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POTATO AND SUGAR BEET TECHNOLOGICAL QUALITY AS RESULTS OF DIFFERENT FERTILIZATION

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ABSTRACT

In the agro-climatic conditions from Brasov area in the years 2014-2015, within the National Institute of Research and Development for Potato and Sugar Beet Brasov, were studied variants with NPK complex fertilizers applied for basic fertilization for potato crop by broadcast after furrow and at soil preparation before sowing at sugar beet crop. The basic fertilization was supplimented on all variants with a second fertilization with different forms of nitrogen. These fertilization technologies are adapted to the cultivation conditions in order to reach the maximum production potential in terms of quantity and quality and with guaranteed profitability for the two crops. In the case of sugar beet, the production on fertilization variants was analyzed qualitatively, the sugar content being strongly influenced by the fertilizer combinations used. Analyzing the technological quality of the potato, it was found a starch content decreasing in all fertilization variants.

INTRODUCTION

Root and tuber quality are by far the most important parameters affecting sugar beet and potato processing. The aim of sugar beet processors, worldwide, is to produce pure sugar, at least cost, from the purchased sugar beet (Dutton & Huijbregts 2006). There are many factors who can influence the potato and sugar beet technological quality; some of them, climate, variety, fertilizers, can have the greatest influence on the quality parameters, as well the year conditions and site location. Märländer (1991) cited by Kenter et al. 2006 demonstrated that the yield potential of sugar beet depends primarily on site and year effects, whereas the influence of agronomic practices is much lower. The highest beet yield can be obtained under conditions of favorable weather and adequate supply of fertilizers (Barlog et al. 2013). For normal soils the ratio for potato crop of N:P2O5:K2O in the fertilizer is usually 1:1:2, but other ratios are required under certain soil conditions (Beukema & Van der Zaag 1990). The same way as in potato crop, only part of the nutrient needs of sugar beet come from the soil. The remainder must be obtained from fertilizers, both mineral and organic, applied in a number of ways (Draycott 2006).

The right source of nutrient applied at the right rate, at the right time and in the right place contribute to the productivity, profitability and sustainability of the potato production system (Mikkelsen & Hopkins 2009). The productive need for fertilizers is partially ensured from the soil reserves and especially through the doses and assortments of applied fertilizers (Vidican et al. 2013).

Research on the fractional application of fertilizers to potato crop was carried out between 1978-1980 in non-irrigated and irrigated conditions, in a vast national network of experiments. It has been found that PK fertilizers can be applied in autumn or spring to land preparation, and those with N in spring from land preparation to the early stages of vegetation (Copony et al. 1982). Nitrogen is given shortly before, or at planting time but a split application may be better if there is a risk of leaching or if the application of large quantities of fertilizer under dry conditions may cause scorching (Beukema & Van der Zaag 1990). The effect of fertilization technologies used in potato and sugar beet crops must be monitored both quantitatively and qualitatively. For sugar beet, high root crop are profitable if the sucrose percentage is also high (Franzen 2018).

Different placement and timing applications of fertilizers can lead to significant productions increasing. Nitrogen is the most studied nutrient for sugar beet and also for potato because of its relationship to plant productivity. The application of less nitrogen in sugar beet crop will result in reduced root tonnage, hawever, the application of too much nitrogen will result in reduced sucrose concentrations and increased impurities (Hergert 2010, 2011). In the late-season, the crop yield potential fulfilling depends, on phosphorus supply. This nutrient is responsible for nitrogen unit productivity, provided an adequate rate of phosphorus (Barlog et al. 2013).

In potato crop, high doses of nitrogen can delay the formation of potato tubers, reduce their specific weight and dry matter content. Applying excessive amounts of nitrogen and potassium can decrease potato specific gravity; application of phosphorus at optimum dose increase tuber starch content (Sud & Sharma 2003), it tends to increase starch synthesis, but in contrast with nitrogen it hastens rather than delays maturity (Stark et al. 2003). Sulfur has significant influence on yield and quality attributes of potato tubers. Sulfur deficiency may lead to decrease in concentration of tuber starch content (Sharma et al. 2011). Being interdependent on each other the interaction of S with N and P greatly influences the yield and quality of potato (Sud & Sharma 2003).

MATERIAL AND METHODS

In 2014-2015, nine fertilization variants with complex fertilizers applied to the preparation of the germination bed, supplemented by a second fertilization with different forms of nitrogen, compared to an unfertilized control were studied for potato and sugar beet crops. The experiments performed in the field, were placed on a cambic chernozem soil representative for the cultivation area in Ţara Bârsei, soil with weak acid reaction and a medium humus content. The supply status in easily absorbable elements during the two years of experience is shown in Table 1.

