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Influence of Nitrogen Fertilization on Chemical Composition of Potato Tubers

W. Leszczyński & G. Lisińska

Department of Storage and Food Technology, Agricultural Academy, Norwida 25, Wrocław, Poland

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ABSTRACT

The present study is focused on the changes in chemical composition of potato tubers (14 varieties) affected by increased doses of nitrogen fertilizers. Intensified nitrogen fertilization decreased the content of dry matter and starch in potato tubers. Moreover, it increased nitrogen content in dry matter and in non-starch dry substance of the potato tubers. Nitrogen fertilization also increased the content of protein nitrogen in dry matter of potato tubers but decreased its contribution to total nitrogen. Nitrogen fertilization consequently increased the content of amide and amino acid nitrogen in potato dry matter and total nitrogen. Increased levels of nitrogen fertilizers were followed by an increase in amino acid content determined in the hydrolyzates of raw potato flesh. No effect of nitrogen fertilization on essential amino acids in conversion to crude protein has been observed.

INTRODUCTION

Changes in chemical composition of potato tubers caused by excessive nitrogen fertilization are already generally known. Many investigators have observed that intensive nitrogen fertilization decreases the content of dry matter and starch in potato tubers (Somorowska, 1976; White & Sanderson,

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1983; Leszczyński & Lisińska, 1986). Moreover, it is found that nitrogen fertilization increases the content of nitrogenous compounds (Varis, 1973; Leszczyński *et al.* 1984; Leszczyński and Lisińska, 1986) and various nitrogen forms in the tubers (Westerlind, 1974; Baerug *et al.*, 1979; Leszczyński *et al.*, 1984), The high biological value of potato protein prompted some researchers to examine the effect of nitrogen fertilization on amino acid composition of potato tubers (Mulder, 1956; Miča, 1971; Dragland, 1978). The majority of the results obtained in the studies have proved that the content of amino acids increases, in potato tubers, proportionally with increased doses of nitrogen fertilizers (Mulder, 1956; Baerug *et al.*, 1979). However, reaction of potatoes to the fertilizers applied can vary according to soil and meteorological conditions, treatments during cultivation and genetic characteristics. Chemical composition of potato tubers and changes resulting from fertilization are varied, since they depend on potato variety (Baerug *et al.*, 1979; Leszczyński *et al.*, 1984). Therefore, general conclusions can only be drawn if a large number of potato varieties are examined.

The purpose of the present study is to determine the effect of various doses of nitrogen fertilizers on chemical composition of potato tubers, with special regard to amino acid composition.

MATERIALS AND METHODS

Materials

The material used in the experiment included potato tubers of different varieties obtained during the studies of the Experimental Station at the Institute of Potato in Olesno Stare in Silesia Region, carried out for a period of 5 years within the program No. 09.2.06. One of the varieties, Pola, was cultivated for 3 years, seven varieties (Bryza, Janka, Narew, Ronda, Sokół, Sowa and Tarpan) for two years and six varieties (Aba, Certa, Elida, Kora, Livia and Odra) were used in one year studies. Potatotes of all the varieties mentioned above were treated with various doses of nitrogen fertilizers: 40, 120 and 200 kg of N/ha during their cultivation.

Plant spacing (40 000 potato plants per ha) and non-nitrogen mineral (120 kg P_2O_5/ha and 180 kg K_2O/ha) and organic fertilization (25 tons manure/ha) were the same for all the experimental plots. Tubers of all potato varieties were harvested in full maturity. The samples for qualitative examinations (8–10 kg of potato tubers) from three field replications for each plot were collected by standard methods.

Methods

Washed potato tubers were comminuted and the following indices were determined in potato pulp:

Dry matter content—thermogravimetrically
Starch content—polarimetrically by modified Ewers-Grossfeld's method (Leszczyński, 1975)
Total nitrogen—Kjeldahl's method
Protein nitrogen—Barnstein's method
Amide nitrogen—Barnstein's method
Amino acid nitrogen—Sörensen's method
Amino acids after acid hydrolysis in 6M HCl using an amino acid analyser AAA 881.

The analysis of variation was done on three programmes—with and without elimination of the varieties used only in one year experiments. This was necessary because the number of experimental plots varied from variety to variety.

The results of statistical calculations thus obtained did not show any significant differences between the varieties and indicated that the contents of components determined for the potato tubers depended on the level of potato fertilization. The significance of the effect of fertilization on chemical composition of potato tubers was estimated on the basis of the least significant difference (LSD).

