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EFFECT OF BIOSTIMULATORS ON YIELD AND SELECTED CHEMICAL PROPERTIES OF POTATO TUBERS

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Abstract

Growth regulators stimulate life processes in plants, improving their stress resistance and health, which translates into higher and better quality yield. Growth regulators can improve biochemical parameters of tubers and enhance the potato's resistance to adverse environmental conditions or pathogens. The purpose of this research was to examine the effect of biostimulators on yield and selected chemical properties of potato tubers. Four table potato cultivars were grown in a field experiment: very early Volumia and medium early Irga, Satina and Sylvana. Starting from stage 39 on the BBCH scale (crop cover complete), potato plants were treated thrice, in 10- to 14-day intervals, with the growth regulators Asahi SL, Bio-Algeen S90 and Kelpak. The reference treatment was composed of potatoes untreated with the bioregulators. The growth regulators, especially Bio-Algeen S90 (6.3 – 16.3%) and Kelpak SL (14.2-24.7%) raised the tuber yield, but the effect was statistically verifiable only in the second year, with less precipitation and lower temperature of the vegetation period. The quality of potato tubers was more strongly dependent on the cultivar-specific traits than on the applied biostimulators. In the second year, too, potato tubers contained on average 34% more N-total than in the first year. During storage, the content of N-total in tubers increased by 35-50%. After a five-month storage period, potato tubers contained more NO_3^- abut less $N\text{-}NH_4^+$.

Keywords: biostimulators, potato cultivars, N-total, nitrates(V), $N\text{-}NH_4^+$, chloride, storage.

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INTRODUCTION

Potato is one of the most popular crops in Poland. In 2011, the total acreage cropped with potato reached 393 thousand ha, and the average yield was 23.2 t ha^{-1} (Central Statistical Office, 2012). The potato consumption in the season of 2010/2011 equalled 112 kg per capita. The main ingredient of the potato tuber dry matter is starch. Protein is another valuable nutrient in potato tubers (Zarzecka, Gugała 2006). Despite its small amounts, potato protein is distinguished by a high biological value, comparable to soybean protein and only slightly worse than hen's egg protein. It is rich in exogenous amino acids, such as leucine, lysine, phenylalanine, threonine, which the human body cannot synthesize. The nutritive value of potatoes is also shaped by mineral components, such as potassium, calcium and magnesium. Potato, and especially the colour population from Chile, is a rich source of phenolic compounds, which possess antioxidant properties (Ah-Hen et al. 2012).

Growth regulators stimulate plants' life processes, thus improving the quality and volume of plant yields (Wierzbowska et al. 2010). In potato, they affect the yield of tubers, improve their biochemical parameters and enhance the potato's resistance to adverse environmental conditions or pathogens (Černý et al. 2002, Sawicka et al. 2011). Extracts from algae are a cheap source of natural growth stimulators and other bioactive substances. They can be used as biostimulators in agriculture and horticulture in order to improve yields and quality of plants (Panda et al. 2012). Algal concentrates can relieve stress caused by deficiency of nutrients, which means that lower doses of mineral fertilizers need to be applied (Papenfus et al. 2013).

The aim of this research was to determine the effect of biostimulators on yields and selected chemical properties of edible potato tubers.

MATERIAL AND METHODS

The research was based on a field experiment set up in a random sub-block design. The experiment was run at the Experimental Station in Tomaszkowo, which belongs to the University of Warmia and Mazury in Olsztyn. Potatoes were grown on arable land of higher medium quality (R IVa), on dystrophic brown soil (dystric Cambisol) developed from loamy sand. The soil had the following characteristics: pH 5.32-5.70 in 1 mol KCl dm^{-3} extract and levels of available minerals 69-72 mg P kg^{-1}, 82-90 mg K kg^{-1} and 38-48 mg Mg kg^{-1}.

