

THE NPK FERTILIZATION EFFECTS ON CULINARY AND TECHNOLOGICAL POTATO QUALITY

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Abstract

In this research we propose different levels of fertilization and NPK ratios, for Roclas and Christian potato varieties. The experiment was done in Braşov in a non-irrigated crop, studied during 2013-2014. Research methods in laboratory included analysis, qualitative and quantitative determinations designed for tubers using purpose. This permits multicriterial qualitative characterization of production from the studied fertilization variants. We analyzed the culinary quality traits and the correlations with tubers starch content before storage. Also we studied the average suitability for processing into chips and correlations between dry matter, starch, reducing sugar, efficiency to processing into chips and chips color before storage. Comparing variants of fertilization, on Roclas variety, tubers from variant with N100 P100 K100 louder crashed on boiling, pulp consistency is more reduced, are more farinaceous and moisture toward the rest of variants for both years, tubers starch contents positively significantly correlate with appreciation notes for milling, moisture and starch structure. With the increase of the NPK ratio from 1:1:1 to 1:0.9:2 and with increasing nitrogen dose combinations from 100 to 200 kg N/ha the decline in yield is found in chips. Notes for the chips' color have a tendency to decrease, which indicates a darker color of chips with increasing doses of nitrogen on variants with ratio 1:0.9:2, on both varieties and both experimental years. No significant correlation was obtained between reducing sugar and color of chips tubers for data achieved in the years 2013-2014, before storage for the studied varieties. The correlation between the efficiency to processing into chips and the color of chips was significant only for Christian variety (0.444*).

Key words: potato, fertilization, culinary quality, technological quality

Culinary quality includes traits related to the overall quality of the boiled tubers: taste, breaking at boiling, consistence, mealiness, moisture, structure of starch granules, pulp color, potato' after-cooking darkening

The technological quality includes traits related to specific gravity, dry matter, starch and reducing sugars, pretability for industrial processing as pommes-frites, chips, flakes, starch and alcohol. Technological quality is assessed on the basis of quality products from potatoes: efficiency to peeling and mechanical processing, color, texture, oil content for chips and pommes-frites.

The dry matter content of tubers used to make chips and pommes frites is preferable to be 20-24% (Kabira and Berga, 2003 quote by Asmamaw, 2010), 21-24% after Frančáková *et al*, (2011).

The percentage of starch tubers content varies between 8 and 30% of dry matter content and directly affects how they are applied (Göncz, 2011).

Natural or chemical fertilization and soil type on which potatoes are grown may influence sugar content. A deficiency of phosphorus and potassium in the soil may lead to a decreased synthesis of starch and to an increased sugar content (Mureşan, 1999). When a nitrogen excess is present in the soil, the dry matter content of the potato tubers decreases (Westermann *et al*, 1994), the specific gravity decreases (Atkinson *et al*, 2003) and the reducing sugars content increases. A good supply with nitrogen is important in achieving economically viable production of potato tubers and achieve potato tubers with size and qualities suitable for processing (Zebarth *et al*, 2012). Potato plants fertilized properly with nitrogen produced tubers with a low concentration of reducing sugars at harvest (Kumar *et al*, 2004).

The phosphorus has smaller effects on production's growth but improves the culinary quality of tubers, prints resistance to boiling (Ianoşi, 2002; Ştefan, 2005).

Potassium deficiency lowers the quantity and quality of potato production; the soil

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potassium deficiency is associated with a decreased specific weight of tubers (Laboski and Kelling, 2007). Under the influence of potassium, the number and percentage of large tubers increase (El-Latif *et al*, 2011), tuber culinary quality improves and their resistance to storage increase (Ianoși, 2002).

MATERIAL AND METHOD

Research methods in the field. Choosing of variances and observations proposed for field experimentation were made based on the knowledge acquired in the domain of fertilization, on a black earth soil from Brasov and according to current practices of fertilization in the region. In experimentation we proposed different levels of fertilization and NPK ratios, for Roclas and Christian varieties, created at N.I.R.D.P.S.B. Brasov. The experiment was done in Brașov in a non-irrigated crop, studied during 2013-2014. The chosen levels of nitrogen fertilization, of 100 and 200 kg N/ha are situated at the lower and upper limit of OSPA Brașov recommendations valid for autumn potato crops. These doses are recommended for production of 20 t/ha and 40 t/ha under non-irrigated conditions.

