veranico' is a Brazilian word to define dry periods during the wet season.

2 Corresponding to Humic Hapludox according to Soil Taxonomy

23, 2008 and the cultivar used was Ágata, nowadays the most grown in Brazil. The seed used was Generation 01 and tubers class II (45 to 55 mm). Prior to planting, the soil preparation and amendment was made, considering the methodology normally applied by producers who use high technology, which included limestone distribution (3.5 T ha^{-1}) and operation of 1st harrowing, rotary tiller, 2nd harrowing and furrowers to establish ridges. To the planting the seed potatoes were manually distributed in an approximate depth of 10 cm, spacing between rows of 0.8 cm and between plants of 0.25 cm with a planting density of 50,000 tubers per hectare. After the distribution of tubers in the furrows a fungicide with active ingredient (a.i.) *Pencycuron* and incecticide (a.i.) *Clorpirifós* were applied aiming to prevent tubers during the initial development.

The experimental design was completely randomized with five treatments and four replications. The experimental unit was 4 rows of 4 meters length spaced 0.8 m, constituting a total area of 16 m^2. The evaluations were performed in two meters of each of the two main lines of the plot. The productivity and the tuber classification were evaluated according to the size and incidence and severity of common scabies (*Streptomyces* spp.) and silver scabies (*Helminthosporium solani* Dur. e Mont.), on the tubers.

The statistic analysis was performed by analysis of variance and comparison test of means by Tukey test at 95% probability. The classification of tubers was conducted according to the diameter classes described on the Decree n° 69 of MAPA of February 21st, 2005 and scabies evaluation was performed according to the methodology proposed by Reifschneider (1987) and Azevedo (1997). Statistic analysis was performed by variance analysis and mean comparison test. The hilling was conducted 27 days after planting. The agrochemicals applied during the plant development cycle are presented in Table 1. *Paraquat* was applied as pre-sowing herbicide and as crop desiccant (95 days after planting - DAP) in order to standardize the end of cycle development to later harvest, which was held on April 12th, 2009, 110 DAP.

Results and Discussion

The result of the chemical soil analysis performed before the application of the treatment was: pH ($CaCl_2$): 4,6; M.O.: 44,3 mg dm^{-3}; P (Mehlich):1,2 mg dm^{-3}; K: 0,13 $cmol_c$ dm^{-3}; Ca: 2,0 $cmol_c$ dm^{-3}; Mg: 2,0 $cmol_c$ dm^{-3}; B: 0,25 mg dm^{-3}; Fe: 49,8 mg dm^{-3}; Cu: 1,0 mg dm^{-3}; Mn: 30,2 mg dm^{-3}; Zn: 1,4 mg dm^{-3}.

Table 2 presents the results of tubers yield to the different gypsum combination together with the formula (NPK) 8-30-20 and 4-14-8. The

Table 1. Date of aplication, active ingredient of the products (fungicides, insecticides and herbicides) applied during the development cycle of potato

	Product (active ingredient) – dosage (ha^{-1})*								
	Clorpirifós	Pencycuron	Paraquat	Mancozeb	Metamidofós	Lambda-Cialotrina	Alfa-Cipermetrina	Metribuzim	Carbaril
	1.5 L	4 kg	1.5 L	3 kg	100 mL	150 mL	100 mL	1,5 L	100 mL
Month	Date of application								
December	23	23	10	-	-	-	-	-	-
January	10	-	-	13, 16, 19, 24, 30	14, 20	16, 24, 30	-	29	
February	-	-	-	2, 4, 6, 10, 13, 16, 18, 22, 24, 27	2, 6, 22	4, 13, 16, 24	10	-	18
March	-	-	27	3, 6, 11, 18, 20, 23, 25	6, 23	3, 11, 20, 25	-	-	18