Four edible potato cultivars were grown: very early Volumia and medium early Irga, Satina and Sylvana. The preceding crop was a cereal (triticale in 2011 and oat in 2012). The soil nourishment consisted of 25 t ha^{-1} of

FYM applied in autumn and mineral fertilization in spring. The mineral fertilization was composed of (in kg ha^{-1}) 40 N as 46% urea, 60 P (17.45% P superphosphate) and 100 K (50% K potassium salt). Potato tubers were seeded in late April (27/04) at 67.5 × 40 cm space distances. All potato cultivars were harvested on the same day (6 September 2011 and 21 August 2012).

During the growth, from phase 39 on the BBCH scale (complete crop cover), the potato plants were treated thrice, in 10- to 14-day intervals, with growth regulators. The following preparations, in doses recommended by the manufacturers, were applied:

- 0.1% solution of Asahi SL (contains natural nitropherols found in plants: ortho-nitropherol, sodium para-nitropherol, sodium 5-nitroguaiacol);
- 1.0% solution of Bio-Algeen S90 (extract from seawater brown alga, contains amino acids, vitamins, alginic acid and macro- (N – 0.2, P_2O_5 – 0.06, K_2O – 0.96, CaO – 3.1, MgO – 2.1 g kg^{-1}) and micronutrients (B – 16.0, Fe – 6.3, Cu – 0.2, Mn – 0.6, Zn – 1.0 mg kg^{-1} and Mo, Se, Co);
- 0.2% solution of Kelpak SL (extract from Brown algae *Ecklonia maxima* (11 mg dm^{-3} auxins and 0.031 mg dm^{-3} cytokines, which means a 350:1 auxin to cytokine ratio).

For evaluation of the efficiency of these preparations, a control object was set up, consisting of potatoes grown without growth stimulators.

After potato harvest, the yields were assessed and potato tuber samples for chemical analyses were taken. The remaining tubers were stored for five months at 4°C. Afterwards, they were submitted to chemical analysis.

After drying and grinding, the plant material was wet mineralized in concentrated sulphuric acid (VI) with hydrogen dioxide added as an oxidant. The prepared plant material underwent analyses with the hypochlorite spectrophotometric method to determine N-total (Baethgen, Alley 1989). In fresh potato tubers, the concentrations of NO_3^-, N-NH_4^+ and Cl^- ions were determined in aqueous extracts: NO_3^- by spectrophotometry with salicylic acid (Caldo et al. 1975); N-NH_4^+ – by the hypochlorite method, Cl^- – by the argentomertic method.

The results were submitted to statistical processing using an analysis of variance (Statistica 10 software package) and differences between means were compared by the Duncan's test at $p = 0.05$.

RESULTS AND DISCUSSION

During the growing season of potato plants, the mean air temperature and amount of rainfall were higher than in the multi-year period (Table 1). Temperatures higher than the multi-year average persisted throughout al-

Table 1

Weather conditions

Month	Temperature (°C)			Rainfall (mm)		
	2011	2012	on average for years 1961-2010	2011	2012	sum for years 1961-2010
April	9.1	7.8	7.0	22.5	73.1	34.2
May	13.1	13.4	12.7	51.1	51.7	54.6
June	17.1	15.0	15.9	81.7	103.2	79.0
July	17.9	19.0	18.0	202.8	121.0	75.4
August	17.6	17.7	17.3	82.1	45.1	68.7
Average/sum	15.0	14.6	14.2	440.2	394.1	311.9

most all the growing season. Much higher precipitations appeared in 2011. After dry spring (April-May), excessive rainfall occurred in summer, especially in July (269% of the norm) and August (120% of the norm). The sum of precipitations was also higher than the multi-year average in 2012. After wet April, the total rainfall in May was slightly lower than the multi-year average for this month. In June and July, however, the rainfall was excessive (130 and 160% of the norm, respectively). In contrast, the final period of the vegetative growth was accompanied by the shortage of rains.

