

## THE INFLUENCE OF INTERCROPS AND FARMYARD MANURE FERTILIZATION IN CHANGEABLE WEATHER CONDITIONS ON CONSUMPTION VALUE OF POTATO TUBERS

### WPLYW MIĘDZYPLONÓW I NAWOŻENIA OBORNIKIEM W ZMIENNYCH WARUNKACH POGODOWYCH NA WARTOŚĆ KONSUMPCYJNĄ BULW ZIEMNIAKA

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#### ABSTRACT

The paper presents the results of research carried out over 1999-2002 with the aims to determine the influence of intercrops and farmyard manure fertilization on consumption value of potato tubers in changeable weather conditions. The following combinations of intercrops fertilization were taken into account: the control plot (without intercrop fertilization), farmyard manure, **undersown crop** (birdsfoot trefoil, birdsfoot trefoil + Italian ryegrass, Italian ryegrass), stubble crop (oleiferous radish, oleiferous radish – mulch). The results pointed that, the conditions of vegetation period, significantly modified the consumption values of potato tubers. The consumption value of potato tubers which were fertilized with intercrops was formed on approximated level, as the potato which was fertilized with farmyard manure. The best consumption features, especially taste, had potatoes which were fertilized with birdsfoot trefoil and with the mixture of birdsfoot trefoil and Italian ryegrass.

Key words: potato, fertilization, intercrop, farmyard manure, consumption value of potato tubers.

#### STRESZCZENIE

W pracy przedstawiono wyniki badań z lat 1999-2002 mające na celu określenie wpływu nawożenia międzyplonami i obornikiem na wartość konsumpcyjną bulw ziemniaka w zmiennych warunkach pogodowych. W doświadczeniu badano następujące kombinacje nawożenia międzyplonem: obiekt kontrolny (bez nawożenia międzyplonem), obornik, wsiewka międzyplonowa (komonica zwyczajna, komonica zwyczajna + życica wielokwiatowa, życica wielokwiatowa), międzyplon ścierniskowy (rzodkiew oleista, rzodkiew oleista-mulcz). Otrzymane wyniki badań pozwalają stwierdzić, iż warunki sezonu wegetacyjnego istotnie modyfikowały cechy konsumpcyjne bulw ziemniaka. Wartość konsumpcyjna bulw ziemniaka nawożonego międzyplonami kształtowała się na zbliżonym poziomie, jak ziemniaka nawożonego obornikiem. Najlepszymi cechami konsumpcyjnymi, a zwłaszcza smakowitością wyróżniały się ziemniaki nawożone komonicą zwyczajną oraz mieszanka komonicy zwyczajnej z życicą wielokwiatową.

Słowa kluczowe: ziemniak, nawożenie, międzyplon, obornik, wartość konsumpcyjna bulw.

**DETAIL ET ABSTRACT**

Wymagania konsumenta co do jakości bulw ziemniaka ograniczają się głównie do oceny cech organoleptycznych i morfologicznych, a o wartości konsumpcyjnej decyduje także ich skład chemiczny. Cechy jakościowe bulw ziemniaka są silnie modyfikowane przez rozkład opadów i temperatur w okresie wegetacji oraz przez nawożenie. Zauważa się tu korzystne oddziaływanie nawożenia organicznego. Jednak niewiele jest danych eksperymentalnych określających oddziaływanie międzyplonów na kształtowanie się cech konsumpcyjnych bulw ziemniaka. Stąd wylania się potrzeba prowadzenia tego typu badań. Celem przeprowadzonych badań było określenie wpływu nawożenia międzyplonami i obornikiem na wartość konsumpcyjną bulw ziemniaka w zmiennych warunkach pogodowych. Badania polowe przeprowadzono w latach 1999-2002 na glebie kompleksu żytznego bardzo dobrego. W doświadczeniu badano następujące kombinacje nawożenia międzyplonem: obiekt kontrolny (bez nawożenia międzyplonem), obornik, wsiewka międzyplonowa (komonica zwyczajna, komonica zwyczajna + życica wielokwiatowa, życica wielokwiatowa), międzyplon ścierniskowy (rzodkiew oleista, rzodkiew oleista-mulcz). Wsiewki międzyplonowe wsiewano w jęczmień jary uprawiany na ziarno, a międzyplony ścierniskowe wysiewano po jego zbiorze. W pierwszym roku po zastosowaniu nawożenia organicznego uprawiano ziemniaki jadalne. Podczas zbioru ziemniaka na każdym poletku określono plon świeżej masy bulw i pobrano średnie ich próby w celu określenia cech konsumpcyjnych: ciemnienie miąższu surowego po 4 godzinach, ciemnienie miąższu ugotowanego po 2 i 24 godzinach oraz smakowość.