** Dosage of the corresponding commercial product*

average tuber yield of the studied treatments on the different combinations of the formula NPK + gypsum was 27.122 kg ha^{-1}, and the treatments present statistic differences significant by the Tukey test (5%). It may be observed that the differences of yield of Treatment 4 (T4 – 1.75 t ha^{-1} of NPK 8-30-20 plus the application of 3 t ha^{-1} of gypsum) to Treatment 2 (T2 - 3,5 t ha^{-1} of NPK 4-14-8 plus the application of 3 t ha^{-1} of gypsum) and of Treatment 4 and Treatment 1 is approximately 8090 kg ha^{-1} and 4680 kg ha^{-1} respectively. This means are close to the average yield found by Feltran (2002) on the cultivars Ágata (28.600 kg ha^{-1}), Liseta (37.200 kg ha^{-1}) and Santana (27.600 kg ha^{-1}), in which was made an application with 4-14-8 in the crop and a cover fertilization with 20-00-20. The average yield obtained in Mucugê/Ibicoara, larger potato producer of the Northest, is 35.000 kg ha^{-1}. Barcelos (2004), working with the fragmentation of the nitrogen fertilization in cover on the potato crop found as an average yield 35.100 kg ha^{-1} (100% of N application in the hilling), 35.200 kg ha^{-1} (50% of N application in the emergence and 50% in the hilling) and 38.000 kg ha^{-1} (50% of N application in the hilling and 50% 15 days after hilling).

Different combinations of gypsum with the NPK formula affect significantly the different plots of tuber height (Table 2), following the same behavior found to the total yield, with differences in the size and classification.

Even though it rarely influences on the yield, the silver scab affects the commercial product appearance, especially in the sophisticated Brazilian market of washed potatoes, where there is a predominance of cultivars with smooth and shiny skins. The incidence of some diseases as common and silver scabies were also evaluated (Table 3) to different combinations of formulas adding gypsum. It was observed that Treatment T3 (1.75 t ha^{-1} of NPK 8-30-20) presented higher effect of superficial silver scabies (24.21%) less incidence of deep scabies 0.67%, with 8.11% of silver scabies and the emergence of cascão of 50.10%. To the other treatments, the results were similar, only Treatment 4 was pointed out since it presents less incidence of superficial scabies that the others with 18.55% by Tukey test (5%).

Conclusion

The use of fertilization with 5 t ha^{-1} of NPK 4-14-8 together with the application of 3 t ha^{-1} of gypsum and 1,75 t ha^{-1} of NPK 8-30-20 plus

Table 2. Tubers yield and classification in function of the NPK formulation

Treatment	> 55 mm	45-55 mm	33-45 mm	< 33 mm	Total yield*		
					kg ha^{-1}	bags ha^{-1}	bags alq^{-1}
T1	6867.2 ab	15085.9 ab	6121.1 b	875.8 ab	28950.0 ab	579.0 ab	1401.2 ab
T2	4550.8 b	13558.6 b	5230.5 b	929.7 a	24269.5 b	485.4 b	1174.6 b
T3	4777.3 b	14750.0 b	4480.5 b	835.9 ab	24843.8 b	496.9 b	1202.4 b
T4	8410.2 a	16418.0 a	6832.0 a	699.2 a	32359.4 a	647.2 a	1566.2 a
T5	7550.8 b	13039.1 b	4046.9 b	554.7 a	25191.4 b	503.8 b	1219.3 b

**Means followed by the same letter in column do not differ by Tukey testa t 5% probability of error*

Table 3. Effect of NPK type of formulation and gypsum on the incidence of common and silver scabies in potato tubers.

Treatment	Superficial	Deep	Silver	Cascão
T1	23.09 ab	0.52 c	6.93 c	45.92 abc
T2	21.74 a	0.87 b	8.28 b	42.98 c
T3	24.21 a	0.69 b	8.11 b	‘50.10 a
T4	18.55 b	0.98 a	10.18 a	47.20 ab
T5	22.11 ab	0.73 b	11.16 a	47.23 ab

** Means followed by the same letter in column do not differ by Tukey testa t 5% probability of error*

the application of 3 t ha^{-1} of gypsum provide the best results to the potato crop and better tuber classification.

The application of gypsum was important to reduce the incidence of common scabies independent of the NPK formula and the application of the NPK formula without gypsum predisposes the crop to a higher incidence of scabies.

References

AZEVEDO, L. A. S. **Manual de quantificação de doenças de plantas.** São Paulo: Novartis Biociência-Setor Agro, 1997. 114 p.

BARCELOS, D. M. **Efeito do parcelamento da adubação nitrogenada em cobertura na cultura da batata.** 2004. 25 f. Monografia (Graduação) - Faculdade "Dr. Francisco Maeda", Ituverava, 2004.