In each year, the smallest tuber yield was formed by the potato cultivar Sylvan grown under control conditions. The cultivar Satina treated with Bio -Algeen S90 and Kelpak SL produced yields about 2.7-fold higher (Table 2). On average per cultivar, the smallest tuber yield (23.47 and 24.91 t ha^{-1}) was produced by the medium early cultivar Sylvana, while the highest one was obtained from another medium early variety, i.e. cv. Satina (50.51 and 56.11 t ha^{-1}). In the first year of the experiment, the growth stimulators did not

Table 2

Potato tuber yield (t ha^{-1})

Biostimulator	Cultivar				Mean per stimulator
	Irga	Satina	Sylvana	Volumia	
2011					
Control	41.61$^{a\text{-}d}$	51.87^{a}	19.38^{d}	41.95$^{a\text{-}d}$	38.70^{A}
Asahi SL	40.62$^{a\text{-}d}$	44.35^{abc}	20.41^{cd}	53.81^{a}	39.80^{A}
Bio-Algeen S90	45.33^{ab}	52.55^{a}	21.62^{bcd}	45.11^{ab}	41.15^{A}
Kelpak SL	48.11^{a}	53.28^{a}	32.48$^{a\text{-}d}$	42.94$^{a\text{-}d}$	44.19^{A}
Mean	43.92^{A}	50.51^{A}	23.47^{B}	45.95^{A}	-
2012					
Control	43.36^{cd}	49.06^{abc}	22.80^{f}	27.32^{def}	35.63^{B}
Asahi SL	38.91^{cd}	56.28^{ab}	22.31^{f}	35.91^{cde}	38.35^{AB}
Bio-Algeen S90	40.55^{cd}	56.28^{a}	23.10^{ef}	41.04^{cd}	41.43^{A}
Kelpak SL	49.70^{bc}	58.06^{ab}	31.43^{def}	38.61^{cd}	44.45^{A}
Mean	43.13^{B}	56.11^{A}	24.91^{C}	35.72^{B}	-

data designated with same letters do not differ significantly at $P \leq 0.05$

affect the weight of tubers, but in the second year they significantly raised the tuber yield (Asahi SL by 7.6%, Bio-Algeen S90 by 16.3% and Kelpak SL by 24.7%).

Wadas et al. (2004) claims that the cultivation technology (with or without cover), cultivar-specific characteristics and weather conditions rather than a dose of nitrogen decide about the total yield and commercial yield of potatoes grown for early harvest. Besides, tubers harvested in seasons with sufficient rainfall have superior quality properties.

Hormones play a key role in the formation and growth of potato tubers. Roumeliotis et al. (2012) showed that the content of auxin in stolons increases dramatically prior to tuberization and remains on a relatively high level during the growth of tubers, which, as some authors conclude, is the manifestation of auxins promoting the formation of tubers. According to Pavlista (2011), the preparations Early Harvest and Auxigro resulted in a 13-15% yield increment, with Auxigro additionally leading to a 20% increase in the share of medium and large tubers.

Asahi SL and Atonik had no influence on the structure of tuber yields, tuber dry matter content or the size of starch grains and their share in the yield (Maciejewski et al. 2007). Kociara et al. (2013) showed the positive influence of extract from *Ecklonia maxima* on yields of common bean. Kelpak SL significantly raised the weight and number of seeds per pod in bean. Papenfus et al. (2013) determined that Kelpak alleviated the adverse consequences of nutrient deficit and improved growth parameters of okra (ladies' fingers) seedlings (*Abelmoschus esculentus* (L.) Moench). In turn, Bio-algeen S90 increased the yield of sugar beet (1.59-7.89%) and sugar yield (2.08-8.97%) (Pospisil et al. 2006). It also improved the yield of motherwort (*Leonurus cardiaca*) (Kiełtyka-Dadasiewicz, Król 2012).

