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THE NPK FERTILIZATION EFFECTS OF TUBERS STARCH, DRY MATTER AND REDUCING SUGAR CONTENT

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Abstract

The content of potato tubers in dry matter, starch and reducing sugar determines their quality characteristics. This study shows how the basic fertilization with different nitrogen doses and NPK ratios influence the content of potato tubers in dry matter, starch and reducing sugar.
The researches were conducted in the years 2013-2014 in the experimental field of INCDCSZ Brasov, located in Brasov Depression, on a cernoziomoid soil at an altitude of 520 m. For the two potato varieties used in the experiment, Christian and Roclas, was made a basic NPK fertilization with two different ratios 1: 1: 1 and 1: 0.9: 2 and two different doses of nitrogen, 100 and 200 kg/ha.
Fertilization ratio 1:0.9:2 as against 1:1:1 ratio had significant effect on reducing the starch content for both varieties, while the reducing of dry matter content is significant only for Christian variety. For both varieties, there were no significant differences in reducing sugar. The higher NPK ratio and nitrogen dose of 200 kg/ha determined reduction of starch in the two years, on average with 0.9-1.2%. Increasing the dose of nitrogen determined a significant decrease in the reducing sugar content only at Christian variety.
The decrease in starch content from tubers of Christian variety with increasing potassium ratio and nitrogen dose is more evident and statistically significant in 2014. For Roclas variety there is the same tendency, differences between variants in the two years are lower.
In the case of the dry matter content differences due to experimental years are stronger and are manifested mostly for dose N200 both at Christian as well as the Roclas. For the tubers reducing sugar content were found significant differences between the two years for both varieties. To all variants of fertilization the content level of reducing sugar was lower in 2013.

Key words: *dry matter, fertilization, potato, starch, reducing sugar.*

INTRODUCTION

Potato culture has a great potential of production, which can be achieved if ecological and technological conditions are ensured. Potato crop has strict requirement for a balanced fertilization management, without which the crop's growth and development of the crop are poor and both yield and quality of tubers are diminished (Imas and Bansal, 1999). Plant nutrition is a key instrument for managing potato quality (Achten, 2005). The content of reducing sugars, dry matter, and starch in potato tubers are important properties for potato processing (De la Fuente, 2011) because quality of final products and efficiency of processing depend on them (Hasse, 2004). Nitrogen is the dominant nutrient taken up by potato and plant nitrogen requirements are greater than other nutrient (El-Galil, 2006). A sufficient amount of nitrogen is important for achieving quality objectives for processing potatoes (Zebarth, 2012). Tuber specific gravity decrease if more nitrogen is available then needed for growth (Westermann et al., 1994; Atkinson et al., 2003).

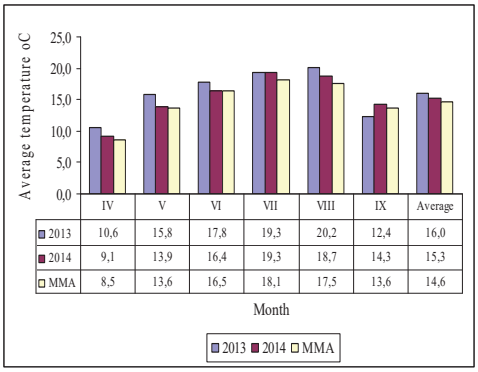
Natural or chemical fertilization and soil type on which potatoes are grown may influence the tubers sugar content. Plants adequately fertilized with nitrogen had tubers with lower reducing sugar concentration at harvest (Kumar et al., 2004).

Potatoes require large amounts of soil K, since this nutrient is crucial to metabolic functions such as movement of sugars from the leaves to

the tubers and the transformation of sugar into potato starch (Mikkesen, 2006).
Phosphorus applications may improve specific gravity when soil test phosphorus levels are low (Laboski and Kelling, 2007).
A deficiency of phosphorus and potassium in the soil may lead to decreased synthesis of starch and sugar content increases (Mureşan, 1999). Potassium plays an important role in the starch structure and reduces the percentage of reducing sugars (Ianoşi, 2002).
Among the major nutrients, potassium not only improves yields but also affects some of the tuber quality parameters like percentage of dry matter and starch content (Imas and Bansal, 1999) and the fertilizer potassium source is known to affect tuber specific gravity (Westermann et al.,1994).
Potassium contributes to various aspects of tuber quality and the balance between nitrogen and potassium supply is of particular importance for potato crop (El-Latif, 2011).
The aim of this work was to assess the effects of different NPK fertilization on the tubers starch, dry matter and reducing sugar content.