Z punktu widzenia wartości konsumpcyjnej ziemniaka istotna jest ocena stopnia ciemnienia miąższu bulw surowych i ugotowanych. Przeprowadzone badania wykazały, że warunki sezonu wegetacyjnego, nawożenie międzyplonem i ich interakcja istotnie modyfikowały plony ziemniaka, ciemnienie miąższu bulw surowych i ugotowanych. W latach 2000 i 2002 ciemnienie miąższu bulw surowych i ugotowanych nie różniło się istotnie, podczas gdy w 2001 roku ziemniaki charakteryzowały się intensywniejszym nasileniem barwy szarej. Wynika to z faktu, iż w latach niekorzystnych, o większej ilości opadów w ostatnich miesiącach sezonu wegetacyjnego, obserwuje się większe nasilenie ciemnienia miąższu bulw niż w latach suchych i ciepłych. Nawożenie międzyplonem również istotnie różnicowało ciemnienie miąższu bulw. Na obiekcie nawożonym komonicą zwyczajną odnotowano istotnie najniższy stopień ciemnienia miąższu surowego i ugotowanego bulw ziemniaka. Smakowość uważana jest za najbardziej

subiektywną cechą charakteryzującą ziemniaki jadalne. Nawożenie międzyplonami poprawiało smakowość bulw ziemniaka w porównaniu do obiektu kontrolnego, bez nawożenia międzyplonem. Najlepszą smakowością charakteryzowały się ziemniaki nawożone komonicą zwyczajną, a także mieszanką komonicy zwyczajnej z życicą wielokwiatową.

Reasumując należy stwierdzić, iż warunki sezonu wegetacyjnego istotnie modyfikowały plony ziemniaka i cechy konsumpcyjne bulw. Wartość konsumpcyjna bulw ziemniaka nawożonego międzyplonami kształtowała się na zbliżonym poziomie, jak ziemniaka nawożonego obornikiem. Najlepszymi cechami konsumpcyjnymi, a zwłaszcza smakowością wyróżniały się ziemniaki nawożone komonicą zwyczajną oraz mieszanką komonicy zwyczajnej z życicą wielokwiatową.

**1. INTRODUCTION**

Potato assigned for direct consumption should be characterized with appropriate external and internal features and organoleptic properties [4,5]. External features taken into account at estimating of quality of table potato are first of all: appearance of skin, diseases, cracks, greening, and internal features: taste, smell, colour of flesh and consistency. External features are taken into account subjectively and they depend on consumer preference [3, 5]. About consumption value of potato tubers decides its chemical composition. Adverse interaction of chemization of agriculture on chemical composition and quality of potato tubers should be the signal to search alternative solutions [4]. Such solution can be the integrated manner of potato cultivation. In this system of production it is prescribed to fill the crop rotation with intercrops, which can be the source of organic substance substituting farmyard manure in fertilization of potato [1, 2, 3, 8]. Certain deficiency of publication is noticed in literature from this range. So there is a requirement of conducting these type of researches. This work presents attempt of partial fulfilment of this deficit and the aim of this work is to determine the influence of intercrops and farmyard manure fertilization on consumption value of potato tubers in changeable weather conditions.

