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## TUBER YIELD AND CHEMICAL COMPOSITION OF TABLE POTATO FERTILIZED OF DIFFERENT ORGANIC MANURE IN ORGANIC AND INTEGRATED SYSTEM

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### ABSTRACT

The work presents research results from 2006–2009. The study aimed at comparing tuber yield performance and quality of potato tubers manured with undersown catch crops in the integrated and organic production system. Two factors were considered in the experiment: 1. manuring with undersown catch crop: control (no catch crop), farmyard manure, undersown catch crop biomass ploughed under in the autumn (Persian clover, Persian clover + westerwolds ryegrass, westerwolds ryegrass), undersown catch crop biomass retained as mulch on the soil surface until the spring (Persian clover, Persian clover + westerwolds ryegrass, westerwolds ryegrass); and 2. production system: integrated and organic. Spring triticale cultivated for grain was undersown with the catch crops and was followed by table potatoes the following year. At harvest, the total and marketable yields of potato tubers were measured. Samples were taken to determine starch content, vitamin C content and true protein content. The results of the study demonstrated that the highest potato tuber yields were harvested from Persian clover/westerwolds ryegrass plots as well as Persian clover mulch plots. Potato tuber yield and chemical composition were affected by the production system. An application of undersown catch crops, excluding westerwolds ryegrass, can fully replace farmyard manure used in potato cultivation.

**Key words:** potato, undersown catch crop, mulch, production system, yield, quality.

### INTRODUCTION

Potato is undoubtedly one of the most valuable crop plants. Farmyard manure is a basic natural manure applied in potato cultivation. Declining farmyard manure production due to a falling number of livestock and development of integrated and organic potato production make farmers search for alternative solutions. Such a situation has highlighted the importance of green manures [1, 2, 4, 17, 19, 26]. Catch crops introduced into production systems are grown not only to produce biomass but also to absorb nutrients to prevent them from leaching out into deeper soil strata and ground waters, which is significant from the standpoint of agricultural environment conservation [1, 6, 26]. Undersown catch crops are the cheapest source of organic matter of all catch crops [17, 22]. Also, they have been observed to favourably affect potato tuber yields and chemical composition. Potato producers, in particular organic farmers, are expected to supply healthier and more nutritious tubers with increased quality. However, there are still relatively few studies comparing the tuber quality of potato grown in different production systems, hence the necessity to carry out such research. The objective of this study was to compare the tuber yield performance and quality of table potato manured with undersown catch crops in the integrated and organic production system.

### MATERIALS AND METHODS

A field experiment was conducted at the Siedlce University of Natural Sciences and Humanities Experimental Farm over the years 2006–2009. The trial was set up on grey brown podzolic soil with average amounts of available phosphorus, potassium and magnesium. The experiment was designed as a split-block arrangement with three replicates. Two factors were examined: 1. manuring with undersown catch crop: control (no catch crop incorporation), farmyard manure (30 t·ha<sup>-1</sup>), undersown catch

crop biomass ploughed under in the autumn (Persian clover 18 kg·ha<sup>-1</sup>, Persian clover + westerwolds ryegrass 9 + 10 kg·ha<sup>-1</sup>, westerwolds ryegrass 20 kg·ha<sup>-1</sup>), undersown catch crop biomass retained as mulch on the soil surface until the spring (Persian clover 18 kg·ha<sup>-1</sup>, Persian clover + westerwolds ryegrass 9 + 10 kg·ha<sup>-1</sup>, westerwolds ryegrass 20 kg·ha<sup>-1</sup>); and 2. production system: integrated and organic.