The variants were made with 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 which was realized NPK 1:0.9:2 ratio. Researches are based on polifactorial experience by type 2A * 2B * 2 C * 4R with following factors and experimental graduations:

- Factor A – variety - a1. Christian and a2. Roclas;
- Factor B – NPK ratio of fertilization: - b1. 1:1:1 from C 15 :15 :15 and b2. 1:0,9:2 from C 5:10:22 + ammonium nitrate;
- Factor C – nitrogen fertilization: - c1 = 100 kg N/ha and c2 = 200 kg N/ha;

The experiment was conducted in Brașov on BLACK earth soil in a non-irrigated crop, studied during 2013-2014 - two years with very different growth conditions in terms of climate.

Research methods in laboratory included analysis, qualitative and quantitative determinations designed for tubers using purpose. This permits multicriterial qualitative characterization of production from the studied fertilization variants.

After harvesting and before introducing tubers in storage into cold store, several determinations were made on experimental variations and repetitions, regarding the tuber starch content (using the Polikeit balance) and the dry matter content of tubers (by drying them in an oven at 105° C for 4 hours).

To establish the class usage of the tubers, their culinary quality was determined by sensorial analysis - accomplished with a panel using the Lugt and Goodijk method (1959) and the scheme for appreciation of potato culinary quality (Constantinescu, 1969, Mureșan, 1999).

We also determined the pretability for processing into chips: for each experimental variant and for the repetition we obtained chips by roasting potato rondelles at 160-170°C; we calculated their efficiency during cleaning, mechanical processing and chips yield. After that we gave notes for chips color, using a standardized color scale for chips quality evaluation, using notes from 1 to 9 (1 = dark color; 9 = light color).

The tubers content in reducing sugars was determined by high performance liquid chromatography using a Shimadzu chromatographic system.

Statistical analyses of obtained data were accomplished using the statistical software package MSTAT-C, a tool for planning, management and statistical processing of data from the experimental field. The program allows concomitant comparison of many variables (Nissen, 1983). SPSS was used for statistical analysis with ANOVA, Duncan test, Pearson correlations and regressions of measurements made in dynamic field and laboratory analyzes (Huzsvai, 2012).

RESULTS AND DISCUSSIONS

Mean culinary quality traits and the correlations with tubers starch before storage.

On average, over the two years 2013-2014, NPK ratios effects on culinary quality traits of boiled tubers were different for the two varieties (*table 1*). For Christian variety, the ratio is favorable for potassium; using the 1:0.9:2 ratio, we obtained tubers with lower consistency and mealiness. At the same ratio, the Roclas variety, compared to NPK ratio 1: 1: 1 had a different behavior, being less crumbly, having a higher consistence and presenting a lower mealiness and higher moisture.

Analyzing the average effects of nitrogen doses we found significant differences only for Roclas variety, to which with increasing the nitrogen levels from N100 to N200 kg/ha, the quality of the boiled tubers changed as follows: they are less crumbly, the mealiness decreased, the moisture increased and the starch structure become finer.

Table 1

The NPK fertilization effects on culinary quality – Brașov 2013 - 2014

Ratio NPK	Dozes N Kg/ha	Sensory appreciation of quality traits to boiling									
		Breaking at boiling		Consistence		Mealiness		Moisture		The structure of starch	
		Christian	Roclas	Christian	Roclas	Christian	Roclas	Christian	Roclas	Christian	Roclas
Interaction NPK ratio* dozes N											
1:1:1	100	1.6a	2.7a	2.0a	2.6a	1.9a	2.9a	2.1a	2.9a	1.7a	2.4a
	200	1.2b	2.0b	2.2a	2.1b	2.0a	2.3b	1.8a	2.2b	1.6a	2.0a
1:0.9:2	100	1.3ab	2.0b	2.3a	1.8b	2.2a	2.4b	2.2a	2.3b	1.7a	2.1a
	200	1.4ab	1.8b	2.1a	1.8b	2.2a	2.1b	2.1a	1.9b	1.6a	1.9a
Means											
Ratio 1:1:1		1.4	2.4	2.1	2.3	1.9	2.6	2.0	2.5	1.6	2.2
Ratio 1:0.9:2		1.3	1.9 ^o	2.2*	1.8 ^o	2.2*	2.2 ^o	2.2	2.1 ^o	1.6	2.0
N 100 kg/ha		1.4	2.4	2.2	2.2	2.1	2.6	2.2	2.6	1.7	2.2
N 200 kg/ha		1.3	1.9 ^o	2.1	2.0	2.1	2.2 ^o	2.0	2.0 ^o	1.6	1.9 ^o
Mean		1.3	2.1	2.2	2.1	2.1	2.4	2.1	2.3	1.6	2.1
Standard deviation		0.3	0.5	0.4	0.6	0.4	0.5	0.4	0.6	0.3	0.5
DS _(variants) 5%		0.5%	0.6%	0.7%	0.7%	0.6%	0.6%	0.5%	0.7%	0.4%	0.7%
DL _(ratio) 5%		0.2%	0.3%	0.3%	0.4%	0.3%	0.4%	0.3%	0.4%	0.3%	0.3%
DL _(doses N) 5%		0.2%	0.3%	0.3%	0.4%	0.3%	0.3%	0.3%	0.4%	0.2%	0.3%