**2. MATERIALS AND METHODS**

Field experiments were carried out in 1999-2002 at the Experimental Station of Zawady belonging to the University of Podlasie in Siedlce. This experiment was established on a very good cereal complex soil, belonging to the quality class IV a. The soil pH was neutral and the available phosphorus and potassium contents were average. Mineral nitrogen content was: N-NH<sub>4</sub> 4.42

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Table 1: Average air temperature and rainfall according to the Zawady Meteorological Station  
Tabela 1: Średnia temperatura powietrza i suma opadów według notowań Stacji Meteorologicznej w Zawadach

Year Rok	Month Miesiąc						Average Średnia
	IV	V	VI	VII	VIII	IX	
	Temperature °C Temperatura °C						
2000	12.9	16.4	19.5	19.0	19.1	11.8	16.5
2001	8.7	15.5	17.1	23.8	20.6	12.1	16.3
2002	9.0	17.0	17.2	21.0	20.2	12.9	16.2
Average of Średnio z lat 1951-1990	7.2	13.2	16.2	17.6	16.9	12.7	14.0
	Rainfalls in mm Opady w mm						
2000	47.5	24.6	17.0	155.9	43.6	61.1	349.7
2001	69.8	28.0	36.0	55.4	24.0	10.0	321.2
2002	12.9	51.3	61.1	99.6	66.5	18.7	310.1
Sum of Suma z lat 1951-1990	29.4	54.3	69.3	70.6	59.8	48.2	331.6

Table 2: The yield of fresh mass of potato tubers, t ha<sup>-1</sup>  
Tabela 2: Plon świeżej masy bulw ziemniaka, t ha<sup>-1</sup>

Intercrop fertilization Nawożenie międzyplonem	2000	2001	2002	Average Średnie
Control plot Obiekt kontrolny	32.2	19.8	45.2	32.4
Farmyard manure Obornik	45.9	26.3	56.0	42.7
Bridsfoot trefoil Komonica zwyczajna	46.8	28.5	57.6	44.3
Bridsfoot trefoil + Italian ryegrass Komonica zwyczajna + życica	49.5	27.3	58.4	45.1
wielokwiatowa				
Italian ryegrass Życica wielokwiatowa	36.9	23.4	51.5	37.3
Oleiferus radish Rzodkiew oleista	45.2	25.8	56.2	42.4
Oleiferus radish-mulch Rzodkiew oleista-mulcz	43.2	25.4	54.1	40.9
Average Średnie	42.8	25.2	54.1	-
LSD <sub>0.05</sub> -NIR <sub>0.05</sub>				
Years Lata				1.0
Intercrop fertilization Nawożenie międzyplonem				1.1
Interaction Intrakcja				1.2

mg kg<sup>-1</sup> and N-NO<sub>3</sub> 7.20 mg kg<sup>-1</sup>. The experiment was a three-replicate split blocks design. Plot size in the assumption was 20 m<sup>2</sup> and for harvest 15 m<sup>2</sup>. The following factors were examined: control plot (without intercrop fertilization), farmyard manure (30 t ha<sup>-1</sup>), undersown crop (birdsfoot trefoil 18 kg ha<sup>-1</sup>, birdsfoot trefoil + Italian ryegrass 9+15 kg ha<sup>-1</sup>, Italian ryegrass 30 kg ha<sup>-1</sup>), stubble catch crop – biomass plowed down in autumn (fodder radish – 30 kg ha<sup>-1</sup>), stubble catch crop – overwintering biomass mulch (fodder radish – 30 kg ha<sup>-1</sup>).

Undersown crops were sown after planting spring barley cultivated for grain whereas stubble catch crops were planted after barley harvest. In the autumn, catch crop fresh matter yield, including the root mass in 30-cm soil layer, was determined on each plot. The average yield for birdsfoot trefoil, birdsfoot trefoil - Italian ryegrass mixture, and Italian ryegrass, fodder radish and fodder radish-mulch amounted: 22.3, 34.7, 35.2, 32.9, 32.9 t ha<sup>-1</sup>, respectively. Then on control plots with farmyard manure the cattle manure was applied. On every plots, with exception of plots with oleiferus radish left till spring in the form of mulch and pre-winter tillage was made. Next,

cattle farmyard manure was applied to the scheduled plots and incorporated (pre-winter ploughing), with exception of plots where fodder radish had been planted because the plants were left to serve as winter mulch.