Spring triticale cultivated for grain was undersown with the catch crops and was followed by table potato cv Zeus the following year. In the integrated potato production system, the per ha rates of early spring-applied mineral fertilisers were as follows: 90 kg N, 39.6 kg P and 99.6 kg K. The rates were calculated taking into account soil availability of the nutrients and anticipated yields. In autumn-ploughed plots, fertilisers were incorporated into the soil by means of a cultivator with a harrow attached to it. In turn, mulched plots were cultivated using a disk harrow followed by a cultivator. In the organic potato production system, mineral fertilisation was replaced with farmyard manure applied at 30 t·ha<sup>-1</sup> prior to seeding of triticale undersown with catch crops. Potatoes were planted in late April and harvested in mid-September. In the integrated production system, mechanical and chemical control was used. Potatoes were hilled and harrowed every 7 days until emergence. Just before potatoes emerged, the field was sprayed with the herbicide mixture Afalon 50 WP + Reglone Turbo 200 SL (1 kg + 1 dm<sup>3</sup>·ha<sup>-1</sup>). Colorado potato beetle and potato blight were controlled using, respectively, Fastac (0.1 dm<sup>3</sup>·ha<sup>-1</sup>) and the fungicide Ridomil MZ 72WP (2 dm<sup>3</sup>·ha<sup>-1</sup>). In the organic system, only mechanical weed control was used. Hilling followed by harrowing was performed every 7 days from planting to canopy closure. Colorado potato beetle was controlled using Novodor SC (2.5 dm<sup>3</sup>·ha<sup>-1</sup>), and potato blight using the fungicide Miedzian 50 WP (4 kg·ha<sup>-1</sup>). Table 1 presents number of sprayings to control potato blight and Colorado potato beetle in the organic system.

**Table 1. Chemicals applied to control potato blight and Colorado potato beetle**

Chemical	Numer of sprayings
Miedzian 50 WP	3
Novodor SC	2

At potato harvest, total and marketable yields were determined for each plot, marketable yield being made up of healthy tubers over 40 mm in diameter. Next, a sample was taken from each plot to measure starch content by the König method [21], vitamin C content by the Pijanowski procedure [21] and true protein contents by the Kjeldahl method after precipitation with trichloroacetic acid [10]. Data for each characteristic studied was subjected to variance analysis and means separation was obtained by the Tukey's test. The statistical calculations were performed using own algorithms in Excel 7.

## RESULTS AND DISCUSSION

The total and marketable yields of potato tubers were significantly affected by manuring with undersown catch crops, production systems and interaction of the two factors (Tab. 2 and 3). Potato tuber yields were the greatest in Persian clover/westerwolds ryegrass plots as well as Persian clover mulch plots. According to Nowak [16] and Mauromicale et al. [14], marked N loss, depending on temperature, humidity and decay speed, can take place during decomposition of leguminous plants. It can be as high as 50%. To prevent this, carbon rich organic material should be added to the decomposing biomass of legumes, e.g. grass, in order to extend the C:N ratio, or retain the biomass as mulch on the soil surface to slow down mineralisation and reduce nutrient, particularly nitrogen, loss. In the present study, the tuber yield of potato harvested from Persian clover and Persian clover/westerwolds ryegrass mulch plots did not differ significantly from potato grown in farmyard manure plots. Only potato in plots manured with westerwolds ryegrass, regardless of how it was applied, produced significantly lower yields compared with farmyard manure. Nevertheless, these yields were higher than the control where no undersown catch crops had been applied. Increased tuber yields following incorporation of grasses were also reported by Sadowski [22], Spiertz et al. [26], Duer and Jończyk [3] and Reust et al. [19]; however, the yields were significantly lower compared with farmyard manure, which was due to an incorporation into the soil of a large quantity of biomass characterised by a low concentration of macroelements [3, 22]. Moreover, grasses are characterised by a narrow C:N ratio. Then, less nitrogen is mineralised as it is used mainly by soil microorganisms. In the experiment reported here, also the second factor, that is production systems, significantly affected potato tuber yield performance. Higher tuber yields were obtained from plots in the integrated vs organic production system, which agrees with reports by Sawicka et al. [24], Hagman et al. [6] and Zarzyńska and Wroniak [30]. In the present work, there was found an interaction of the factors which indicated that the greatest potato tuber yields were harvested from Persian clover/westerwolds ryegrass plots and Persian clover mulch plots maintained in the integrated production system, and the lowest yields from the control where no undersown catch crop had been applied in the organic production system.

