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THE EFFECT OF HIGH NPK LEVELS ON POTATO YIELD SIZE STRUCTURE AND TUBERS STARCH CONTENT

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Abstract

The aim of this study was to highlight yield quantitative and qualitative changes of two mid-early potato varieties Christian and Roclas, as a result of base fertilization with different doses and NPK (nitrogen, phosphorus, potasium) reports. The experiment was done between 2013-2014, on a cernoziomoid soil, non-irrigated crop. Nitrogen fertilization levels applied, 100 and 200 kg N/ha, lies on the lower and upper boundary OSPA Braşov recommendations for autumn potato crops. The variants were realized with two complex fertilizers administered before planting: C15-15-15, for NPK report 1:1:1 and C5:10:22 supplemented with ammonium nitrate through which was achieved the NPK report of 1:0.9: 2.

On average, in those two years, NPK report, with higher potassium level did not influenced significantly the total yield of Christian and Roclas varieties. Were found weak growths of tubers yield with diameters bigger than 60 mm on behalf of productions of tuber fraction 35-60 mm. On both varieties fertilization with NPK report 1:0.9:2 resulted in significant declines of tubers starch content compared with NPK report 1:1:1. Increasing nitrogen levels from 100 to 200 kg N/ha had similar effects on yield and starch content of the tubers.

*For the studied period, correlation of total yield, commercial yield, yield from fraction bigger than 60 mm and fraction smaller than 35 mm with tubers starch content, was significant on Christian variety (r = -0.638***, -0.630***, -0.722***, -0,559***). On Roclas variety, only correlation between large tuber yield and starch concentration was significant (r = -0,433*).*

Key words: *fertilization, potato, starch, yield.*

INTRODUCTION

Potato is a plant that consumes large quantities of nutrients and capitalizes better mineral and organic fertilizers applied rationally. Potato yield is influenced by both quantitatively and qualitatively. Rational fertilization aims at balancing the amount of nutrients through fertilizers, taking into account the contribution of soil (Ianoşi et al., 2002).

Excessive application rates of nitrogen and potassium, along with excessive soil levels of eithers nutrient, may reduce tuber solids (Carrie Laboski and Kelling, 2007). Potato crop has strict requirement for a balanced fertilization management, without which yield and quality of tubers are diminished. Potassium improves yields and some of the tuber quality parameters as tuber size, percentage of dry matter, starch content are affected by potassium nutrition (Patricia Imas and Bansal, 1999).

K fertilization generally reduces specific gravity (Locascio et al., 1992, cited by Kelling et al., 2002) if applied in excess of rates (Lisińska and Leszczyński, 1989; Davenport, 2000). Based on a research on the influence of potassium fertilisation on yield and dry matter content for the cultivar Asterisc and Fontane, Demeulemeester and Bries (2011) reported that potassium fertilization resulted only in a small yield increase, which could be correlated with the moderated to high K content of the soil. Potassium deficiencies reduce the yield, size and quality oft he potato crop (Mikkelsen, 2006).

Nitrogen is the one most often limiting for potato growth; application of fertilizer N is necessary to ensure profitable potato production and, in general, N application increases the proportion of larger-sized tubers (Zebarth and Rosen, 2007). Proper N management influences almost all of the

important properties related to tuber yield and quality (Mikkelsen, 2006).
Nitrate fertilization determine yield increase and although have an influence on potato chemical composition and tuber quality. Too much available N can have negative effects on tuber yield and quality; excess N at or before tuberization can reduce yield and specific gravity (Atkinson et al., 2003).
In a field experiment, Eleiwa (2012) reported that increasing the NPK levels significantly increased yield parameters. The highest values of the yield parameters were obtained by using the highest NPK (120:80:100) as compared with other two NPK levels (102:68:85 and 90:60:75). According to Cucci and Lacolla (2007) trials conducted on potato fertilization at different rates of nitrogen, phosphorus and potassium have shown that the tubers with the highest specific gravity and starch content values are obtained when applying respectively 200 and 50 kg/ha of nitrogen and phosphorus.
Fertilization with large quantities of nitrogen is ageing the tubers, dry matter content being reduced and increases the content of nitrates in the tubers. The dry matter content can fall so much that the tubers will no longer be able to be used for industrial processing (www.potato.nl).
In this experiment, our objectives were to study the effect of base fertilization with different doses and NPK (nitrogen, phosphorus, potassium) reports on yield and tuber quality of two mid-early potato varieties Christian and Roclas.