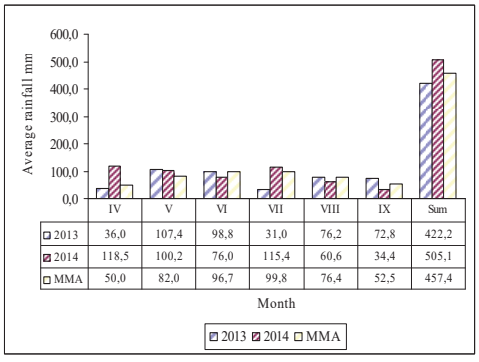
MATERIALS AND METHODS

The experimental design was based on the knowledge acquired in the domain of fertilization, on a black earth soil from Braşov and according to current practices of fertilization in the region. In these polifactorial experience we propose levels of fertilization and different NPK ratios, for Roclas and Christian varieties created at N.I.R.D.P.S.B. Brasov.
The chosen levels of nitrogen fertilization, of 100 and 200 kg N/ha are situated at the lower and upper limit of OSPA Braşov recommendations valid for autumn potato crops. These doses are recommended for production of 20 t/ha and 40 t/ha under non-irrigated conditions.
Two complex fertilizers given before planting: C15-15-15, for NPK ratio of 1:1:1 and C5:10:22, supplemented with ammonium nitrate through for obtaining a 1:0.9:2 NPK ratio.
The experiment was done in Braşov in a non-irrigated crop, studied during 2013-2014. The research was conducted in two years with very different growth conditions in terms of climate.
In 2013 the vegetation period was warm, with an average temperature of 16ºC and 422.2 mm precipitation, compared to the year 2014, at which the average air temperature was 15.3°C and there has been rainfall of 505.1 mm (Figures 1 and 2).
In 2014, the amount of rainfall during the growing season exceeded the multiannual average (MMA) and the average temperature during the growing season was close to the multiannual value ensuring high yields in both studied varieties.



	IV	V	VI	VII	VIII	IX	Average
2013	10,6	15,8	17,8	19,3	20,2	12,4	16,0
2014	9,1	13,9	16,4	19,3	18,7	14,3	15,3
MMA	8,5	13,6	16,5	18,1	17,5	13,6	14,6

Figure 1. Average temperatures – Braşov 2013-2014



	IV	V	VI	VII	VIII	IX	Sum
2013	36,0	107,4	98,8	31,0	76,2	72,8	422,2
2014	118,5	100,2	76,0	115,4	60,6	34,4	505,1
MMA	50,0	82,0	96,7	99,8	76,4	52,5	457,4

Figure 2. Average rainfall – Braşov 2013-2014

After harvesting and before cold storage of potato tubers, we made determinations on experimental variants and repetitions, regarding the tuber starch content, using the Polikeit balance. Also we determined the dry matter content of tubers by drying them in an oven at 105° C for 4 hours. Tubers content, from experimental variants, in reducing sugars (glucose, fructose) was determined by the

chromatographic method using Shimadzu HPLC system.

RESULTS AND DISCUSSIONS

On average, for the two experimental years, varieties differed in starch content, dry matter and reducing sugar before storage (Table 1.). In Christian variety there were recorded on average lower levels of starch, dry matter and reducing sugar (15.0%, 23.9% and 0.18%) compared to the Roclas variety (16.5%, 24.8% and 0.34%). Standard deviations indicate moderate variation of values calculated for starch and dry matter and high variation for reducing sugar.

The fertilization ratio 1:0.9:2 compared with that of 1:1:1 had significant effect on reducing the starch content for both varieties, while the reducing of dry matter content was significant only for Christian variety. For both potato varieties there were no significant differences in reducing sugar. The higher NPK ratio and nitrogen dose of 200 kg/ha determined reduction of starch in the two years, on average with 0.9-1.2%

Increasing the dose of fertilizer from N100 to N200 determined a decrease in the starch content for both varieties, with no significant differences for dry matter. Although with increasing nitrogen level it can be noted a decrease for the reducing sugar content; decrease was significant only for Christian variety.

The Duncan test revealed that for the lowest level of fertilization (N100 NPK 1:1:1 ratio) was recorded the highest starch content, 16.1% for Christian variety and 17.7% for Roclas variety, while for variant with the highest level of fertilization (N200 1:0.9:2 ratio), the starch content for the two varieties decreased to 13.9%, for Christian and 15.6% la Roclas.