Tekalign and Hammes (2005) conclude that substances used to control flowering (MCPA, etephon, naphtylacetamide and 2,4-D-amine) reduce the berry formation, which leads to higher potato tuber yields and higher dry matter content in tubers. Thornton et al. (2013) demonstrated that synthetic auxins, especially 2,4-D, used to improve the colouration of potato skin, cause some damage to leaves and have an adverse effect on the size of tubers. At the same time, 2,4-D decreased the infestation rate by potato scab (*Streptomyces scabies*), but increased the infestation by powdery scab (*Spongospora subterranea*). Effects produced by ABA synthetic analogues on tuber yields, incidence of potato skin diseases and skin colour were varied (Waterer 2010). A treatment consisting of sprays with growth regulators (GA_3, NAA, TIBA and ethrel) affected the size and yield of tubers. The highest yield was obtained following the application of GA_3 and ethrel (37.0 and 35.0 t ha^{-1}, respectively); for comparison, potatoes not treated with growth regulators produced yields on the level of 30.4 t ha^{-1}. The smallest losses, after short-term storage at ambient temperature, were observed among NAA treated tubers. At the end of the storing period, a significant increase in the tuber dry matter was observed in potatoes treated with ethrele, TIBA and NAA

(Birbal et al. 2009). According to Mărghitaş et al. (2011), balanced organic and mineral fertilization, in which the potato's nutritional demands are taken account, helps to reduce quantitative losses during potato storage.

The quality of potato tubers was more strongly dependent on the cultivar-specific traits than on the applied biostimulators (Tables 3-6, Figure 1). The concentration of nitrogen in potato tubers is a product of the cultivar characteristics and environmental conditions. Potato tubers contained on average 34% more nitrogen in the second than in the first year of the experiment (Table 3). The smallest difference in the N-total content was determined in tubers of the early cv. Volumia (26%), while the biggest one was observed in tubers of cv. Satina (47%). Due to the transformations which occur in stored potatoes, the tuber content of N-total increased. In the first year, this increase reached about 35%, approaching 50% in the second year. The smallest N-total increment during storage appeared in tubers of cv. Volumia

Table 3

Content of N-total in potato tubers (g kg^{-1} DM) in each year (means and confidence interval)

Year	Cultivar				On average
	Irga	Satina	Sylvana	Volumia	
On harvest					
2011	7.51^{b}±0.71	7.11^{b}±0.44	7.46^{b}±0.72	9.40^{a}±1.24	7.87^{A}±0.47
2012	10.31^{a}±0.54	10.44^{a}±1.27	9.65^{a}±1.69	11.87^{c}±0.55	10.57^{B}±0.55
After storage					
2011	11.36^{abc}±1.04	9.35^{a}±1.23	10.94^{ab}±2.43	10.78^{a}±2.67	10.61^{A}±0.94
2012	13.59^{bcd}±1.14	13.85^{cd}±3.54	16.15^{de}±1.87	17.52^{e}±2.60	15.28^{B}±1.17

data designated with same letters do not differ significantly at $P \le 0.05$

Table 4

Content of N-total in potato tubers (g kg^{-1} DM) (means for years and confidence intervals)

Biostimulator	Cultivar				On average
	Irga	Satina	Sylvana	Volumia	
On harvest					
Control	9.85^{abc}±2.04	9.43^{abc}±3.71	8.62^{ab}±1.19	9.85^{abc}±2.45	9.44^{A}±1.03
Asahi SL	8.65^{ab}±3.26	9.10^{ab}±5.07	9.55^{abc}±3.72	10.69^{abc}±3.03	9.50^{A}±1.23
Bio-Algeen S90	9.04^{ab}±2.67	8.65^{ab}±2.88	8.47^{ab}±1.43	10.09^{bc}±3.43	9.06^{A}±0.88
Kelpak SL	8.11^{ab}±2.45	7.90^{a}±0.71	7.60^{a}±1.50	11.92^{c}±0.71	8.88^{A}±1.07
Mean	8.91^{A}±0.86	8.77^{A}±1.09	8.56^{A}±1.00	10.64^{B}±0.90	-
After storage					
Control	13.13^{abc}±2.19	9.83^{a}±3.33	12.56^{abc}±8.24	11.03^{ab}±6.23	11.64^{A}±1.81
Asahi SL	11.56^{ab}±4.33	11.30^{ab}±4.45	14.15^{bc}±2.78	14.70^{bc}±5.81	12.92^{AB}±1.58
Bio-Algeen S90	13.27^{abc}±2.60	14.12^{bc}±6.47	14.22^{bc}±0.88	16.31^{c}±3.13	14.48^{B}±1.31
Kelpak SL	11.96^{ab}±1.02	11.93^{ab}±1.03	12.25^{ab}±6.85	13.26^{abc}±1.51	12.36^{A}±1.11
Mean	12.48^{AB}±0.93	11.80^{A}±1.15	13.30^{AB}±1.73	13.82^{B}±1.74	-

data designated with same letters do not differ significantly at $P \le 0.05$

Table 5

Content of NO_3^- (mg kg^{-1} FM)