The Duncan test revealed that on average for two years, for Roclas variety tubers from the variant with the NPK ratio 1:1:1, with the lowest levels of fertilizer N100 it is breaking at boiling, the consistency of the pulp is reduced, the mealiness increased and the moisture decreased from the rest of the variants.

Table 2 shows the average percentage of starch content, the dry matter and the reducing sugar in Christian and Roclas potato tubers varieties, in years 2013-2014 (two years with very different climate conditions).

In 2013, on average, between this two varieties were significant differences regarding the percentage of starch (16.9% for Roclas variety

and 16.2% for Christian variety). The other analyses presented were located at the same level.

In 2014, the studied varieties were strongly differentiated in terms of the starch content, dry matter and sugars. The starch content of the Roclas variety (16.2%) exceeded that of Christian variety (13.9%) with 2.3%. Similarly, the dry matter of variety Roclas (24.1%) was significantly higher compared to the variety Christian (22.9%). A significant difference was recorded also for the reducing sugars' content; after harvesting, the reducing sugar content of the variety Roclas was higher than the Christian variety with 0.24%.

Table 2

The average values of starch, dry matter and reducing sugars content in the tubers, Brașov, 2013-2014

	Starch %			Dry matter %			Reducing sugar (glucose +fructose) %		
	2013	2014	Media	2013	2014	Media	2013	2014	Media
Christian	16.2	13.9	15.1± 1.5	25.0	22.9	23.9±1.9	0.12	0.25	0.19±0.15
Roclas	16.8	16.2	16.5±1.0	25.5	24.1	24.8±1.9	0.18	0.49	0.34±0.20
Differences (Roclas-Christian)	+0.7*	+2.3*	+1.5	+0.5	+1.2*	+0.85	+0.06	+0.24*	+0.15
DL 5%	0.7%	0.7%		1.2%	1.1%		0.11%	0.10%	

Table 3.

Comparison of correlation coefficients between starch and notes of appreciation for culinary quality traits

	Year	Starch	Breaking at boiling	Consistence	Mealiness	Moisture	Structure of starch
Starch	2013	1					
	2014	1					
Breaking at boiling	2013	0.443*	1				
	2014	0.769**	1				
Consistence	2013	0.234	0.406*	1			
	2014	-0.182	0.028	1			
Mealiness	2013	0.229	0.636**	0.604**	1		
	2014	0.274	0.488**	0.526**	1		
Moisture	2013	0.451**	0.575**	0.460**	0.659**	1	
	2014	0.373*	0.360*	0.030	0.610**	1	
Structure of starch	2013	0.405*	0.678**	0.340	0.594**	0.354*	1
	2014	0.660**	0.729**	0.245	0.691**	0.583**	1

N = 32

** Correlation is significant for 0.01

* Correlation is significant for 0.05

The appreciation notes for breaking at boiling are positively significantly correlated with mealiness (0.636** and 0.488**), moisture (0.575** and 0.360*) and structure of starch (0.678** and 0.729**) (table 3). Correlations that are distinct, positive, significant are recorded between the notes and consistence and mealiness (0.604** and 0.526**) and correlations between appreciation notes of mealiness with moisture (0.659** and 0.610**) and structure of starch (0.594** and 0.691**), respectively moisture notes with starch structure (0.354* and 0.583**).