Table 1. Mean effects of different with NPK ratios and dozes fertilization on tubers starch, dry matter and reducing sugar content from Christian and Roclas varieties (Braşov 2013-2014)

Ratio NPK	Doses N Kg/ha	Starch %		Dry matter %		Reducing sugar %	
		Christian	Roclas	Christian	Roclas	Christian	Roclas
1:1:1	100	16.1 a	17.7 a	24.6 a	25.5 a	0.21 ab	0.41 a
	200	14.9 ab	16.2 bc	24.5 a	24.8 a	0.10 b	0.28 a
1:0.9:2	100	15.2 ab	16.5 b	23.7 a	24.7 a	0.29 a	0.33 a
	200	13.9 b	15.6 c	23.0 a	24.2 a	0.13 b	0.32 a
Means							
Ratio 1:1:1		15.5	17.0	24.6	25.1	0.16	0.35
Ratio 1:0.9:2		14.6 o	16.1 o	23.3 o	24.4	0.21	0.33
N 100 kg/ha		15.7	17.1	24.1	25.1	0.25	0.37
N 200 kg/ha		14.4 o	15.9 o	23.8	24.5	0.12 o	0.30
Mean		15.0	16.5	23.9	24.8	0.18	0.34
Standard deviation		1.5	1.0	1.9	1.9	0.16	0.21
LDS(variants)5%		2.0%	1.0%	2.7%	2.8%	0.21%	0.31%
DL (ratio) 5%		1.1%	0.7%	1.3%	1.4%	0.11%	0.15%
DL (doses N) 5%		1.0%	0.6%	1.4%	1.4%	0.10%	0.15%

On average fertilization variants were not significantly differentiated for the varieties researched, as regards the dry matter content.

The average content of reducing sugar of variants studied presented significant differences only for Christian variety. To this variety, for both fertilization ratios passing from N100 at N200 strongly reduced the content of reducing sugar (from 0.21% to 0.10% for NPK 1:1:1 and from 0.29% to 0.13% for NPK 1:0.9:2).

The content of starch, dry matter and reducing sugar of tubers was significantly influenced by growing conditions.

Due to the more favorable climatic hydro and thermal conditions alongside with higher yields for Christian variety accumulation of starch in tubers was significantly lower (16.2% as against 13.9%) in 2014 compared with 2013 (Figure 3.). On average, for Roclas variety, was maintained the high starch content from tubers, there are no significant differences between the two years (16.8% and 16.2%).

The decrease in starch content from tubers of Christian variety with increasing potassium ratio and nitrogen dose is more evident and statistically significant in 2014. For Roclas variety there is the same tendency, but the differences between variants in the two years are lower.

In the case of the dry matter content, the differences due to experimental years are stronger and are manifested mostly for the N200 dose, for both varieties (Figure 4).

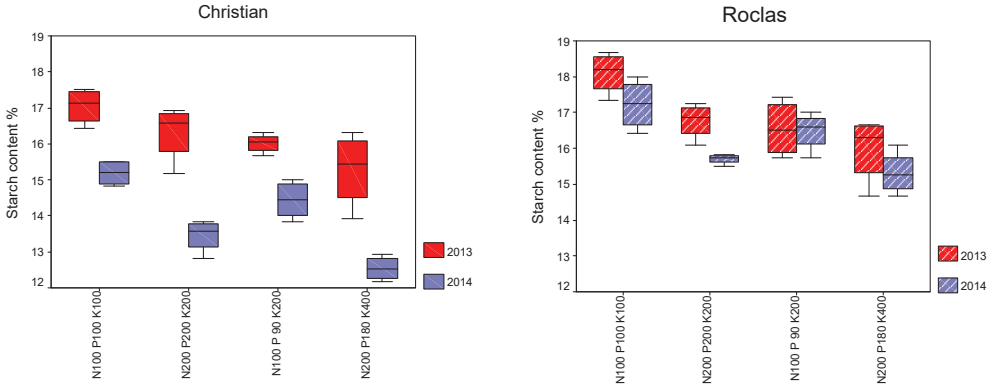


Figure 3. Comparison of the average starch content of tubers for fertilization variants - Braşov, 2013-2014