**Table 2. Total yield of potato tuber fresh matter (means for 2007–2009) [dt·ha<sup>-1</sup>]**

Kind of organic manure	Production system		Means
	Integrated	Organic	
Control	298	241	270
Farmyard manure	452	324	388
Persian clover	449	322	386
Persian clover + westerwolds ryegrass	485	347	416
Westerwolds ryegrass	377	277	327
Persian clover – mulch	469	334	402

Persian clover + westerwolds ryegrass – mulch	455	320	388
Westerwolds ryegrass – mulch	360	258	309
Means	418	303	–
LSD <sub>0,05</sub> Kind of organic manure = 13 Production system = 10 Interaction: production system x kind of organic manure = 18			

**Table 3. Marketable yield (means for 2007–2009) [dt·ha<sup>-1</sup>]**

Kind of organic manure	Production system		Means
	Integrated	Organic	
Control	237	189	213
Farmyard manure	423	302	363
Persian clover	419	299	359
Persian clover + westerwolds ryegrass	470	333	402
Westerwolds ryegrass	317	228	273
Persian clover – mulch	452	320	386
Persian clover + westerwolds ryegrass – mulch	438	305	372
Westerwolds ryegrass – mulch	301	212	257
Means	382	274	–
LSD <sub>0,05</sub> Kind of organic manure = 11 Production system = 09 Interaction: production system x kind of organic manure = 15			

Statistical analysis revealed a significant effect of the experimental factors and their interaction on potato tuber content of starch (Tab. 4). The highest starch content was recorded in tubers of potato manured with either Persian clover/westerwolds ryegrass mulch or westerwolds ryegrass mulch. Research by Boligłowa and Gleń [1], Makaraviciute [13] and Rudell et al. [20] has demonstrated that an application of catch crop mulches positively affects potato tuber chemical composition, including starch content. In the present study, starch content of potato tubers harvested from all the plots, excluding Persian clover units, was similar to farmyard manure plots. It agrees with reports by Sadowski [22], Jansen et al. [9], Hamouz et al. [7] and Kołodziejczyk et al. [11]. On the contrary, Mazur and Jułkowski [14] have stated that the starch content of potato manured with yellow lupine green matter is higher compared with farmyard manure. In the study reported here, also the production system had a significant influence on starch concentration in potato tubers. A significantly higher starch content was found in tubers produced in the integrated rather than organic production system, which agrees with findings reported by Grandstedt et al. [5], Reust et al. [19], Sawicka and Kuś [23], Rudell et al. [20], Rembiałkowska et al. [18] as well as Szmith [25]. By contrast, Zarzyńska and Wroniak [30] found that starch content was higher in organic potatoes grown in heavy soil, lower in tubers produced in an integrated system and in light soil and the lowest in organic potatoes grown in light soil. Also an interaction of the factors studied was found in the current study meaning that the highest starch concentration was recorded in the tubers produced in Persian clover/westerwolds ryegrass plots in the integrated and organic production system, in the tubers harvested from westerwolds ryegrass mulch plots in the integrated production system, and in tubers obtained from Persian clover/westerwolds ryegrass plots in the integrated production system. By contrast, the lowest starch content was recorded in control tubers produced in the integrated and organic production system.

**Table 4. Starch content in potato tubers (means for 2007–2009) [%]**

Kind of organic manure	Production system		Means
	Integrated	Organic	
Control	13.6	13.4	13.5
Farmyard manure	14.7	14.3	14.5
Persian clover	14.1	13.7	13.9
Persian clover + westerwolds ryegrass	14.9	14.5	14.7
Westerwolds ryegrass	14.6	14.4	14.5
Persian clover – mulch	14.5	14.1	14.3
Persian clover + westerwolds ryegrass – mulch	15.3	14.9	15.1
Westerwolds ryegrass – mulch	15.0	14.7	14.9
Means	14.6	14.3	–
LSD <sub>0,05</sub> Kind of organic manure = 0.3 Production system = 0.2 Interaction: production system x kind of organic manure = 0.4			

Vitamin C content in potato tubers was significantly affected by manuring with undersown catch crop, production system and