Average suitability for processing into chips and correlations between dry matter, starch, reducing sugar, efficiency to processing into chips and chips color before storing tubers 2013-2014

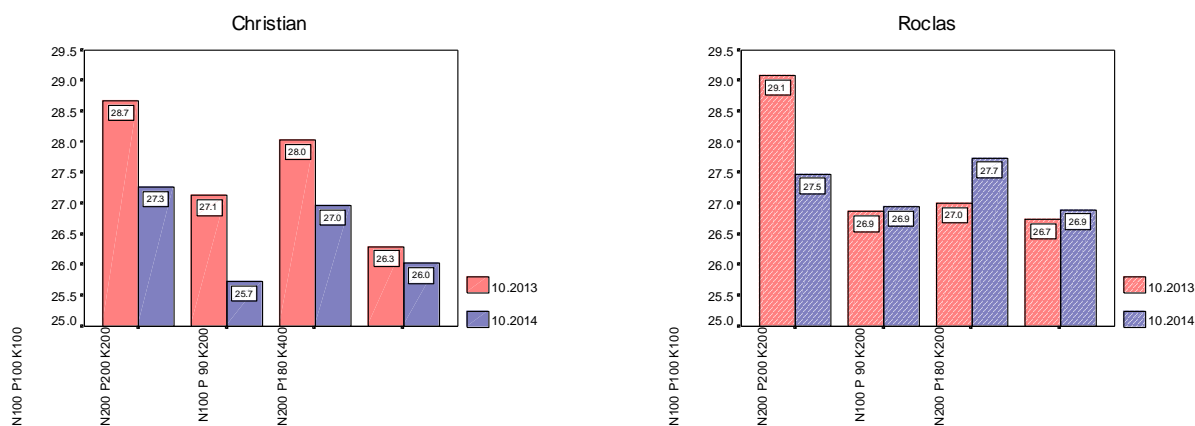
For the two years, on average, the chips' yield did not significantly differentiate; also, the

average note for chips color did not differentiate significantly for two varieties researched.

The effects of fertilization variants on performance and chips color due to different growth conditions are illustrated in comparison for the two varieties in figures 1 and 2.

The level of tuber efficiency to processing into chips differs stronger for Christian variety compared to Roclas variety, differentiation with similar trends in the two years of study.

From graphs it can be seen the decrease of chips yield with increasing NPK ratio from 1:1:1 to 1:0.9:2, respectively with increasing nitrogen dose in combination of 100 to 200 kg N/ha. Notes for chips color have a decreasing trend, which indicates a darker chips color with increasing doses of nitrogen for variants with ratio 1:0.9:2 for both varieties, in two experimental years.


Figure 1 Comparison of fertilization variants for chips yield before storage 2013-2014

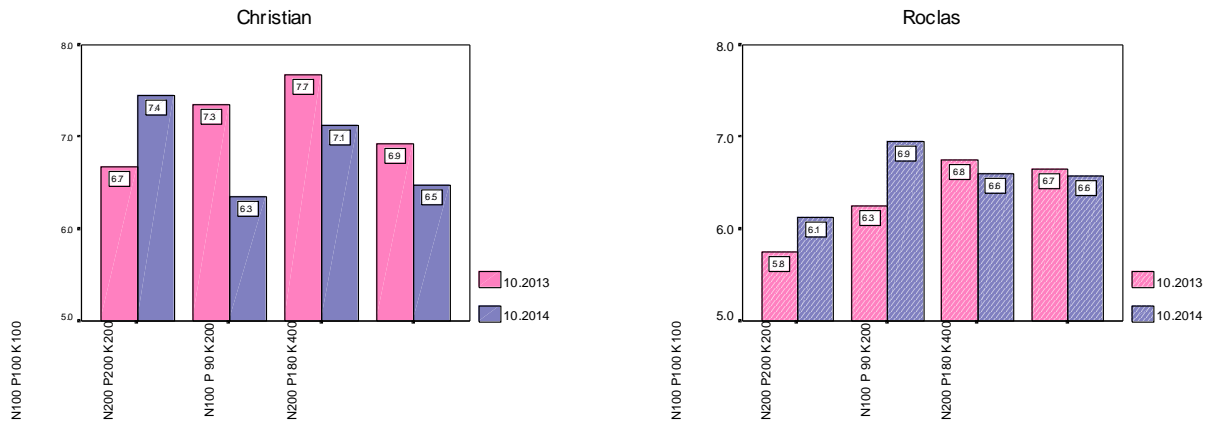


Figure 2 Comparison of fertilization variants for chips color before storage 2013-2014

Mean values for indicators of pretability for processing into chips on experimental cycle are

presented in comparison for Christian and Roclas varieties in table 4.

