https://doi.org/10.17221/353/2023-PSE

Six-year results on the effect of organic mulching on potato yield and tuber damages

Anikó Südiné Fehér[1], Mihály Zalai[2], György Turóczi[2], Ferenc Tóth[3]*

[1]Doctoral School of Plant Sciences, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary
[2]Department of Integrated Plant Protection, Plant Protection Institute, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary
[3]Hungarian Research Institute of Organic Agriculture (ÖMKI), Budapest, Hungary
**Corresponding author: fehranik@gmail.com*

Citation: Südiné Fehér A., Zalai M., Turóczi Gy., Tóth F. (2024): Six-year results on the effect of organic mulching on potato yield and tuber damages. Plant Soil Environ., 70: 11–16.

Abstract: Due to its positive effects, mulching with organic matter is a popular soil conservation tool. However, opinions are divided on the effects of mulching on pests and pathogens. Our research aimed to investigate the effect of organic mulch on potato tuber damage caused by soil-dwelling pests and soil-borne pathogens. Therefore, mulching trials were carried out at four sites over six years, comparing the effects of straw, walnut leaves, mixed leaves, compost and two sowing methods (in soil, on soil surface, and under mulch). The total yield of the mulched plots was equal (2013, 2014) or significantly higher (2015, 2016, 2017, 2018) than the control, while the weight of damaged tubers did not increase. Total yield was higher in plots mulched with compost, walnut leaves and mixed leaves than in control and straw-mulched plots. The seeding method had no effect on yield or tuber damage for any of the cover crops. Mulching potatoes with organic matter, especially compost and leaves, is recommended, as their application positively affected yield but did not increase the number of damaged tubers. Sowing potatoes under mulch can reduce the digging work and cutting damage without reducing the yield.

Keywords: *Solanum tuberosum* L.; organic mulch materials; soil protection; tuberous crop; intact tuber

Soil is increasingly recognised as an important non-renewable natural asset. Its protection and proper management are receiving increasing attention. Mulching with organic matter is a popular tool for soil protection. This is mainly due to the physico-chemical and biological improvements in the soil due to mulching (Nowroz et al. 2021).

Potato is the most important non-cereal food crop (Fan et al. 2011), and its cultivation can be easily and effectively integrated with mulching, resulting in yield growth (Wang et al. 2019). However, there is no research on the effects of different organic mulches on the incidence of soil-dwelling pests and soil-borne pathogens in potatoes.

Among soil cover materials, straw is also the most popular for potatoes. It increases tuber yield and improves yield quality (Kar and Kumar 2007, Chang et al. 2020), reduces aphid populations and thus reduces Potato Y Virus (Saucke and Döring 2004, Kirchner et al. 2014), and attracts natural enemies (Dudás et al. 2016). Tuber yield was also positively affected by dry meadow grass (Momirovic et al. 1997), which reduced *Phytophthora infestan's* infestation compared to the control treatment (Dvořák et al. 2010). Compost, like straw, also increased the number of intact tubers in potatoes (Gent et al. 1999, LaMondia et al. 1999, Král et al. 2019).

Less studied cover material is fallen leaves, which are most natural (similar to forest litter) and available in large quantities in gardens. However, it is not used for mulching, and walnut leaves are not even used for composting. Coder (1983) found that

https://doi.org/10.17221/353/2023-PSE

juglone in leaves degrades over time, and its quantity is reduced by microorganisms in the soil during the composting process. Petrikovszki (2022) found that walnut leaves did not have an allelopathic effect on tomatoes and, when used as a cover material, promoted plant growth. Furthermore, cover materials in potato mulching experiments do not use walnut leaves or mixed leaves of deciduous trees.

The use of mulch also allows an alternative method of potato sowing (sowing on the soil surface, under mulch) and no-tillage, which is also less researched but has positive yield results (Adamchuk et al. 2016). The combination of mulch and conservation tillage (no-tillage) increased potato yield (Hou and Li 2019), improved potato quality and reduced potato production costs by 27% (Sarangi et al. 2020).