their interaction (Tab. 5). The highest vitamin C concentration was determined in potatoes harvested from Persian clover plots, Persian clover/westerwolds ryegrass plots where the manure was either autumn-incorporated or retained to be spring-incorporated and westerwolds ryegrass mulch plots. In plots where westerwolds ryegrass was autumn-incorporated, vitamin C content in potato tubers did not differ significantly from farmyard manure plots, it being significantly lower in control tubers only. Also Weber and Putz [28], Leszczyński [12], Sawicka and Kuś [23], Hamouz et al. [7, 8] as well as Plaza and Ceglarek [17] have pointed out to a positive correlation between organic manuring and vitamin C content in potato tubers. In this study, there was found a significant effect of production system on potato tuber content of vitamin C. Similarly to findings by Grandstedt et al. [5], Warman and Havard [27], Rembiałkowska et al. [18] as well as Sawicka and Kuś [23], significantly higher vitamin C concentration was obtained in tubers of potato produced in the integrated system. On the contrary, Zarzyńska and Wroniak [30] have reported a higher vitamin C concentration in organic potatoes, the differences being insignificant, however. In the present work, there was observed an interaction which indicated that vitamin C concentration was the highest in potatoes harvested from Persian clover mulch plots, regardless of the production system, and the lowest in organic control tubers.

**Table 5. Vitamin C content in potato tubers (means for 2007–2009) [g·kg<sup>-1</sup> f.m.]**

Kind of organic manure	Production system		Means
	Integrated	Organic	
Control	168.2	164.8	166.5
Farmyard manure	181.5	178.5	180.0
Persian clover	190.4	187.9	189.2
Persian clover + westerwolds ryegrass	185.6	182.9	184.3
Westerwolds ryegrass	180.6	177.4	179.0
Persian clover – mulch	195.9	193.2	194.6
Persian clover + westerwolds ryegrass – mulch	190.1	188.3	189.2
Westerwolds ryegrass – mulch	184.5	184.8	184.7
Means	184.6	182.2	–
LSD <sub>0.05</sub>			
Kind of organic manure = 2.5			
Production system = 1.4			
Interaction: production system x kind of organic manure = 3.2			

Statistical analysis demonstrated a significant effect of manuring with undersown catch crops and interaction of the experimental factors on true protein content in table potato tubers (Tab. 6). A significantly highest true protein content was recorded in tubers harvested from autumn- and spring-incorporated Persian clover plots as well as units where Persian clover/westerwolds ryegrass mulch had been applied. It is due to the fact that legume biomass nitrogen is gradually mineralised and became available for potato plants, which assures a complete conversion of this N into protein nitrogen [29]. In the study discussed here, the true protein content in the tubers of potato produced in plots where a Persian clover/westerwolds ryegrass mix had been autumn-incorporated was not significantly different from farmyard manure plots. When autumn- or spring-incorporated westerwolds ryegrass had been used, the true protein content in tubers was significantly lower compared with farmyard manure plots. Similarly to Reust et al. [19], Smith [25] as well as Zarzyńska and Wroniak [30], the production systems examined in the present study did not significantly affect the potato tuber content of true protein. However, a higher concentration of this component was noted in organic potato tubers. On the contrary, in their works Sawicka and Kuś [23] as well as Smith [25] have found that true protein was higher when integrated production system had been used. In the present study, an interaction of the experimental factors was found which means that a highest true protein concentration was recorded in tubers of potato harvested from plots where Persian clover, either autumn- or spring-incorporated, was used in the integrated and organic production system. The lowest concentration of true protein was determined in the tubers of control potato in the integrated and organic production system.

**Table 6. True protein content in potato tubers (means for 2007–2009) [% d.m.]**

Kind of organic manure	Production system		Means
	Integrated	Organic	
Control	4.20	4.32	4.26
Farmyard manure	5.18	5.34	5.26
Persian clover	5.91	6.05	5.98
Persian clover + westerwolds ryegrass	5.25	5.42	5.34
Westerwolds ryegrass	4.56	4.70	4.63
Persian clover – mulch	6.15	6.31	6.23
Persian clover + westerwolds ryegrass – mulch	5.48	5.70	5.59
Westerwolds ryegrass – mulch	4.77	4.93	4.85
Means	5.19	5.35	–
LSD <sub>0.05</sub>			
Kind of organic manure = 0.37			
Production system – n.s.			

## CONCLUSIONS

1. The highest potato tuber yields were harvested in Persian clover/westerwolds ryegrass plots and the plots where Persian clover had been spring-incorporated as mulch.
2. Production system significantly affected potato tuber yields and chemical composition. Higher yields of potato with more starch and vitamin C were recorded in the integrated production system.
3. Starch content was the highest in the tubers of potato manured with a Persian clover/westerwolds ryegrass mulch as well as westerwolds ryegrass mulch. Vitamin C content was the highest in potato tubers harvested from undersown catch crop plots, excluding autumn-incorporated westerwolds ryegrass. True protein was the highest in potatoes cultivated in autumn- and spring-incorporated Persian clover plots and Persian clover/westerwolds ryegrass mulch plots.
4. Manuring with undersown catch crops, excluding westerwolds ryegrass, fully replaces farmyard manure in the integrated and organic systems of table potato cultivation.