Biostimulator	Cultivar				On average
	Irga	Satina	Sylvana	Volumia	
On harvest					
Control	46.82^{bcd}	32.51^{ab}	34.62^{ab}	36.61^{ab}	37.64^{A}
Asahi SL	31.76^{ab}	27.40^{a}	32.39^{ab}	37.61^{abc}	32.29^{A}
Bio-Algeen S90	31.39^{ab}	30.14^{ab}	43.10^{a-d}	73.21^{ef}	44.45^{A}
Kelpak SL	75.32^{f}	47.56^{bcd}	61.63^{def}	56.29^{cde}	60.20^{B}
Mean	46.32^{AB}	34.40^{A}	42.93^{AB}	50.93^{B}	-
After storage					
Control	167.69^{abc}	98.17^{a}	111.23^{ab}	168.43^{abc}	136.38^{A}
Asahi SL	130.02^{ab}	146.63^{abc}	109.71^{ab}	137.67^{abc}	131.01^{A}
Bio-Algeen S90	109.96^{ab}	97.78^{a}	123.50^{ab}	194.03^{bc}	131.32^{A}
Kelpak SL	222.15^{c}	137.62^{abc}	183.85^{bc}	139.10^{abc}	170.68^{A}
Mean	157.41^{A}	120.05^{A}	132.07^{A}	159.81^{A}	-

data designated with same letters do not differ significantly at $P \leq 0.05$

Table 6

Content of $N\text{-}NH_4^+$ in potato tubers (mg kg^{-1} FM)

Biostimulator	Cultivar				On average
	Irga	Satina	Sylvana	Volumia	
On harvest					
Control	94.12^{def}	104.4^{f}	97.88^{ef}	70.88^{ab}	91.82^{B}
Asahi SL	94.42^{def}	64.04^{b}	98.56^{ef}	28.56^{a}	71.40^{A}
Bio-Algeen S90	81.08^{b-e}	87.00^{c-f}	67.34^{bc}	80.26^{b-e}	78.92^{AB}
Kelpak SL	94.72^{def}	73.34^{bcd}	84.98^{b-f}	70.72^{bc}	80.94^{AB}
Mean	91.08^{A}	82.20^{A}	87.18^{A}	62.60^{B}	-
After storage					
Control	10.95^{abc}	9.75^{ab}	8.70^{a}	19.35^{cd}	12.19^{A}
Asahi SL	16.02^{a-d}	12.45^{abc}	18.60^{bcd}	22.05^{d}	17.32^{B}
Bio-Algeen S90	13.20^{a-d}	14.25^{a-d}	18.75^{cd}	16.65^{a-d}	15.71^{AB}
Kelpak SL	13.80^{a-d}	15.45^{a-d}	12.05^{abc}	14.65^{a-d}	13.99^{AB}
Mean	13.54^{AB}	12.97^{A}	14.52^{AB}	18.18^{B}	-

data designated with same letters do not differ significantly at $P \leq 0.05$

in the first year (14.7%), and the highest one – in tubers of cv. Sylvana in the second year (67.3%).