The aim of our work was to investigate in field experiments the effects of mulching with different organic matter and different sowing methods on the damage by soil-dwelling pests and soil-borne pathogens of potatoes and on the yield.

MATERIAL AND METHODS

The experiments were conducted for six consecutive years (2013–2018) at four different locations in Hungary, using five different organic materials and six potato cultivars (Table 1).

The amount of annual precipitation in central Hungary is around 560 mm, and its temporal distribution is uneven. This is not sufficient for growing most types of vegetables, including potatoes, without irrigation (Láng et al. 2007). The mean annual temperature ranges between 9.5–10.0 °C. The number of hours of sunshine is 1 960 annually (Dövényi et al. 2008).

Two of the experimental sites were located in Gödöllő, Hungary, in the experimental field of the MATE Plant Protection Institute (47°35'22"N, 19°22'04"E) and Blaha (47°37'25.7"N, 19°20'04.8"E). The third site was in Isaszeg (47°33'03.7"N, 19°22'35.1"E), and the fourth experimental site was in Nagyecsér (47°46'04.2"N, 20°47'22.3"E).

The soil of the university's experimental field is coarse sand, a physical soil dominated by brown forest soil, as in Blaha and Isaszeg. The physical soil type in Nagyecsér is also sand; the soil type is loess-silt. The pH value of the experimental plots is medium, varying between 6.8 and 7.2 depending on the season. In the first three years of the experiment, the metal-sealed seed tubers were planted 10–15 cm deep in the soil, at a distance of 20–25 cm apart, in 90 or 70 cm rows. The potatoes were grown in ridge and furrow cultivation (tubers were planted in the ridges) and weeded by hand when necessary. No chemicals, irrigation or fertilisers were used.

In the last three years, we created 72 microplots (2 × 2 m) and planted four potato bushes (one bush per m^2) into each of these. Half of the tubers were placed 10–15 cm deep in the soil or on the soil's surface and covered with mulch.

The organic mulching material was collected at each site in the simplest and most practical way possible. The grass was collected with a mower from the areas immediately surrounding the experimental plots (*Lolium perenne* L., *Poa pratensis* L., *Dactylis glomerata* L., *Elymus repens* L., *Festuca ovina* L., *Agrostis capillaris* L.). The mixed leaves were collected from landscaped areas of the University (*Platanus* × *acerifolia* L., *Quercus robur* L., *Acer campestre* L.). Walnut leaves were collected separately from private gardens in Gödöllő. The wheat straw was also obtained from Gödöllő. We used fresh straw (harvested the previous summer) for mulching every year. The used compost was a commercially available product (04.2/3245-2/2017 NÉBIH 2019) produced by Zöld Híd B.I.G.G. Nonprofit Kft. from municipal and residential green waste.

The continuous cover was done by hand with a 10–15 cm mulch layer before planting (about 70 t/ha of cut grass, 40 t/ha wheat straw, walnut leaves and mixed leaves, and about 1 500 t/ha of compost). In 2013–2015, half of the rows were mulched, and the other half were not. In 2016–2018, the arrangement of cover crops and sowing methods in the microplots was a random block arrangement.

Potato tubers were harvested by hand in September, weighed (per treatment), and damaged tubers were examined individually.

Three types of damage were distinguished:

- parallel chew marks following the incisors of rodents (Rodentia);
- holes larger than 5 mm in diameter and of variable depth (Melolonthidae, *Agrotis* spp.);
- holes less than 5 mm in diameter (Elateridae).