RESULTS

Increased dosage of nitrogen fertilizers resulted in significant decreases in dry matter and starch contents of potato tubers. At the same time, a considerable increase in nitrogen content in dry matter of the potato tubers was observed (Table 1). Increased content of total nitrogen was accompanied by a remarkable increase in the content of all nitrogen compounds being determined, i.e. protein, amide and amino acid. However, such increase in relation to the content of these compounds in potatoes from the plots fertilized with a dose of 40 kg of N/ha was not always the same. The highest relative increase was noted for amide nitrogen, the lowest for protein nitrogen (Fig. 1). Intensification of nitrogen fertilization decreased the contribution of protein nitrogen to total nitrogen, whereas the contribution of amide nitrogen to total nitrogen increased markedly.

Increased levels of nitrogen fertilization in potato cultivation resulted in an increased content of several amino acids determined in hydrolyzates of potato flesh (Table 2). The highest increases were noted for proline, arginine,

TABLE 1

Influence of Different Levels of Nitrogen Fertilization on the Content of Some Components of Potato Tubers

Component	*Nitrogen level (kg/ha)*			*LSD*
	40	*120*	*200*	
Dry matter (%)	20·22	19·82	19·43	0·35
Starch (%)	14·88	14·46	13·88	0·36
Reducing sugars (%)	0·58	0·57	0·57	NS
Total sugars (%)	0·87	0·86	0·86	NS
Total nitrogen (% dry matter)	1·59	1·84	2·03	0·06
Protein nitrogen (% dry matter)	0·64	0·69	0·74	0·02
Amide nitrogen (mg/100 g dry matter)	112	136	160	6
Amino acid nitrogen (mg/100 g dry matter)	317	374	418	17
Phosphorus (mg/100 g dry matter)	311	322	337	10
Potassium (mg/100 g dry matter)	2424	2401	2354	NS
Ascorbic acid (mg/100 g)	11·5	11·8	11·5	NS

NS, no significant differences.

TABLE 2

Influence of Different Levels of Nitrogen Fertilization on the Content of Some Amino Acids in Potato Tubers (mg/100 g)

Amino acid	*Nitrogen level (kg/ha)*			*LSD*
	40	*120*	*200*	
Leucine	98	110	117	7
Valine	101	113	124	7
Phenylalanine	69	79	82	5
Lysine	121	136	151	6
Isoleucine	63	70	76	5
Threonine	61	71	74	5
Tyrosine	55	61	64	5
Glycine	54	62	65	3
Alanine	52	59	62	3
Histidine	48	54	58	3
Serine	61	69	72	5
Arginine	84	96	108	5
Proline	48	59	63	4
Glutamic acid	267	312	339	17
Aspartic acid	347	403	438	20