MATERIALS AND METHODS

The experiment was done between 2013-2014, on a cernoziomoid soil, non-irrigated crop. The experience was of poli-factorial type, with plots subdivided, into who have been studied quantitative and qualitative changes of the yield of two mid-early potato varieties, Christian and Roclas, as a result of the basic fertilization with dosages and different NPK ratios. Nitrogen fertilization levels applied, 100 and 200 kg N/ha, lies on the lower and upper boundary OSPA Braşov recommendations for autumn potato crops. The variants were realized with two complex fertilizers administered before planting: C15-15-15, for NPK report 1:1:1 and C5:10:22 supplemented with ammonium nitrate through which was achieved the NPK report of 1:0.9:2.
The researches were conducted in two years with very different growth conditions from the climatic point of view. From October 2012, to March 2013, prior to the potato crop, the average temperature was 0.9°C higher (Table 1), face of Multi-annual Average (MMA).
Rainfall amount achieved was practically equal with the value characteristic for this area.
In 2014, preliminary period to potato crop was characterized by a fall-winter particularly mild with 2.5°C higher than the average. The amount of rainfall in winter has been closely to MMA for Braşov area, ensuring a good supply of water into the soil.

Table 1. Average temperatures and the amount of rainfall, 2012-2013 and 2013-2014 (Braşov)

Year	Average temperature °C			The amount of rainfall mm		
	MMA	Achieved	Deviation	MMA	Achieved	Deviation
Winter period (October – March)						
2012-2013	0.7	1.6	+0.9	177.0	174.9	-2.1
2013-2014		3.2	+2.5		172.6	-4.4
Vegetation period (April – September)						
2013	14.6	16.0	+1.4	457.4	422.2	-35.2
2014		15.3	+0.6		505.1	+47.7

In 2013, vegetation period was characterized by higher temperatures than normal, the average exceeding with 1.4°C the MMA value. In 2014, between April-September, monthly average temperatures were close to normal.
With all that in 2013 the amount of rainfall was approaching fallen (92.3%) of the value of a multi-annual, the level of rainfall was very low since the second decade of July until mid-August (Figure 1).

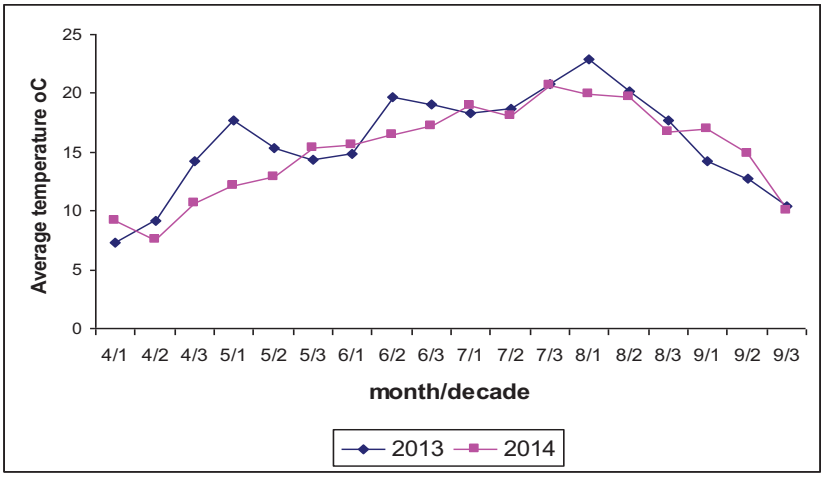

Figure 1. Average temperatures (monthly decade) during the growing season Braşov 2013-2014

In 2014, by the end of July, the thermo-hydrate conditions were very favorable for potato plants growth. High temperatures and low rainfall in August led to the maturation of the plant and end of vegetation in case of Christian and Roclas varieties (Figure 2).