Rywal cultivar of table potato was cultivated in the first year after organic fertilizer application. It is edible cultivar, middle early, consumption type B (widely functional), with yellow flesh. In early spring mineral-fertilizers were distributed on each plots. Their amounts depended on soil fertility and anticipated yields and equalled: 90 kg N, 39.6 P and 99.6 K per 1 ha. On the plots that had been ploughed in the autumn the fertilizers were incorporated by means of a cultivator combined with a harrow. On the mulched plots disc harrowing was followed by cultivator application. Potatoes were planted in the third decade of April and harvested in the second decade of September. During the potato harvest 5-to-7-kg samples were collected from each plot to measure their consumption values. The determination was made on crosswise section of 10 tubers. The darkening of raw tubers flesh and of cooked tubers flesh was based on coloured tables of Danish 9-degree scale: where 9 means that flesh does not change

Table 3: Darkening of raw tuber flesh of potato after 4 h, in points  
Tabela 3: Ciemnienie mięszu surowego bulw ziemniaka po 4 godz., w punktach

Intercrop fertilization Nawożenie międzyponem	2000	2001	2002	Average Średnie
Control plot Obiekt kontrolny	6.4	5.7	6.8	6.3
Farmyard manure Obornik	7.2	6.7	7.4	7.1
Birdsfoot trefoil Komonica zwyczajna	7.9	7.6	8.2	7.9
Birdsfoot trefoil + Italian ryegrass Komonica zwyczajna + życica wielokwiatowa	7.5	7.0	7.8	7.4
Italian ryegrass Życica wielokwiatowa	7.0	6.4	7.0	6.8
Oleiferus radish Rzodkiew oleista	7.0	6.4	7.2	6.9
Oleiferus radish-mulch Rzodkiew oleista-mulcz	7.3	6.6	7.4	7.1
Average Średnie	7.2	6.6	7.4	-
LSD <sub>0.05</sub> -NIR <sub>0.05</sub>				
Years Lata				0.2
Intercrop fertilization Nawożenie międzyplonem				0.4
Interaction Intrakcja				0.5

Table 4: After cooking darkening of cooked potato tuber flesh after 2 h, in points  
Tabela 4: Ciemnienie miąższu ugotowanego bulw ziemniaka po 2 godz., w punktach

Intercrop fertilization Nawożenie międzyplonem	2000	2001	2002	Average Średnie
Control plot Obiekt kontrolny	7.7	7.5	8.2	7.8
Farmyard manure Obornik	8.4	8.0	8.6	8.3
Birdsfoot trefoil Komonica zwyczajna	8.8	8.6	9.0	8.8
Birdsfoot trefoil + Italian ryegrass Życica wielokwiatowa	8.6	8.4	8.8	8.6
Italian ryegrass Życica wielokwiatowa	8.3	7.9	8.4	8.2
Oleiferus radish Rzodkiew oleista	8.4	7.8	8.5	8.2
Oleiferus radish-mulch Rzodkiew oleista-mulcz	8.5	8.3	8.7	8.5
Average Średnie	8.4	8.1	8.6	-
LSD <sub>0.05-NIR<sub>0.05</sub></sub> Years Lata				0.2
Intercrop fertilization Nawożenie międzyplonem				0.3
Interaction Interakcja				0.3

and 1-black flesh. The darkening of fresh mass was determined after 4 hours of cutting potatoes, and boiled mass after 2 and 24 hours. The evaluation of taste was based on 9-degree scale: where 9 means-very good and 1 very bad. Each of the characteristics was subjected to analysis of variance according to the split-block linear model. Means for significant sources of variation were compared by the Tuckey test.

Years of conducting the researches were characterized with considerable disparity of weather conditions (Table 1). The most favourable year for cultivation of potato was 2002. A little bit worse weather conditions were in year 2000, but the worst was in the dry and warm 2001.

### 3. RESULTS

Statistic analysis showed significant influence of weather conditions intercrop and its interaction on potato tubers yield (Table 2). The highest yield of potato tubers were collected in favourable year 2002. A little bit worse weather conditions appeared in 2000 caused the decrease of potato tubers yield about 11.3 t ha<sup>-1</sup>, and unfavourable in 2001 caused further decrease of potato tubers yield

about 17.6 t ha<sup>-1</sup>. The intercrops which were used also significantly modified the potato tubers yield. The highest yields were collected from objects fertilized with birdsfoot trefoil and Italian ryegrass mixture and birdsfoot trefoil. The potato tubers yield fertilized with oleiferus radish did not significantly differ from those noted on farmyard manure. But potato yield fertilized with oleiferus radish in the form of mulch, Italian ryegrass and on control object were significantly lower than on farmyard manure. There was an interaction which showed, that the highest potato tubers yields were collected in favourable year 2002 from object fertilized with farmyard manure, and the lowest in 2001 from control object.