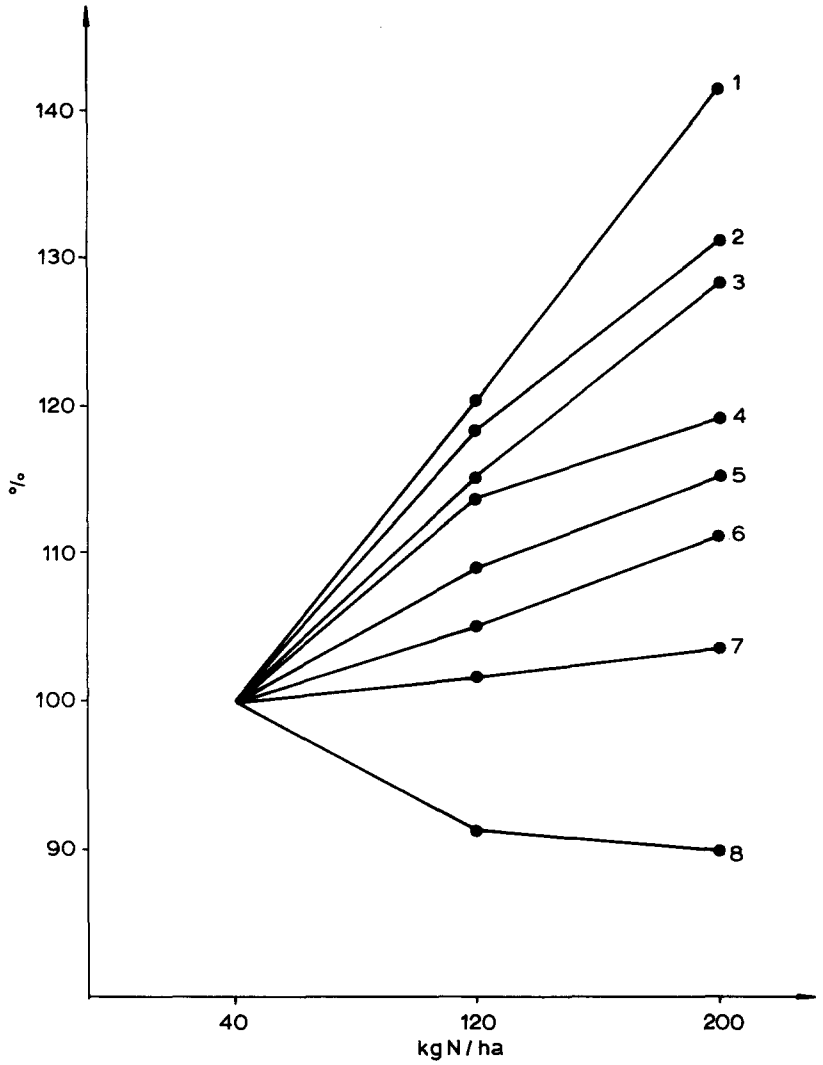

Fig. 1. Influence of nitrogen fertilization on nitrogen compounds contents in potato tubers (100% = dose 40 kg N/ha).

1. $\frac{\text{N amide}}{\text{dry matter}}$
2. $\frac{\text{N amino acid}}{\text{dry matter}}$
3. $\frac{\text{N total}}{\text{dry matter}}$
4. $\frac{\text{N total}}{\text{non-starch dry matter}}$
5. $\frac{\text{N protein}}{\text{dry matter}}$
6. $\frac{\text{N amide}}{\text{N total}}$
7. $\frac{\text{N amino acid}}{\text{N total}}$
8. $\frac{\text{N protein}}{\text{N total}}$

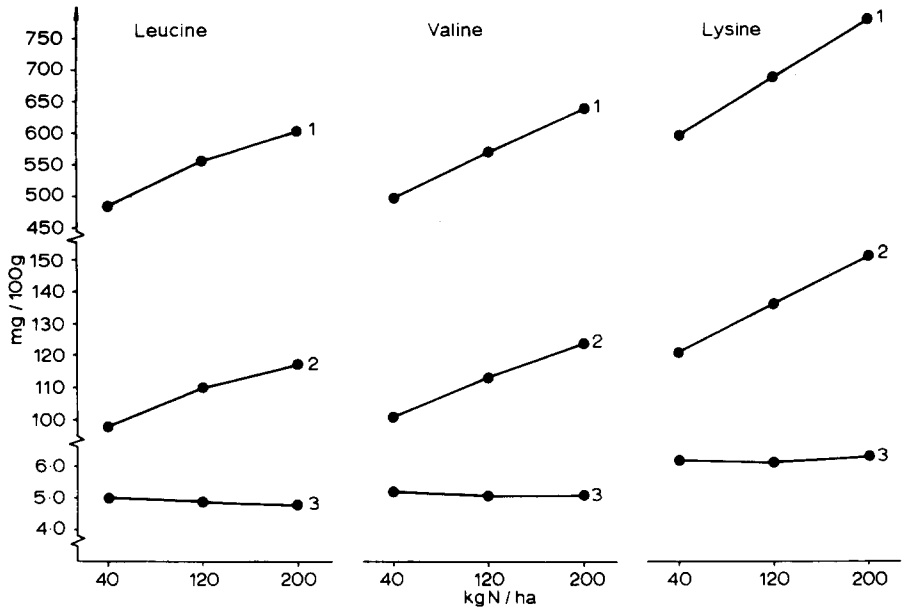

Fig. 2. Influence of nitrogen fertilization on essential amino acid content (mg/100 g). 1, in dry matter; 2, in fresh weight; 3, in protein.