In the years 2013-2014, soil samples were pick up and analyzed at University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Soil-Plant Laboratory, in accordance with the methodology recommended by the I.C.P.A. Bucharest. In the two years, 2013-2014, analyzed soil had a ph=5.3 respectively 8.3, good supply of organic matter 3.6-4.8%, poor in phosphorus supply 62-21 ppm P-AL, good in potassium supply 260-400 ppm K-AL and a good in nitrogen supply $I_{N=}$2.3 respectively 4.6.

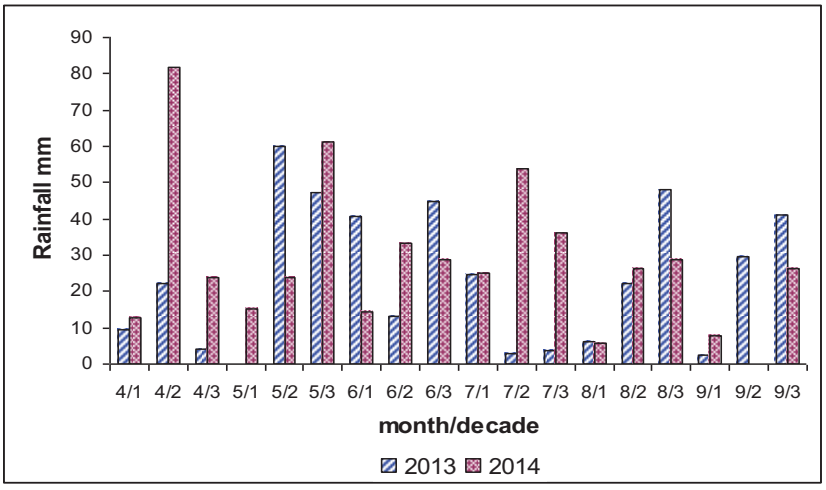

Figure 2. The amount of rainfall during vegetation period (monthly decade), Braşov 2013-2014

RESULTS AND DISCUSSIONS

Very different growing conditions in those two years are led to large differences in yield from one year to the next, for all the research factors and interactions (Table 2). On average, in 2013, on the trial was realized a yield of 26.9 t/ha, while in 2014, the experimental yield was 47 t/ha.

Table 2. Effects of different fertilization with NPK dozes and reports on the total yield of tuber - Christian and Roclas varieties (Braşov 2013-2014)

Variety	Report NPK	Dozes N Kg/ha	Total yield t/ha		
			2013	2014	Average
Christian	1:1:1	100	26.3 fg	44.3 cde	**35.3 abc**
		200	24.6 fg	45.3 bcd	**35.0 bc**
	1:0,9:2	100	29.2 fg	43.7 de	**36.4 abc**
		200	26.4 fg	38.4 e	**32.4 c**
Roclas	1:1:1	100	29.4 f	50.5 bc	**39.9 a**
		200	27.3 fg	51,0 b	**39.2 ab**
	1:0.9:2	100	30.2 f	45.6 bcd	**37.9 ab**
		200	22.4 g	57.4 a	**39.9 a**
Average report NPK	**1:1:1**		**26.9 b**	**47.8 a**	**37.3**
	1:0,9:2		**27.1 b**	**46.2 a**	**36,6**
Average dozes N kg/ha	**100**		**28.8 b**	**46.0 a**	**37.4**
	200		**25.2 c**	**48.0 a**	**36.6**
Average varieties	**Christian**		**26.6 c**	**42.9 b**	**34.8 -**
	Roclas		**27.3 c**	**51.1 a**	**39.2 ***
Average years			**26.9**	**47.0 ***	

DL (year) 5% = 6.2 t/ha
DL (variety) 5% = 3.6 t/ha
DL (report) 5% = 2.1 t/ha
DL (dozes N) 5% = 2.1 t/ha
LDS (year*variety) 5% = 5.1 t/ha
LDS (year*rep) 5% =3.0 t/ha
LDS (year*dozes) 5% = 3.0 t/ha
LDS (year*variety*rep*dozes) 5% = 6.0 t/ha

The potato varieties have differed significantly from each other, the yield of Roclas variety averaging 39.2 t/ha higher than 34.8 t/ha of Christian variety.