The averages of the monthly temperatures in the two years of study, 2014 and 2015, (Figure 1) were generally higher than the averages of the multiannual monthly temperatures, on average by 1.6 °C and 1.7 °C per agricultural year. In 2014, the rainfall during the winter was below the multiannual averages for this period, while in 2015 the amount of rainfall during the period, preceding the potato and sugar beet crops, exceeded the multiannual average for Brasov area, ensuring a good water supply to the soil.

Table 1

Soil content in easily absorbable elements on the analyzed surface – Brașov

Year		pH	Humus %	Total N %	N mineral NO3 ppm	P-AL ppm	K-AL ppm
2014	Average	6.17	2.87	0.15	5.8	24.7	58.0
	CV%	1.94	13.59	11.83	25.1	29.6	36.3
	Min.	6.02	2.32	0.13	3.8	14.1	20.0
	Max.	6.38	3.54	0.19	8.0	38.7	85.0
2015	Average	5.99	2.79	0.14	8.2	53.6	90.9
	CV%	1.55	18.14	9.63	20.5	15.1	7.7
	Min.	5.77	2.28	0.12	6.6	42.5	80
	Max.	6.12	3.56	0.16	11.0	74.7	100

During the vegetation period the evolution of precipitation was different in the two years of study. Thus, the vegetation period started in 2014 with heavy rainfall in April and May (137% and 22.2% higher than MMA - multiannual average) contributing to a good start of potato and sugar beet crops by uniform emergence, with complete emergence on the rows until the second decade of May and the rapid development of foliage, while in 2015 the precipitation in these months was below the level of the corresponding multiannual averages.

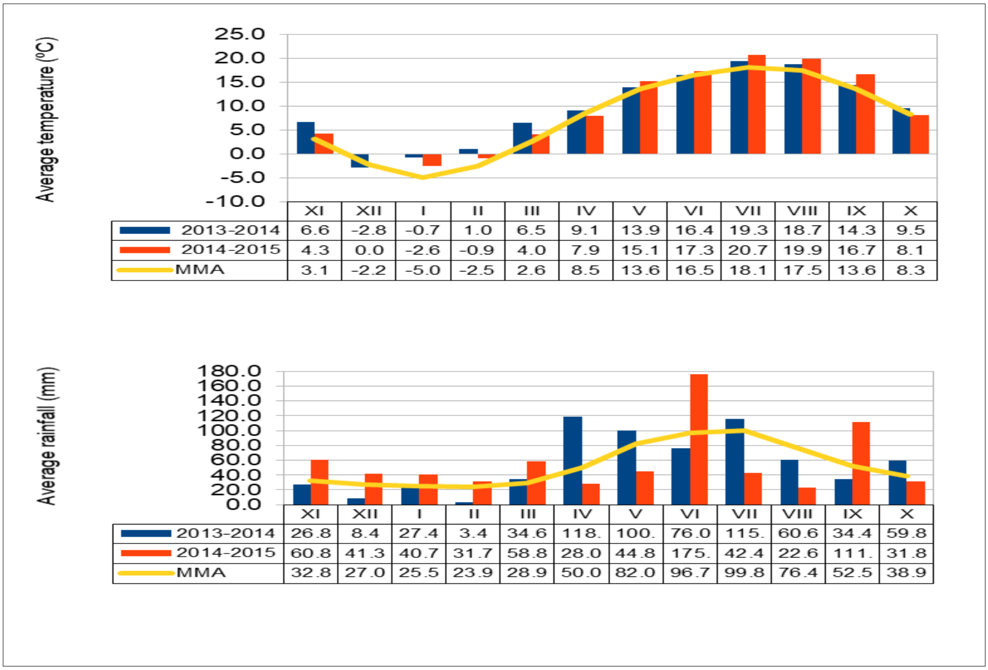

Figure 1. Average hydrothermal conditions (Brașov, 2014-2015)

In 2014, in June and September, the precipitations were below the MMA level, but in 2015 their level exceeded the MMA by 81.6%, respectively 111.4%. In the two years, the dry conditions in the second part of the potato vegetation favored the maturation of the plants, the abundant rains from September 2015 not being able to be capitalized in the absence of the active foliage.