Microsoft Excel (Redmond, USA) was used to analyse the data. Treatments were compared using a one-way analysis of variance and Tukey's post hoc test with SPSS statistical software (Armonk, USA). For analysis in 2016–2018, the data were logarithmically transformed ($\ln(X + 1)$) in the case of total yield and arcsine was used in the case of the proportion of tuber damage.

https://doi.org/10.17221/353/2023-PSE

Table 1. Location, area size, previous crop, number of repetitions, potato cultivar, mulch materials, sowing method, average annual precipitation and average annual temperature in the experimental years of 2013–2018

	Experiment location	Area size (m^2)	Pre-crop	Number of repititions	Potato cultivar	Mulch materials	Sowing method	Average annual precipitation (mm)	Average annual temperature (°C)
2013	Gödöllő (MATE)	292	potato	2	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	cutted grass	into the soil	600–650	11–12
	Gödöllő (Blaha)	1032	potato	1	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	cutted grass	into the soil	600–650	11–12
	Isaszeg	40	potato	1	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	cutted grass	into the soil	600–650	11–12
	Nagyecsér	65	potato	1	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	cutted grass	into the soil	650–700	11–12
2014	Gödöllő (MATE)	432	potato	2	Démon, Hópehely, Sárpo Mira, White Lady	mixed leaves	into the soil	600–700	11–12
	Isaszeg	40	potato	1	Démon, Hópehely, Sárpo Mira, White Lady	cutted grass	into the soil	600–700	11–12
	Nagyecsér	65	potato	1	Démon, Hópehely, Sárpo Mira, White Lady	straw	into the soil	500–600	11–12
2015	Gödöllő (MATE)	348	potato, maize	4	Démon, Hópehely	mixed leaves	into the soil	500–550	11–12
2016	Gödöllő (MATE)	288	potato	8	Démon, Hópehely	compost, mixed leaves, walnut leaves, straw	into the soil/ on the soil surface	650–700	11–12
2017	Gödöllő (MATE)	288	potato	8	Démon	compost, mixed leaves, walnut leaves, straw	into the soil/ on the soil surface	600–650	11–12
2018	Gödöllő (MATE)	288	potato	8	Démon	compost, mixed leaves, walnut leaves, straw	into the soil/ on the soil surface	600–650	11–12

https://doi.org/10.17221/353/2023-PSE

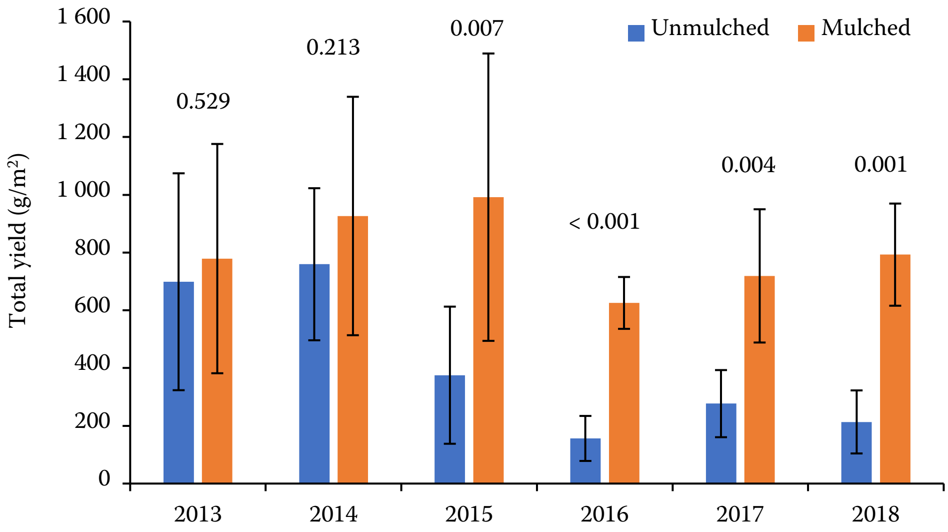

Figure 1. Annual potato yield of all experimental sites in mulched and non-mulched plots between 2013–2018 (the annual average was obtained by averaging the unweighted average of the yields of all locations per year; error bar: CI (confidence interval) 95%)

RESULTS

Examining the total annual yield, we found that in the first two years (2013, 2014), the yield-increasing effect of mulching was not statistically detectable, but in the other four years, significantly more potatoes were produced in the mulched plots (Figure 1).