On average, in those two years, NPK report, with higher potassium level did not influenced significantly the total yield of Christian and Roclas varieties. Were found weak growths of tubers yield with diameters bigger than 60 mm on behalf of productions of tuber fraction 35-60 mm.

The only significant effects of increasing nitrogen dose of 100 to 200 kg/ha have been recorded at the ratio 1:0.9:2 which in 2013 determined the decrease of the total yield from 30.2 t/ha to 22.4 t/ha. In 2014, by increasing the level of nitrogen the total yield of tubers has grown from 45.6 t/ha to 57.4 t/ha.

In 2013, due to scarcity of rainfall during yield accumulation, at high doses of nitrogen was observed light yield declines of all fertilization variants and on both potato cultivars. In the year with favourable thermo-hydrate conditions for potato (2014), with the exception of high potassium report on Christian variety, the trends of yield increases were statistically insignificant. The response to N fertilization varies greatly with sites and climatic conditions and that field specific recommendations are required for the optimum management of N (Belanger, 2000).

In 2013 have not become manifested significant structural changes due to fertilization on studied potato varieties. The yield structure of both varieties was significantly amended by increasing the tuber yield in a favourable year, 2014 (figure 3 and 4). In this year on Roclas variety it appears that to the increased yield has contributed 35-60 mm fraction also. In 2013 and 2014, NPK ratio and dosage levels of nitrogen have not influenced the yield of small tubers.

The starch content of the tubers was significantly influenced by the growth conditions. In both potato varieties, the accumulation of tuber starch was significantly lower in 2014 face to 2013 (table 3). Higher ratio of NPK and nitrogen dose of 200 kg/ha resulted in decreasing of starch content in those two years, on average with 0.9-1.2%.

Downs potato starch content of Roclas variety, with the increase of the dose of potassium and nitrogen is more evident and statistically significant in both the years surveyed. The largest starch accumulation was recorded at NPK ratio 1: 1: 1 with nitrogen level of 100 kg/ha.

On Christian variety, it was revealed that the statistical effect of decrease in starch content is very strong at NPK ratio 1: 1: 1, with nitrogen level of 200 kg/ha.

For the studied period, correlation of total yield, commercial yield, yield from fraction bigger than 60 mm and fraction smaller than 35 mm with tubers starch content (table 4), was significant on Christian variety (r = -0.638***, -0.630***, -0.722***, -0.559***). On Roclas variety, only correlation between large tuber yield and starch concentration was significant (r=-0.433*).

Purposes of correlations indicate very significant downs starch content as a result of increases of yields.

In case of Roclas variety only the correlation between the tubers yield and starch concentration was significant (r = -0.433*).

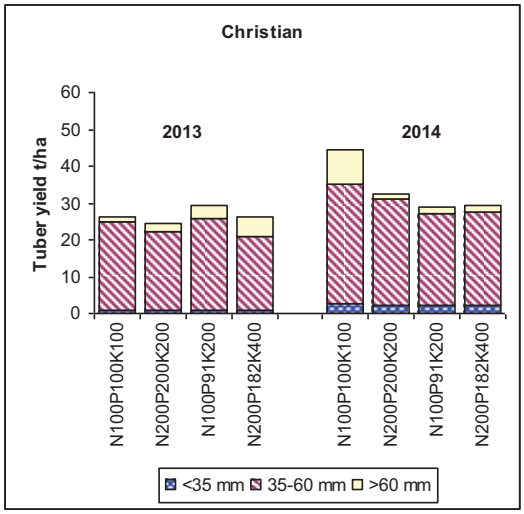

Figure 3. Yield size structure of Christian variety for different variants of fertilization