The forerunner crop was autumn wheat. Basic fertilization was performed for both crops when the soil was prepared for planting and sowing. For basic fertilization complex fertilizers with a higher degree of solubilization and accessibility than simple fertilizers (Bîlteanu 1993) were administered for potato crop by broadcast after furrow is made and at soil preparation before sowing at sugar beet crop. For the potato crop, the single-factor experiment was performed in randomized blocks in four repetitions. In the experiment, the Christian potato variety was used, the planting being done semi-mechanized in 2014 in the first decade of April and in 2015 in the second decade of April. Second fertilization was carried out just before plant emergence in the first decade of May (2014) and the second decade of May (2015). The fertilization options for the two crops, potato and sugar beet are shown in Table 2.

Table 2

The fertilization variants experimented in 2014-2015, N.I.R.D.P.S.B. Brașov

Year	Var	Basic fertilization	t/ha	Second fertilization	t/ha
2014	M	Unfertilized	-	Unfertilized	-
	V1	NPK+S 15:15:15 + 7	0.6	Ammonium nitrate 27	0.385
	V2	NPK+S 15:15:15 + 7	0.6	NPK 20:20:0	0.495
	V3	NPK+S 15:15:15 + 7	0.6	Urea 46	0.226
	V4	NPK 20:20:0	0.6	Ammonium nitrate 27	0.385
	V5	NPK 20:20:0	0.6	NPK 20:20:0	0.495
	V6	NPK 20:20:0	0.6	Urea 46	0.226
	V7	NPK+S 14:14:17+14.5	0.738	Ammonium nitrate 27	0.385
	V8	NPK+S 14:14:17+14.5	0.738	NPK 20:20:0	0.495
	V9	NPK+S 14:14:17+14.5	0.738	Urea 46	0.226
2015	M	Unfertilized	-	Unfertilized	-
	V1	NPK+S 15:15:15 + 7	0.6	Ammonium nitrate 27	0.385
	V2	NPK+S 15:15:15 + 7	0.6	NPK+S 21:7:13+5	0.495
	V3	NPK+S 15:15:15 + 7	0.6	Urea 46	0.226
	V4	NPK 15:15:15	0.6	Ammonium nitrate 27	0.385
	V5	NPK 15:15:15	0.6	NPK+S 21:7:13+5	0.495
	V6	NPK 15:15:15	0.6	Urea 46	0.226
	V7	NPK+S 14:14:17+14.5	0.738	Ammonium nitrate 27	0.385
	V8	NPK+S 14:14:17+14.5	0.738	NPK+S 21:7:13+5	0.495
	V9	NPK+S 14:14:17+14.5	0.738	Urea 46	0.226

During the vegetation period, treatments to control diseases, pests and weeds were carried out. Harvesting was done semi-mechanically in the third decade of September for both experimental years. The potatoes production per hectare was determined on experimental variants; determinations were made regarding the starch content. For sugar beet, the experiment was performed in randomized blocks in three repetitions. Each repetition plot was sown in 6 rows with a length of 10 m. The Clementine disease tolerant triple hybrid (KWS) was used, whith sown seed of 1.3 UG/ha. The soil was prepared with the combine and the beet was sown in the third decade of April with the Kleine precision sower on 6 rows. Second fertilization with different forms of nitrogen was performed with the first mechanical weeds destruction. The treatments for combating diseases, pests and weeds were performed according to the climatic specifics of each experimental year and 2 mechanical weeds destruction were performed. At harvest in the third decade of October, the production of beet roots per hectare was determined on experimental variants and root samples were taken from each plot/repetition for laboratory analyzes on the technological quality of beets. The statistical calculation of the research results was done using the analysis of variance and Duncan test.

RESULTS AND DISCUSSIONS

In the fertilization experiment for sugar beet the sugar content was strongly influenced by the used fertilizer combinations in 2014 (Table 3). The roots sugar content varied from a minimum of 19.83 ºS (for the unfertilized control), to a maximum of 21.98 ºS for V6.

Table 3.