CAIRES, E.F.; CHUEIRI, W.A.; MADRUGA E.F.; FIGUEIREDO, A. Alterações de características químicas do solo e resposta da soja ao calcário e gesso aplicados na superfície em sistema de cultivo sem preparo do solo. **Revista Brasileira de Ciência do Solo**, v.22, p.27-34, 1998

CARVALHO, M.C.S.; RAIJ, B.V. Calcium sulphate phosphogypsum e calcium carbonate in the amelioration of acid subsoils for root growth. **Plant and Soil, The Netherlands**, v. 192, p. 37-48, 1997.

DIAS, L.E.; ALVAREZ, V.H.; COSTA, L.M.; NOVAIS, R.F. Dinâmica de algumas formas de enxofre em colunas de solos tratados com diferentes doses de fósforo e gesso. **Revista Brasileira de Ciência do Solo**, v.18, p.373-380, 1994.

EMBRAPA. **A cultura da batata**. Brasília: SNH. 1999. 184p.

EMBRAPA-Empresa Brasileira de Pesquisa Agropecuária. **Tecnologia de produção de soja–Região Central do Brasil 2005**. Londrina: Embrapa Soja, 2004.

ERNANI, P.R. Alterações em algumas características químicas na camada arável do solo pela aplicação de gesso agrícola sobre a superfície de campos nativos. **Revista Brasileira de Ciência do Solo**, v.10, p.241-245, 1986.

ERNANI, P.R.; BARBER S.A. Composição da solução do solo e lixiviação de cátions afetadas pela aplicação de cloreto e sulfato de cálcio em um solo ácido. **Revista Brasileira de Ciência do Solo**, v.10, p.41-46, 1993.

FILGUEIRA, F. A. R. 1987. **Cultivares de batatinha para Goiás.** Circular Técnica DID/ENGOPA n.11, 21 p.

FREITAS, B.J. A disposição do fosfogesso e seus impactos ambientais. In: SEMINÁRIO SOBRE O USO DO GESSO NA AGRICULTURA, 2., 1992, Uberaba. **Anais...**Uberaba: Ibrafós, 1992. p. 325-339.

LOPES, C. A.; J. A. BUSO. 1997. Cultivo de Batata (*Solanum tuberosum* L.). Instrução Técnica EMBRAPA/CNPH 8: 1-8.

LORENZI, J.O.; MONTEIRO, P.A.; MIRANDA FILHO, H.S.; RAIJ, B.van. Raízes e tubérculos. In: RAIJ, B.van; CANTARELLA, H.; QUAGGIO, J.A.; FURLANI, A.M.C., eds. **Recomendações de adubação e calagem para o Estado de São Paulo.** Campinas, Instituto Agronômico de Campinas, 1997. p.221-229 (Boletim Técnico, 100)

MIRANDA FILHO, H.S.; GRANJA, N.P.; RAMOS, V.J. **E**feito do cálcio na produtividade e qualidade de dois cultivares IAC de batata I: Produção e classificação. **Horticultura Brasileira**, v8 p.53, 1990.

QUAGGIO, J. A.; RAIJ, B. VAN; GALLO, P. B.; MASCARENHAS, H. A. A. Respostas da soja à aplicação de calcário e gesso e lixiviação de íons no perfil do solo**. Pesquisa agropecuária Brasileira**, Brasília, v. 28, n.3, p.375-383, 1993.

QUAGGIO, J.A.; DECHEN, A.R.; RAIJ, B. VAN. Efeitos da aplicação de calcário e gesso sobre a produção de amendoim e lixiviação de bases no solo. **Revista Brasileira de Ciência do Solo**, Campinas, v.6, p.186-194, 1982.

REIFSCHNEIDER, F. S. B. **Produção de batata.** Brasília: Linha, 1987. 239 p.

SOUSA, D.M.G.; LOBATO, E. Correção da acidez do solo. In: SOUSA, D.M.G.; LOBATO, E. (Ed.). **Cerrado: correção do solo e adubação.** Brasília: Embrapa, 2004. cap.3. p.81-95.

SOUZA, J. C.; P. R. REIS. 1999. **Pragas da batata em Minas Gerais.** Boletim Técnico, EPAMIG n.5, 21 p.

VIEIRA, F. C.; SUGIMOTO, L. S., Importância da Adubação na Cultura da Batata. ABBA, Associação Brasileira da Batata Basileira. **Batata Show**. Ano 2, n.5. 2002.