## REFERENCES

1. Boligłowa E., Gleń K., 2003. Yielding and quality of potato tubers depending on the kind of organic fertilization and tillage method. *Elec. Jour. of Pol. Agric. Univ., Top Agron.*, 1(6) [www.ejpau.pl](http://www.ejpau.pl)
2. Castagnoli M., Lovatti L., 1999. Agronomic performance and quality behavior of "chair ferme" potato varieties under integrated farming system in Emilia-Romagna (northern Italy). *Proceedings of 14th Triennial Conference of the European Association for Potato Research*. Sorrento, Italy, 02–07.05.1999, 710–711.
3. Duer I., Jończyk K., 1998. Nawożenie pod ziemniak uprawiany w gospodarstwach ekologicznych. [Pre-plant fertilisation of potato grown on organic farms] *Frag. Agron.*, 1(57), 85–95 [in Polish].
4. Dzienia S., Szarek P., Pużyński S., 2004. Plonowanie i jakość plonu bulw ziemniaka w zależności od systemu uprawy roli i nawożenia organicznego. [Potato tuber yield and yield quality depending on soil cultivation system and organic manuring] *Zesz. Probl. Post. Nauk Rol.*, 500, 235–242 [in Polish].
5. Grandstedt A., Kjellenberg L., Rožmila P., 1997. Long – term field experiment in Sweden: Effects of organic and inorganic fertilizers on soil fertility and crop quality. *Agricultural Production and Nutrition*. Proceeding of a Conference in Boston, MA, USA, 19–21.03.1997, 79–90.
6. Hagman J.E., Mårtensson A., Grandin U., 2008. Cultivation Practices and Potato Cultivars Suitable for Organic Potato Production. *Pot. Res.*, 52(4), 319–330.
7. Hamouz K., Lachman J., Dvořák P., Pivec V., 2005. The effect of ecological growing on the potatoes yielding and quality. *Plant Soil Envir.*, 51, 397–402.
8. Hamouz K., Lachman J., Dvořák P., Duskova O., Cizek M., 2007. Effect of conditions of locality, variety and fertilization on the content of ascorbic acid in potato tubers. *Plant Soil Envir.*, 53, 252–257.
9. Jansen G., Flamme W., Shüller K., Vändrey M., 2001. Tuber and starch quality of wild and cultivated potato species and cultivars. *Pot. Res.*, 44(2), 137–146.
10. Kerłowska-Kulaś M., 1993. Badania jakości produktów spożywczych. [Studies of quality of foodstuffs] PWE, Warszawa [in Polish].
11. Kołodziejczyk M., Szmigiel A., Kielbasa S., 2007. Plonowanie oraz skład chemiczny bulw ziemniaka w warunkach zróżnicowanego nawożenia. [Yield performance and chemical composition of potato tubers under various fertilisation conditions] *Frag. Agron.*, 2(94), 142–150 [in Polish].
12. Leszczyński W., 2002. Zależność jakości ziemniaka od stosowania w uprawie nawozów i pestycydów. [Potato quality as affected by fertilisers and pesticides applied in cultivation] *Zesz. Probl. Post. Nauk Rol.*, 489, 47–64 [in Polish].
13. Makaraviciute A., 2003. Effect of organic and mineral fertilizers on the yield and quality of different potato varieties. *Agron. Res.*, 1(2), 197–209.
14. Mauromicale G., Signorelli P., Lema A., Foti S., 2003. Effects of intraspecific competition on yield of early potato grown in Mediterranean environment. *Am. Jour. of Pot. Res.*, 80, 281–288.
15. Mazur T., Julkowski M., 1982. Wpływ nawożenia organicznego i mineralnego na plonowanie, cechy jakościowe dwóch odmian ziemniaka uprawianego na glebie lekkiej. [The effect of organic and mineral fertilisation on yield performance, and qualitative characteristics of two potato cultivars grown in light soil] *Zesz. Nauk. ART Olsztyn, Ser. Rol.*, 34, 187–194 [in Polish].