The conditions of vegetation period, intercrop fertilization and its interactions significantly modified the darkening of raw tubers flesh (Table 3). In years 2000 and 2002 the darkening of raw tubers flesh did not differ importantly, but in year 2001 potatoes characterized with higher intensity of grey colour than tubers collected in favourable years. Potatoes cultivated after intercrops pointed out smaller tendency of darkening raw tubers flesh than tubers of plants cultivated on control plot. The level of darkening of raw tubers flesh which were fertilized with

Table 5: After cooking darkening of cooked potato tuber flesh after 24 h, in points  
 Tabela 5: Ciemnienie mięszu ugotowanego bulw ziemniaka po 24 godz., w punktach

Intercrop fertilization Nawożenie międzyplonem	2000	2001	2002	Average Średnie
Control plot Obiekt kontrolny	7.4	7.0	7.8	7.4
Farmyard manure Obornik	8.1	7.8	8.4	8.1
Birdsfoot trefoil Komonica zwyczajna	8.7	8.5	8.9	8.7
Birdsfoot trefoil + Italian ryegrass Komonica zwyczajna + życica	8.5	8.1	8.6	8.4
wielokwiatowa Italian ryegrass Życica wielokwiatowa	7.9	7.5	8.1	7.8
Oleiferus radish Rzodkiew oleista	7.8	7.6	8.2	7.9
Oleiferus radish-mulch Rzodkiew oleista-mulcz	8.1	7.8	8.4	8.1
Average Średnie	8.1	7.8	8.3	-
LSD <sub>0,05</sub> -NIR <sub>0,05</sub> Years Lata				0.2
Intercrop fertilization Nawożenie międzyplonem				0.3
Interaction Interakcja				0.4

intercrops with exception of birdsfoot trefoil did not differ significantly from the level of darkening of potato tubers fertilized with farmyard manure. However, on plots fertilized with birdsfoot trefoil, the lowest level of darkening of raw tubers flesh was recorded. It was lower about 0,8 points than in case of tubers fertilized with farmyard manure. An interaction was recorded that the level of darkening of raw tubers flesh was the lowest in potatoes fertilized with birdsfoot trefoil in year 2002, and the highest in case of potatoes from control plot in year 2001.

Statistical analysis indicates the important influence of conditions of vegetation period, intercrop fertilization and their interactions on after cooking darkening of tubers flesh after 2 and 24 hours (Table 4 and 5). In year 2001 potato tubers were characterized with more intensive darkening than tubers collected in favourable years, that is 2000 and 2002. It results from the fact that unfavourable weather conditions to potato cultivation (the excess of falls in September and its lack in remaining months of vegetation period) seems to be favourable to gather such components in tubers like melanins and phenolics

responsible for intensive increasing of grey colour of raw and cooked tubers flesh. Also the fertilization of intercrops can importantly modify the level of after cooking darkening of tuber flesh. Potatoes cultivated after intercrops and farmyard manure show lower tendency to darkening after 2 hours, on average 0.6 point and after 24 hours, on average 0.8 point than potatoes collected from control plot. The level of darkening fertilized with intercrops, with exception of birdsfoot trefoil did not differ importantly from the level of darkening fertilized with farmyard manure. Differences among individual plots were within in the range of statistical errors. However, the level of darkening in cooked tubers flesh after 2 and 24 hours in potatoes fertilized with birdsfoot trefoil was significantly lower than the level of darkening in cooked tubers flesh fertilized with farmyard manure. An interaction was found and it indicated that the lowest level of darkening cooked tubers flesh had potatoes fertilized with birdsfoot trefoil in 2002, and the highest potatoes from control plot in year 2001.