The fertilizer application effect on sugar beet sugar content

	Var.	Root yield	Sugar content					1 Sugar yield				
		t/ha	(º S)	Relative %	Diff. (º S)	Sign.	Duncan test	t/ha	Relative %	Diff. t/ha	Sign.	Duncan test
2014	M	59.47	19.83	100	-	-	E	11.79	100.0	-	-	C
	V1	75.80	20.52	103.5	+0.69	**	D	15.56	132.0	+3.77	***	B
	V2	74.42	21.15	106.7	+1.32	***	C	15.74	133,5	+3.95	***	B
	V3	73.97	21.25	107.2	+1.42	***	C	15.72	133.5	+3.93	***	B
	V4	76.10	21.52	108.5	+1.69	***	ABC	16.39	139.0	+4.60	***	AB
	V5	74.43	21.13	106.6	+1.30	***	C	15.74	133.5	+3.95	***	B
	V6	72.60	21.98	110.8	+2.15	***	A	15.95	135.3	+4.16	***	B
	V7	72.57	21.50	108.4	+1.67	***	BC	15.60	132.3	+3.81	***	B
	V8	75.67	21.05	106.2	+1.22	***	C	15.93	135.1	+4.14	***	B
	V9	80.35	21.88	110.3	+2.05	***	AB	17.58	149.1	+5.79	***	A
		DL 5% DL 1% DL 0.1%	0.43 ºS 0.59º S 0.78º S					0.38 t/ha 1.86 t/ha 2.48 t/ha				
2015	M	52.5	17.15	100	-	-	**A**	9.01	100.00	-	-	B
	V1	69.75	18.15	105.8	+1.00.	ns	A	12.67	140.62	+3.66	***	A
	V2	66.00	17.72	103.3	+0.57	ns	A	11.71	129.97	+2.70	***	A
	V3	67.00	17.47	101.9	+0.32	ns	A	11.69	129.74	+2.68	***	A
	V4	70.25	17.52	102.2	+0.37	ns	A	12.29	136.40	+3.28	***	A
	V5	67.50	17.75	103.5	+0.60	ns	A	11.98	132.96	+2.97	***	A
	V6	67.25	18.35	107.0	+1.20	ns	A	12.32	136.73	+3.31	***	A
	V7	71.00	17.30	100.9	+0.15	ns	A	12.30	136.51	+3.29	***	A
	V8	70.00	17.53	102.2	+0.38	ns	A	12.25	135.96	+3.24	***	A
	V9	71.50	17.35	107.0	+0.20	ns	A	12.40	137.62	+3.39	***	A
		DL 5% DL 1% DL 0.1%	1.5 ºS 2.0 º S 2.7 º S					1.21 t/ha 1.63 t/ha 2.18 t/ha				

All fertilized variants exceeded the unfertilized control in root sugar content with very significant differences between 6.2% and 10.8% for eight of them and for one fertilized variant (V1) with significant differences, 3.5%. Analizing the diferences between variants was found that the variant V6 with the highest value of sugar content (21.98 ºS) registers significant differences from most variants except V4 and V9. The nine fertilization options resulted in a substantial increase in sugar yield/ha, between 32.0% and 49.1% compared to the unfertilized control; the highest yield of sugar/ha was recorded in variant V9 (17.58 t sugar/ha), exceeding the unfertilized control by 5.79 tons/ha, the differences compared to the unfertilized control being very significant for all fertilization variants. With the exception of variant V4, variant V9 registered significant differences compared to all fertilization variants.

In 2015, the sugar content of sugar beet was influenced by the fertilizer combinations used. The sugar content ranged from a minimum of 17.15 ºS (for the unfertilized control) to a maximum of 18.35 ºS for variant V6. The highest sugar content was recorded for the fertilization variant V6 which exceeded the unfertilized control with 1.20 ºS. On the 2nd place in the sugar content was ranked the V1 fertilization variant which exceeded the unfertilized control with 1.00 ºS. All the proposed fertilization options resulted in a substantial increase in sugar production/ha compared to the unfertilized control, with increases between 29.97 and 40.62%. The highest production of sugar/ha was recorded in fertilization variant V2 (12.67 t sugar/ha), which exceeded the unfertilized control by 3.66 t organic sugar/ha (40.62%). On the 2nd place in the production of sugar/ha was the variant V9, which exceeded the unfertilized control by 3.39 t sugar/ha (37.62%).

Experimental data recorded in both years in Brasov show that all fertilizer variants tested for sugar beet respond with significant increases in root production/ha and sugar production/ha. Significant differences were also found in the sugar root content in 2014, while in 2015 the insignificant differences could be attributed to climatic conditions, very heavy rainfall and high temperatures in September that exceeded this month's MMA by 111.4% and by 22.8%, respectively (Figure 1).