At harvest, the highest N-total was found in tubers of cv. Volumia (10.64 g kg^{-1}), while tubers of the other cultivars contained similar concentrations of this element (8.56-8.91 g kg^{-1}) – Table 4. The biostimulators only slightly modified the content of N-total. Kelpak SL decreased the concentration of

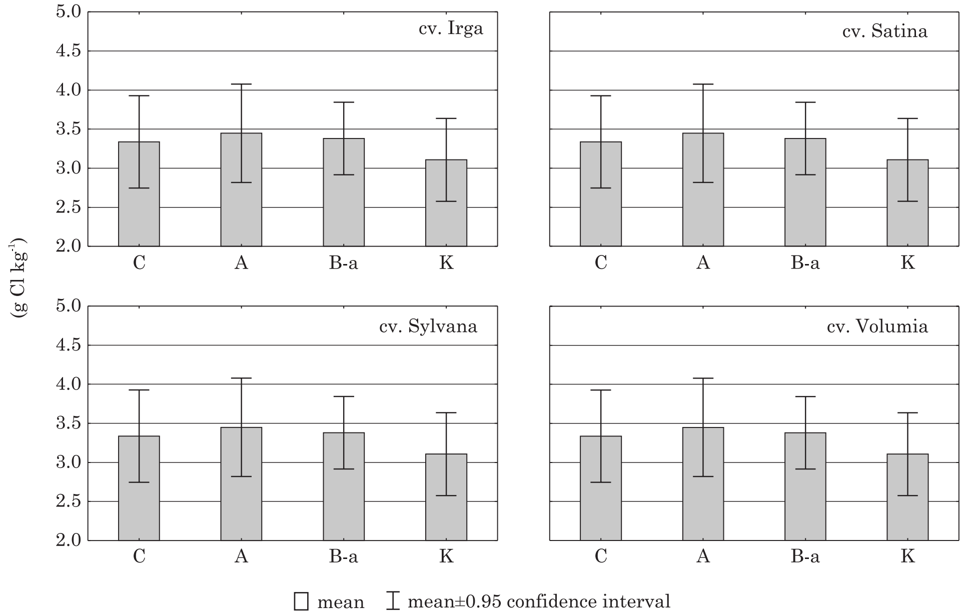

Fig. 1. Content of chloride in potato tubers at harvest: C – control, A – Asahi SL, B-a – Bio-Algeen S90, K – Kelpak SL

this element but the differences were not confirmed statistically. Due to the transformations during the five-month storage, the N-total content increased by 30-35%. The least nitrogen was in tubers of cv. Satina (11.80 g kg^{-1}), while tubers of cv. Volumia contained statistically more N (13.82 g kg^{-1}). Biostimulators varied the content of nitrogen. After storage, most N-total was determined in potato tubers treated with Bio-Algeen S90 (over 24% more than in the control potato tubers).

Zarzecka and Gugała (2006) stated that the weather conditions during the yield formation (June and July) significantly differentiated the content of total and true protein, also affecting the contribution of true to total protein. In a study by Ciećko et al. (2010), nitrogen fertilization increased the content of N-total and N-protein, whereas magnesium enrichment of soil resulted in a slight decrease in both nitrogen forms. In turn, Bartova et al. (2012) demonstrated that a nitrogen dose raised from 100 to 200 kg ha^{-1} significantly decreased the content of starch, while increasing the content and yield of total protein.

Majkowska-Gadomska and Wierzbicka (2013) determined that the content of nitrogen in fruit from aubergine treated with Asahi SL was lower than in control plants. The growth regulators Poteitin oraz Mival improved the quality of potato tubers as raw produce for making French fries, especially when the temperature was high and precipitation low during the growing season (Sawicka, Mikos-Bielak 2002). Extract from seawater algae (*Sar-*

gassum wightii Grev.) used on peanut (*Arachis hypogaea* L.) plantations had a beneficial effect on biomass accumulation, morphological traits, content of chlorophyll and organic compounds, such as proteins, carbohydrates and lipids (Sridhar, Rengasamy 2011).

The content of nitrates (V), similarly to total proteins, depends on the genotype of a potato cultivar, environmental conditions and the geographical location of a plantation. In contrast, the cultivation system (conventional or organic) does not influence the accumulation of the above substances in potato tubers (Lachman et al. 2005).