Taste of potato tubers changed under the influence of vegetation conditions, intercrop fertilization and their

Table 6: The taste of potato tubers, in points  
Tabela 6: Smakowitość bulw ziemniaka, w punktach

Intercrop fertilization Nawożenie międzyplonem	2000	2001	2002	Average Średnie
Control plot Obiekt kontrolny	5.8	4.8	6.2	5.6
Farmyard manure Obornik	6.6	5.9	7.0	6.5
Bridsfoot trefoil Komonica zwyczajna	8.5	7.4	8.7	8.2
Bridsfoot trefoil + Italian ryegrass Komonica zwyczajna + życica	7.7	6.6	7.4	7.2
wielokwiatowa Italian ryegrass Życica wielokwiatowa	6.8	6.3	7.1	6.7
Oleiferus radish Rzodkiew oleista	6.4	5.8	6.8	6.3
Oleiferus radish-mulch Rzodkiew oleista-mulcz	6.8	5.9	7.1	6.6
Average Średnie	6.9	6.1	7.2	-
LSD <sub>0.05</sub> -NIR <sub>0.05</sub> Years Lata				0.3
Intercrop fertilization Nawożenie międzyplonem				0.4
Interaction Interakcja				0.5

interactions (Table 6). Potato tubers collected in years 2000 and 2002 were characterised with better taste than potatoes collected in 2001. Intercrops fertilization improved the taste of potato tubers (average about 1.4 point) in comparison to control plot, without intercrop fertilization. The best taste was recorded when potatoes were fertilized with birdsfoot trefoil, and also with a mixture of birdsfoot trefoil and Italian ryegrass. On the remaining plots fertilized with intercrops the taste of potato tubers did not differ significantly from that noticed on farmyard manure. The interaction of years with intercrop fertilization, indicated that potato tubers fertilized with birdsfoot trefoil in 2002 were characterized with the best taste, and the worst tubers from control plot in year 2001.

#### 4. DISCUSSION

Internal quality features of potato tubers decide about their usefulness for direct consumption. In the present experiment the interaction of the conditions of vegetation period and intercrop fertilization on the level of darkening

of raw and cooked tuber flesh and taste of potato tubers were investigated. The darkening of raw tubers flesh occurs during the enzymatic oxidation of phenolic compounds [4, 9, 12]. The darkening of cooked tubers flesh is a not enzymatic process and it is considered as a variety feature connected to the content of phenolic compounds, lemon acid, chlorogenic acid, amino acids, iron and calcium in potato tubers. The amount of this compounds depends on the variety itself and the edaphic conditions, but mainly from fertilization [6, 10, 12]. In personal researches intercrops fertilization significantly modified the darkening of tubers flesh. Potatoes cultivated on intercrops recorded lower tendency to the darkening of raw and cooked tubers flesh than potato tubers cultivated on control plot. Above-mentioned dependence confirms researches of Ceglarek and others [1] and Różyła [8], who showed that potatoes cultivated only on mineral fertilizers are characterized with bigger increase of grey colour than potatoes cultivated on farmyard manure.

Weather conditions in vegetation period of potato also significantly modified the level of darkening of raw and cooked tubers. In unfavourable years, with the highest

amount of falls in last months of vegetation period, the increase of darkening raw and cooked tubers flesh was observed than in dry and warm years [7, 9, 11]. Analogous dependence was noticed in personal researches.

Taste is considered as the most subjective feature which characterizes table potatoes. The taste of potato tubers fertilized with intercrops was similar and even reached higher values than the taste of potato tubers fertilized with farmyard manure. Birdsfoot trefoil is very important here because after its usage potatoes characterized with the best taste. Similar conclusions were formulated by many authors: Ceglarek and Płaza [2] and Różyła [8]. It can be explained by the fact that potatoes cultivated in position fertilized with legumes contain more nutritious components, especially crude protein, vitamins and mineral salts.

## 5. CONCLUSION

Summing up, it can be stated that conditions of vegetation period significantly modified the yields, level of darkening of raw and cooked tubers flesh and taste of potato tubers. The highest yields of potato tubers were collected from objects fertilized with birdsfoot trefoil with Italian ryegrass mixtures and Italian ryegrass. The consumption value of potato tubers which were fertilized with intercrops was formed on approximated level, as the potato which was fertilized with farmyard manure. The best consumption features, especially taste, was recorded when potatoes were fertilized with birdsfoot trefoil or with the mixture of birdsfoot trefoil and Italian ryegrass.

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