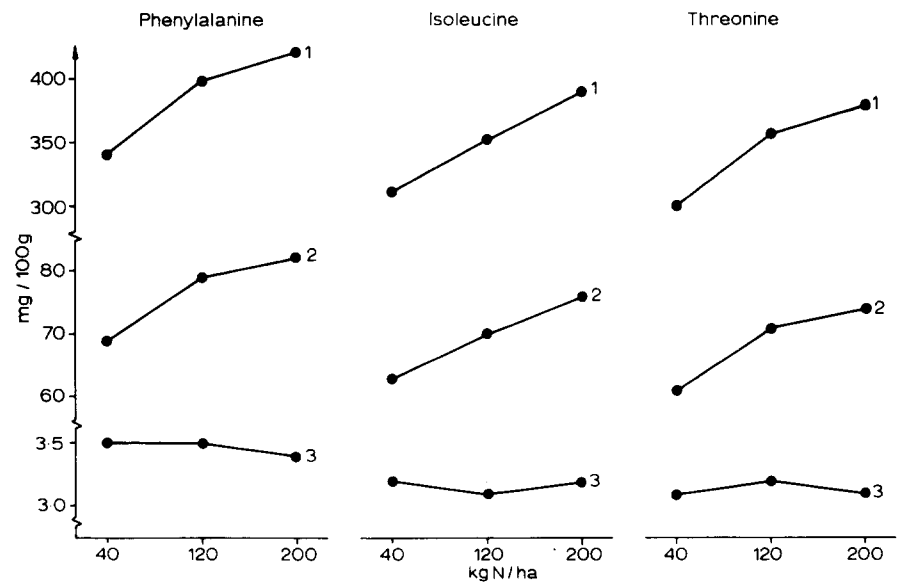

Fig. 3. Influence of nitrogen fertilization on essential amino acid content (mg/100 g). 1, in dry matter; 2, in fresh weight; 3, in protein.

glutamic acid, aspartic acid and lysine. The lowest increases were observed for tyrosine, serine, alanine and phenylalanine. Figures 2 and 3 show some changes in the content of six essential amino acids in potato tubers due to intensified nitrogen fertilization. The contents of all six amino acids increased both in raw potato flesh and in conversion to dry matter content. On the other hand, no effect of nitrogen fertilizers on the content of essential amino acids in total protein was observed. The increased content of these amino acids was related to the increased content of protein in potato tubers which was the consequence of nitrogen fertilization.

Increased doses of nitrogen fertilizers resulted in a significant increase in the content of phosphorus in dry matter of potato tubers (Table 1).

No effect of nitrogen fertilization on the content of ascorbic acid, potassium, total sugars and reducing sugars has been observed. However, the influence of nitrogen fertilization on the content of reducing sugars depended on potato varieties.

DISCUSSION

Results confirming that the increased doses of nitrogen fertilization applied in potato cultivation result in decreased dry matter and starch content have already been obtained by many authors (White & Sanderson, 1983; Mazur & Kreft, 1983; Leszczyński *et al.*, 1984; Leszczyński & Lisińska, 1986). The present investigation proves that increased doses of nitrogen fertilization were subsequently followed by increased contents of nitrogen not only in dry matter of the potato tubers but also in non-starch dry matter content (difference between dry matter and starch content) (Fig. 1). This accounts for the fact that such an increase was not relative to the dry matter (being dependent on varying starch content) but was a real increase in nitrogen content. Similar results were obtained in other studies (Leszczyński & Lisińska, 1986). The increased amounts of protein nitrogen in potato tubers observed in the present experiment were also found in other studies (Ciećko & Mazur, 1974; Leszczyński *et al.*, 1984; Leszczyński & Lisińska, 1986). Also, many authors have found higher increases in non-protein nitrogen forms, especially amides and amino acids, than total protein or protein nitrogen (Ciećko & Mazur; 1974; Westerlind, 1974; Baerug *et al.*, 1979; Leszczyński *et al.*, 1984; Leszczyński & Lisińska, 1986). These observations have been confirmed by the results of other studies proving that increased doses of nitrogen fertilization increased the content of low molecular weight proteins while the level of high molecular weight proteins was decreased (Kiriuchin & Uskov, 1986).

The present paper and many other studies prove that intensive nitrogen

fertilization increases amino acid content in potato tubers (Mulder, 1956; Baerug *et al.*, 1979; Talley, 1983). The results of the present study have not confirmed any changes in the contribution of essential amino acids to protein. However, there are some reports in the literature which indicate that progressively increasing fertilization doses decrease the content of essential amino acids in protein (Miča, 1971; Baerug *et al.*, 1979; Westerlind, 1974; Talley, 1983). Some authors maintain that these changes are comparatively small and insignificant (Mulder, 1956; Dragland, 1978) and depend on potato variety (Mazur & Kreft, 1983).

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