No difference was found between the weight of damaged tubers (as a percentage of the total yield per year) in the covered and uncovered plots in any of the years (Table 2). Similar to the studies of Dvořák et al. (2010), we found that mulching did not increase the number of damaged tubers.

Examining the mulch materials, we found that in 2016 and 2018, significantly more potatoes were grown under the walnut leaves, mixed leaves and compost than in the unmulched control plots for both sowing types. Contrary to the results of several experiments (Gent et al. 1999, Kar and Kumar 2007, Král et al. 2019, Chang et al. 2020), the positive effect of straw on total yield was not detectable in our experiment. The yield under straw did not differ from the control (Table 3), as in the experiments of LaMondia et al. (1999). In 2017, the yields of the compost plots exceeded those of the control plots, while the yields of the other mulches were not different from each other or from the control.

We found no differences between the cover materials or sowing methods after examining tubers damaged by *Fusarium solani* and soil-dwelling pests (chewed). Only in 2018 CO we had an outstanding *F. solani* infestation. In contrast to the experiment by Majumder et al. (2016), we found no consistent difference between cover treatments for either greening or other biotic damage.

The effect of the sowing method on the total yield did not differ over the years in contrast to the results of the potato trial by Adamchuk et al. (2016). On the other hand, two characteristic differences could be observed based on the sowing methods. More green tubers were found when tubers were planted on the soil surface, under the mulch. In 2016, the WO had

Table 2. The weight of the tubers damaged by different pests and pathogens in the studied locations, as a percentage (%) of the total yield, in the mulched (M) and unmulched (U) plots

	2013		2014		2015		2016		2017		2018	
	U	M	U	M	U	M	U	M	U	M	U	M
Fusarium solani damage	4.5[a]	2.3[a]	2.7[a]	3.1[a]	20.6[a]	10.6[a]	3.6[a]	1.2[a]	1.7[a]	0.5[a]	1.6[a]	1.8[a]
Wireworm damage	2.8[a]	2.3[a]	1.5[a]	3.0[a]	28.1[a]	21.5[a]	8.6[a]	9.7[a]	15.3[a]	7.4[a]	34.6[a]	19.9[a]
Cutworm/Chafer grub damage	1.6[a]	0.8[a]	0.9[a]	1.0[a]	8.3[a]	15.0[a]	11.7[a]	7.7[a]	4.5[a]	3.7[a]	3.0[a]	3.9[a]
Rodent damage	0.0[a]	0.0[a]	6.6[a]	4.2[a]	0.4[a]	0.0[a]	1.7[a]	0.6[a]	0.4[a]	0.2[a]	2.6[a]	1.6[a]

The weight values of the tubers damaged in various ways are shown in several columns. The significance groups compare the proportion of the yield in mulched and unmulched plots damaged in the same way in the same years they show

https://doi.org/10.17221/353/2023-PSE

Table 3. Effects of combinations of different cover materials and sowing methods in an outdoor micro plot potato experiment