16. Nowak G., 1982. Przemiany roślinnej materii organicznej znakowanej izotopem C14 w glebach intensywnie nawożonych. [Transformation processes of C14-marked plant organic matter in intensively-fertilised soils] *Zesz. Nauk. ART Olsztyn, Ser. Rol.*, 35, 3–57 [in Polish].
17. Płaza A., Ceglarek F., 2009. Tuber quality of edible potato fertilized with catch crops and barley straw. *Annales UMCS, Sec. E, LXIV(3)*, 79–90.
18. Rembiałkowska E., Kazimierzczak R., Zarzyńska K., Halman E., Świetlikowska K., 2010. Evaluation of the quality features of the cultivars of potatoes from conventional, organic and integrated crop production systems. *Sci. Hortic.*, 263, 179–194.
19. Reust W., Neyroud J.A., Dutoid J.P., 1999. Potato fertilization in integrated farming system. 14th Triennial Conference of the European Association for Potato Research. Sorrento, Italy, 02–07.05.1999, 259–260.
20. Rudella C.A., Davenport J.R., Evans R.G., Hattendorf M.J., Alva A.K., Boydston R.A., 2005. Relating potato yield and quality to field scale variability in soil characteristics. *Am. Jour. of Pot. Res.*, 79(5), 317–323.
21. Rutkowska U., 1981. Wybrane metody badania składu i wartości odżywczej żywności. [Selected methods of examination of food composition and nutritive value] PZWL, Warszawa [in Polish].
22. Sadowski J., 1992. Porównanie efektywności obornika, słomy, nawozów zielonych i biohumusu w uprawie ziemniaka. *Mat. konf. nauk. nt. „Produkcyjne skutki zmniejszenia nakładów na agrotechnikę roślin uprawnych”*. [Comparison of effectiveness of farmyard manure, straw, green manured and biohumus in potato cultivation. Proc. of the conf. 'Production consequences of decreasing outlays on crop plant agrotechnology'] *ART Olsztyn*, 25–26.03.1992, 216–222 [in Polish].
23. Sawicka B., Kuś J., 2002. Zmienność składu chemicznego bulw ziemniaka w warunkach ekologicznego i integrowanego systemu produkcji. [Variation in potato tuber chemical composition in the organic and integrated production system] *Zesz. Probl. Post. Nauk Rol.*, 489, 273–282 [in Polish].
24. Sawicka B., Barbaś P., Kuś J., 2007. Variability of potato yield and structure in organic and integrated crop production systems. *Elec. Jour. of Pol. Agric. Univ., Top. Agron.*, 10(1), [www.ejpau.pl](http://www.ejpau.pl)
25. Smith O., 2007. Potato quality. *Am. Jour. of Pot. Res.*, 28(10), 732–737.
26. Spiertz J.H.J., Haverkort A.J., Vereijken P.H., 1996. Environmentally safe and consumer friendly potato production in The Netherlands. 1. Development of ecologically sound production system. *Pot. Res.*, 39, 371–378.
27. Warman P.R., Havard K.A., 1998. Yield, vitamin and mineral contents of organically and conventionally grown potatoes and seed com. *Agric. Ecos. Envir.*, 68(3), 207–216.
28. Weber L., Putz B., 1999. Witamin C content in potato. *Proceedings of 14th Triennial Conference of the European Association for Potato Research*, Sorrento, Italy, 02–07.05.1999, 230–231.

29. Wiater J., 2002. Wpływ współdziałania niektórych odpadów z roślinami motylkowatymi na ilość i jakość białka ziemniaka. [The effect of interaction between some waste materials and leguminous plants on potato tuber quantity and quality] Zesz. Probl. Post. Nauk Rol., 484, 743–752 [in Polish].
30. Zarzyńska K., Wroniak J., 2008. Różnice w składzie chemicznym bulw ziemniaka uprawianego w systemie ekologicznym i integrowanym w zróżnicowanych warunkach klimatyczno-glebowych. [Differences in tuber chemical composition of potato grown in the organic and integrated system under varying climatic and soil conditions] Zesz. Probl. Post. Nauk Rol., 530, 249–257 [in Polish].

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