In 2014, for the potato crop regarding the effect of differentiated fertilization on the starch content (Table 4), eight of the experimental variants registered a significant decrease in the starch content compared to the unfertilized control, between 1.29-1.87% starch. The lowest starch content was recorded in variant V8 (13.10% starch) and the highest starch content was recorded in variant V1 (13.81%). The production of starch/ha registered increases compared to the unfertilized control for all fertilization variants, significant increases having all variants with second fertilization with ammonium nitrate 27 V1, V4, V7 and also V2 and V9; the highest starch/ha production being registered at variant V1 5.8 t/ha compared to the control variant 4.0 t/ha). Significant differences were found between the experimental variants only for the V1 and V8 variants (5.8 t/ha and 4.6 t/ha starch). In 2015 the starch content of potato tubers was lower in all fertilization variants compared to the unfertilized control (16.27% starch); significant decreases were registered in five variants V3, V4, V5, V6, V7, the largest decrease being for V6 variant (1.92% starch). There were no significant differences in starch content between the experimental variants. Regarding the starch yield/ha, there were significant increases compared to the unfertilized control (4.3 t/ha) for variants V2, V3 and V4 (5.4-5.8 t/ha). The V4 variant with fertilization with ammonium nitrate 27 had the highest increase in starch production/ha (5.8 t/ha). Between the experimental variants were found significant differences at V7, V2 and V4.

Table 4

The fertilizer application effect on potato starch content

	Variants	Yield	Starch content					Starch yield				
		t/ha	(%)	Relative %	Diff. (%)	Sign.	Duncan test	t/ha	Relative %	Diff. t/ha	Sign.	Duncan test
2014	M	26.8	14.96	100	-	-	A	4.0	100	-	-	C
	V1	41.9	13.81	92.3	-1.15	ns	B	5.8	145.0	+1.8	***	A
	V2	39.3	13.67	91.4	-1.29	o	B	5.4	135.0	+1.4	**	AB
	V3	34.8	13.60	90.9	-1.36	oo	B	4.7	117.5	+0.7	ns	ABC
	V4	37.4	13.26	88.6	-1.70	oo	B	5.0	125.0	+1.0	*	ABC
	V5	36.8	13.23	88.4	-1.73	oo	B	4.9	122.5	+0.9	ns	ABC
	V6	35.4	13.20	88.2	-1.76	oo	B	4.7	117.5	+0.7	ns	ABC
	V7	39.8	13.21	88.3	-1.75	oo	B	5.3	132.5	+1.3	**	AB
	V8	35.2	13.10	87.6	-1.86	ooo	B	4.6	115.0	+0.6	ns	BC
	V9	38.2	13.35	89.2	-1.61	oo	B	5.1	127.5	+1.1	*	ABC
		DL 5% DL 1% DL 0.1%	1.22% 1.36% 1.81%					1.0 t/ha 1.3 t/ha 1.74 t/ha				
2015	M	26.5	16.27	100	-	-	A	4.3	100	-	-	C
	V1	33.3	14.83	91.1	-1.44	ns	BC	4.9	114.1	+0.6	ns	ABC
	V2	38.3	14.79	90.9	-1.48	ns	BC	5.7	131.3	+1.4	*	A
	V3	36.8	14.71	90.4	-1.56	o	BC	5.4	124.4	+1.1	*	AB
	V4	39.9	14.52	89.2	-1.75	o	BC	5.8	133.6	+1.5	**	A
	V5	34.2	14.52	89.2	-1.75	o	BC	5.0	115.2	+0.7	ns	ABC
	V6	36.5	14.35	88.2	-1.92	o	C	5.2	120.5	+0.9	ns	ABC
	V7	30.7	14.67	90.2	-1.60	o	BC	4.5	103.7	+0.2	ns	BC
	V8	34.6	14.83	91.1	-1.44	ns	BC	5.1	118.0	+0.8	ns	ABC
	V9	35.4	15.06	92.6	-1.21	ns	B	5.3	122.1	+1.0	ns	ABC
		DL 5% DL 1% DL 0.1%	1.55% 2.04% 2.62%					1.1 t/ha 1.45 t/ha 1.8 t/ha				

CONCLUSIONS

The sugar beet production on all fertilization variants was analyzed qualitatively, the root sugar content being significant positiv influenced by the fertilizer combinations used in 2014 and 2015; this positive difference was not statistically assured due to climatic conditions, very heavy rainfall and high temperatures in September.

Experimental data recorded in both years in Brasov show that all fertilizer variants respond with significant increases sugar production/ha.

All fertilization variants applied to the potato crop led to decrease in the tuber starch content compared to the unfertilized control.

The significant differences of yield starch/ha registered in 2014 for the three fertilization variants V1, V4 and V7 with ammonium nitrate were not repeated in 2015 except for variant V4.

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