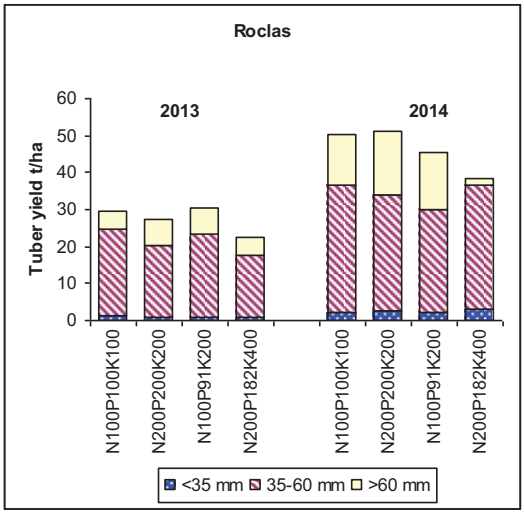

Figure 4. Yield size structure of Roclas variety for different variants of fertilization

Table 3. Effects of different fertilization with NPK dozes and reports on tubers starch content from Christian and Roclas varieties (Braşov 2013-2014)

Variety	Report NPK	Dozes N Kg/ha	Starch content %		
			2013	2014	Average
Christian	1:1:1	100	17.0 b	15.2 ef	**16.1 bc**
		200	16.3 bcd	13.5 g	**14.9 e**
	1:0.9:2	100	16.1 cde	14.4 f	**15.3 de**
		200	15.3 ef	12.5 h	**13.9 f**
Roclas	1:1:1	100	18.1 a	17.2 b	**17.7 a**
		200	16.8 bc	15.7 de	**16.2 bc**
	1:0.9:2	100	16.5 bcd	16.5 bcd	**16.5 b**
		200	16.0 cde	15.3 ef	**15.7 cd**
Average report NPK	**1:1:1**		**17.1 a**	**15.4 c**	**16.2 -**
	1:0.9:2		**16.0 b**	**14.7 d**	**15.3** ^{0}
Average dozes N kg/ha	**100**		**16.9 a**	**15.8 b**	**16.4 -**
	200		**16.1 b**	**14.3 c**	**15.2** ^{0}
Average varieties	**Christian**		**16.2 b**	**13.9 c**	**15.0 -**
	Roclas		**16.9 a**	**16.2 b**	**16.5 ***
Average years			**16.5**	**15.0** ^{0}	

DL (year) 5% = 0.4 %
DL (variety) 5% = 0.4 %
DL (report) 5% = 0.3 %
DL (dozes N) 5% = 0.3 %
LDS (year*variety) 5% = 0.6 %
LDS (year*rep) 5% = 0.4 %
LDS (year*doze) 5% = 0.4 %
LDS (year*variety*rep*doze) 5% = 0.8 %

Table 4. Potato yield – starch content simple correlations and regressions

Yield structure mm	Christian				Roclas			
	Average t/ha	a	b	r	Average t/ha	a	b	r
Total	34.8	18.43	-0.098	-0.638***	39.2	17.48	-0.025	-0.316
>35	33.9	18.46	-0.103	-0.630***	37.42	17.49	-0,026	-0.314
> 60	7.9	16.43	-0.176	-0.722***	11.4	17.26	-0,065	-0.433**
35-60	25.2	17.10	-0.082	-0.269	26.1	17.03	-0,020	-0.135
<35	1.68	16.66	-0.965	-0.559***	1.8	17.18	-0.366	-0.304

CONCLUSIONS

In conditions of a non-irrigated crop, in 2013, with a deficit of moisture during the yield accumulation period, production results were not significant at increasing fertilizer NPK ratio 1:1:1 to 1:0.9:2, respectively on doubling the doses of nitrogen from 100 to 200 kg/ha at mid-early varieties Christian and Roclas.

In 2014 more favourable in terms of thermo-hydrate, the increases yields of Christian had not justified the increase in the level of fertilization, while the highest yield of Roclas (57.4 t/ha) was achieved by fertilization with NPK ratio 1:0.9:2 at a dose of 200 kg nitrogen/ha.

The yield structure of both varieties was significantly amended by increasing the yield with big tuber in 2014. In the same year it is found that to the increased yield of Roclas variety has contributed the 35-60 mm fraction also.

The starch content of the tubers was significantly influenced by the growth conditions, in both varieties, the accumulation of starch in tubers was significantly lower in 2014 comparatively with 2013.

Increasing doses of nitrogen on both cultivars in two years, independent of NPK ratio, caused the decrease in starch content.

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