Table 4

Mean values for indicators of suitability for processing into chips before storage, Braşov 2013-2014

Ratio NPK	Dozes N Kg/ha	Efficiency to peeling %		Efficiency to mechanical processing %		Efficiency to processing into chips %		Notes for chips color (1-9)	
		Christian	Roclas	Christian	Roclas	Christian	Roclas	Christian	Roclas
1:1:1	100	83.4a	82.8a	80.5a	80.4a	28.0a	28.3a	7.1a	5.9b
	200	83.1a	82.9a	80.3a	80.7a	26.4bc	26.9a	6.9a	6.6a
1:0.9:2	100	83.6a	83.9a	81.2a	81.5a	27.5ab	27.4a	7.4a	6.7a
	200	84.0a	83.0a	81.2a	80.6a	26.2c	26.8a	6.7a	6.6a
Means									
Ratio 1:1:1		83.3	82.9	80.4	80.6	27.2	27.6	7.0	6.3
Ratio 1:0.9:2		83.8	83.5	81.2	81.0	26.8	27.1	7.1	6.6
N 100 kg/ha		83.5	83.3	80.8	81.0	27.7	27.8	7.2	6.3
N 200 kg/ha		83.6	83.0	80.8	80.7	26.3 ^o	26.9	6.8	6.6
Mean		83.5	83.2	80.8	80.8	27.0	27.3	7.0	6.4
Standard deviation		1.1	1.2	1.6	1.4	1.3	1.6	0.8	0.6
DS _(variants) 5%		1.6%	1.6%	2.3%	2.0%	1.6%	2.2%	1.1%	0.8%
DL _(ratio) 5%		0.8%	0.8%	1.1%	1.0%	0.9%	1.1%	0.6%	0.8%
DL _(doses N) 5%		0.8%	0.8%	1.2%	1.0%	0.8%	1.1%	0.6%	0.4%

After studying the coefficients, only Christian variety is established statistically significant positive correlations between dry

matter from tubers and efficiency to processing into chips (0.406*) and between dry matter and notes of chips color (0.370*) (table 5).

Table 5

The coefficients for the correlations between dry matter, starch, reducing sugar, efficiency to processing into chips and colour of chips before storage

	Variety	Dry matter	Starch	Reducing sugar	Efficiency to processing into chips	Colour of chips
Dry matter	Christian	1				
	Roclas	1				
Starch	Christian	0.772**	1			
	Roclas	0.677**	1			
Reducing sugar	Christian	-0.421*	-0.246	1		
	Roclas	-0.331	-0.167	1		
Efficiency to processing into chips	Christian	0.406*	0.687**	0.232	1	
	Roclas	0.163	0.375*	0.181	1	
Colour of chips	Christian	0.370*	0.420*	0.157	0.444*	1
	Roclas	-0.271	-0.381*	-0.069	0.125	1

N = 32

** Correlation is significant for 0.01

* Correlation is significant for 0.05

The starch content of the tuber is positive statistically assured correlated tubers efficiency to processing into chips, $r = 0.687^{**}$, for Christian variety and $r = 0.375^*$ for Roclas variety. Correlations of starch content with notes of chips' color for two varieties had values of 0.420^* and -0.381^* .

No significant correlation was obtained between reducing sugar and color of chips tubers for data achieved in the years 2013-2014, before storage for studies varieties. The correlation between the efficiency to processing into chips and the color of chips was significant only for Christian variety (0.444^*).

CONCLUSIONS

Because the researches were conducted in two years with very different growth conditions in terms of climate, the accumulation of starch and dry matter in tubers was significantly low in 2014 comparing with 2013.

On average, on those two years, the differences due fertilization variants were not provided statistical for dry matter content of tubers. For 2014 fertilization variants with high nitrogen level led to significant decreases in dry matter content to both fertilizing ratios, on both varieties. On both varieties the content of reducing sugar was significantly higher in 2014 comparatively with 2013.

Comparing variants of fertilization, on Roclas variety, tubers from variant with N100 P100 K100 louder crashed on boiling, pulp consistency is more reduced, are more farinaceous and moisture toward the rest of variants for both years, tubers starch contents positively significantly correlate with appreciation notes for milling, moisture and starch structure.

With the increase ratio from NPK 1:1:1 to 1:0.9:2 respective with increasing nitrogen dose combinations from 100 to 200 kg N/ha the decline in yield is found in chips. Notes for the chips' color have a tendency to decrease, which indicates a darker color of chips with increasing doses of nitrogen on variants with ratio 1:0.9:2, on both varieties and both experimental years.

The starch content of tubers correlates positively, assured yield statistically in chips of the tubers, $r = 0.687^*$ - Christian and $r = 0.375$ at Roclas variety. There were no significant correlations between reducing sugar from tubers and chips color for the data obtained in the years 2013-2014 before storage.

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