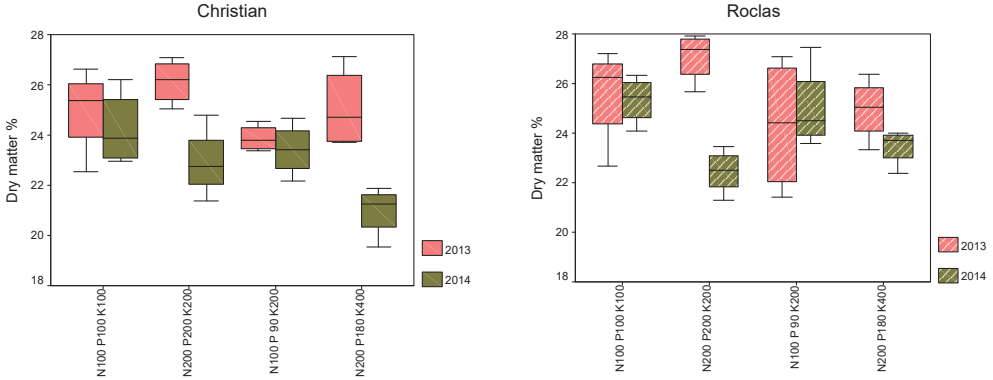


Figure. 4. Comparison of the average dry matter content of tubers for fertilization variants - Braşov, 2013-2014

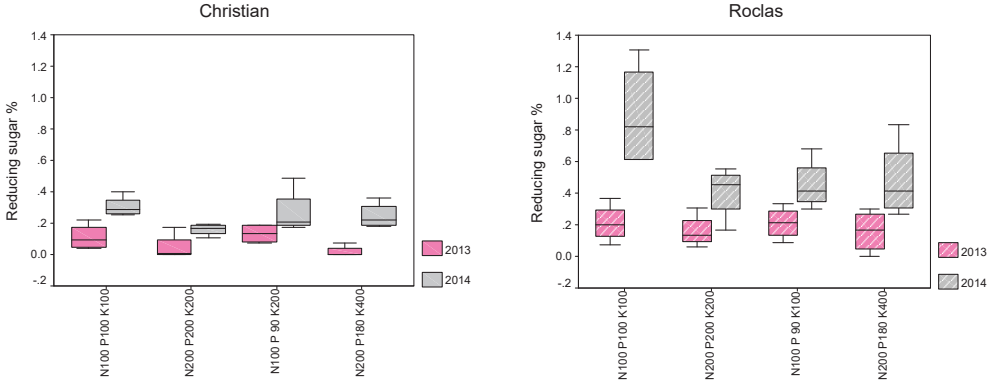


Figure 5. Comparison of the average reducing sugar content of tubers for fertilization variants - Braşov, 2013-2014

For the two studied years, correlations were made between the content of starch, dry matter and reducing sugar from tubers and total production from tubers. Pearson correlation coefficients for Christian and Roclas varieties are presented in Table 2.

Table 2. Pearson corelattion coefficients for total yield, starch, dry matter and reducing sugar content of tubers (Braşov, 2013-2014)

	Christian			Roclas		
	Starch	Dry matter	Reducing sugar	Starch	Dry matter	Reducing sugar
Starch	-	0.772**	-0.246	-	0.677**	-0.167
Dry matter	0.772**	-	-0.421*	0.677**	-	-0.331
Reducing sugar	-0.246	-0.421*	-	-0.044	-0.218	-
Total yield	-0.638**	-0.454**	0.488**	-0.315	-0.369*	0.689**

For both varieties the correlation between content of starch and dry matter is positive and statistically assured (r = 0.772** for Christian and r = 0.677** for Roclas). Correlations between reducing sugar, starch and dry matter for both varieties are negative. Only for Christian variety correlation between dry matter and reducing sugar content was statistically assured (r = -0.421*). Correlations of total production with concentration of starch from tubers was significant for Christian variety (r = -0.638**). The sense of correlations indicates very strong decreases of starch content due production increases, especially in 2014.

The correlations between the total production with starch content and dry matter from tubers were negative and statistically assured, for Christian variety and for Roclas variety correlations were lower. The correlations of the total production with reducing sugar were for both varieties positive and statistically assured.

CONCLUSIONS

Very different climatic conditions in those two years determined high yield differences from one year to another, and the accumulation of starch and dry matter in tubers was significantly lower in 2014 comparing with 2013.

On average, in both varieties, the highest starch content, was accumulated by the variants with fertilization N100: P100: K100 and on those two years, the differences due fertilization variants were not provided statistical for dry matter content of tubers. For 2014, the fertilization variants with high nitrogen level led to significant decreases in dry matter content for both fertilizing ratios, for both varieties.

Both potato varieties revealed a significantly higher content of reducing sugar in 2014 comparatively with 2013.

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