In our investigations, the content of nitrates(V) in potato tubers on harvest did not exceed the permissible level (200 mg NO_3^- kg^{-1}) set by the Regulation of the Ministry of Health of 13 January 2003 (Table 5). Tubers of the cultivar Volumia contained 48% more of this form of nitrogen than tubers of cv. Satina. The tubers of potato plants treated with Kelpak SL contained 60% more NO_3^- ions than control tubers, and 86% more than tubers from potato plants treated with Asahi SL. During storage, the content of nitrates(V) increased by 3- to 4-fold. The highest content of this nitrogen form accumulated in tubers of cv. Irga plants treated with Kelpak SL (222.15 mg NO_3^- kg^{-1}), while the lowest content of nitrates(V) was determined in tubers harvested from cv. Satina treated with Bio-Algeen S90 and grown on control plots (97.78 and 98.17 mg NO_3^- kg^{-1}, respectively).

Jarych-Szyszka (2006) demonstrated that table potato cultivars contained more nitrates(V) but less dry matter and starch than cultivars grown for production of potato crisps and dry potato products. The accumulation of nitrates in potato tubers is promoted by high temperature and shortage of rainfall (Czajka, Żołnowski 2006, Wadas et al. 2005). Higher nitrogen fertilization doses are followed by a growing content of NO_3^- in tubers, whereas a higher dose of nitrogen applied as a foliar fertilizer as well as the foliar application of manganese resulted in a decrease in this nitrogen form in tubers (Ciećko et al. 2010). According to Wadas et al. (2005), the use of anti-weed textile covers in potato cultivation for very early harvest improves the quality of tubers by reducing their content of nitrates(V). Czajka and Żołnowski (2006) suggested that more NO_3^- accumulated in tubers less infected by *Phytophtora infestans*.

In the first months of storage, the content of NO_3^- ions decreased slightly, only to rise in later months, especially when tubers were stored at the temperature of 8°C (Zgórska, Sowa-Niedziałkowska 2005). Ciećko et al. (2010) noticed a large increase in the concentration of NO_3^- in stored tubers harvested from potato plants fertilized with liquid manure.

The content of N-NH_4^+ in potato tubers on harvest depended on the potato cultivar and the applied biostimulator, ranging from 28.56 mg kg^{-1} (cv. Volumia treated with Asahi SL) to 104.4 mg kg^{-1} (cv. Satina – control) – Table 6. The smallest N-NH_4^+ concentration (62.60 mg kg^{-1}) was recorded in tubers of cv. Volumia. The other cultivars had similar amounts of this nitrogen form in their tubers (82.20-91.08 mg kg^{-1}). The biostimulators, in particular Asahi SL, reduced the content of N-NH_4^+ in tubers.

After the five-month storage period, the content of N-NH_4^+ declined slightly. The highest concentration of this nitrogen form was in tubers of cv. Volumia, while cv. Satina had the smallest level of N-NH_4^+. The biostimulators, especially Asahi SL, favoured the accumulation of this nitrogen form.

The content of chloride in potato tubers ranged from 2.78 (cv. Satina treated with Kelpak SL) to 4.25 g Cl^- kg^{-1} DM (cv. Volumia treated with Asahi SL) – Figure 1. The biostimulators did not have a significant effect on the content of chlorides, and the highest amount of these ions was detected in tubers of the cultivar Volumia.

According to Podleśna (2009), most chlorine appears in leaves. The content of chlorine in roots and aerial parts of plants diminishes as the nitrogen fertilization level grows. A good supply of plants with chlorine reinforces their resistance to biotic and abiotic stresses (Fixen 1993).

CONCLUSIONS

1. The effect of growth regulators depended on the weather, and the applied biostimulators increased tuber yield significantly only in the second year of the experiment with less precipitation and lower temperature during the vegetation period.

2. The content of total nitrogen in tubers was mainly determined by the course of the weather conditions and traits of a potato cultivar. The highest content of N-total was detected in tubers of the very early cultivar Voluminia.

3. The content of nitrates(V) at harvest did not exceed the permissible norms. The spraying of plants with Kelpak SL caused an increase in the content of this nitrogen form in tubers. The highest content of NO_3^- was found in tubers of cv. Volumia.

4. After the five-month storage period, potato tubers contained more N-total and NO_3^- abut less N-NH_4^+.

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