Year	Variable	Unit	ANOVA		Combination of cover materials and sowing methods								
			F	*P*-value	UI	SI	SO	WI	WO	MI	MO	CI	CO
2016	total yield	g	14.932	0	625^{a}	$1\,231^{abc}$	$1\,109^{ab}$	$1\,995^{bcd}$	$1\,961^{bc}$	$2\,072^{bc}$	$2\,334^{cde}$	$4\,260^{de}$	$5\,055^{e}$
	dry rot	%	2.013	0.059	3.6^{a}	0^{a}	0^{a}	0^{a}	1.1^{a}	0^{a}	0.7^{a}	2.2^{a}	1.6^{a}
	chewed	%	1.957	0.067	19.2^{a}	15.8^{a}	3.9^{a}	19.8^{a}	7.4^{a}	21.1^{a}	10.6^{a}	22.4^{a}	19.8^{a}
	green	%	10.36	0	0^{a}	0.3^{a}	6.7^{ab}	7.7^{c}	28.7^{ab}	2.8^{ab}	15.3^{b}	5.2^{ab}	13.5^{b}
	cutting	%	4.124	0.001	22.8^{b}	5.9^{a}	2^{a}	12.1^{a}	4.8^{ab}	9^{ab}	4.1^{a}	10.2^{ab}	2.4^{a}
2017	total yield	g	7.967	0	$1\,107^{a}$	$1\,287^{a}$	$1\,326^{a}$	$2\,057^{ab}$	$2\,106^{abc}$	$2\,611^{abc}$	$2\,358^{abc}$	$5\,269^{bc}$	$5\,998^{c}$
	dry rot	%	2.067	0.053	1.7^{a}	0^{a}	0^{a}	0^{a}	0^{a}	0.2^{a}	0.4^{a}	0.4^{a}	1.2^{a}
	chewed	%	0.803	0.602	17.6^{a}	14.9^{a}	13.5^{a}	7.2^{a}	11.2^{a}	10.2^{a}	8.1^{a}	13.6^{a}	11^{a}
	green	%	4.024	0.001	0.8^{ab}	0.1^{a}	2.1^{abc}	1.8^{bc}	7.5^{bc}	1.3^{ab}	8.7^{c}	2.8^{abc}	6.9^{abc}
	cutting	%	5.758	0	11.3^{b}	1.9^{ab}	0^{a}	11.5^{a}	0^{a}	11.7^{b}	1^{a}	7.2^{ab}	0.4^{a}
2018	total yield	g	16.924	0	854^{a}	686^{a}	$1\,024^{a}$	$3\,346^{bc}$	$4\,197^{bc}$	$2\,213^{b}$	$2\,924^{bc}$	$5\,054^{bc}$	$5\,924^{c}$
	dry rot	%	2.587	0.016	1.6^{ab}	0.1^{a}	0^{a}	1.2^{ab}	1.3^{ab}	0^{a}	0.3^{ab}	2.2^{ab}	4.1^{b}
	chewed	%	0.729	0.665	39.4^{a}	30.9^{a}	27^{a}	21.8^{a}	19^{a}	26.1^{a}	20^{a}	24.5^{a}	29.1^{a}
	green	%	3.062	0.006	0^{a}	1.3^{ab}	0^{a}	1.7^{b}	6.2^{b}	0.1^{a}	3.8^{ab}	1.3^{ab}	3.2^{ab}
	cutting	%	3.959	0.001	19.3^{b}	11.3^{ab}	0^{a}	20^{a}	0^{a}	11.2^{ab}	0^{a}	7.5^{ab}	0.3^{a}

Mulch materials: U – unmulched; S – straw; W – walnut leave; M – mixed leave; C – compost; sowing methods: I – planted in soil; O – planted under mulch, on the surface of the soil

the most green tubers, followed by MO and CO treatments. 2017, the WO and MO treatments had significantly more green tubers than the control. In 2018, the WO treatment had the most green tubers.

On the other hand, more of the tubers sown in the soil were damaged by tillage machinery during harvesting. In 2016, there were more cut tubers in UI than in the cases of SI, SO, WO, MO, and CO treatments. In 2017, the weight of cut tubers in the UI, WI and MI treatments also exceeded the weight of the cut tubers found under all cover materials when the tubers were sown under mulch (SO, WO, MO, CO). Furthermore 2018, UI and WI resulted in more cut tubers compared to the SO, WO, MO, and CO treatment.

DISCUSSION

Our review of the national and international literature found no research similar to ours that investigated the effects of mixed leaves and walnut leaves, the sowing methods on potato yield, or the soil-dwelling pests and soil-borne pathogens.

There was not always a consistent difference in yield between the mulch materials, but there was a tendency for the compost mulched plots to produce the most potatoes over the years, followed by walnut and mixed leaves, which did not differ, and finally, straw, which did not differ from the control in any year.

We have refuted negative stereotypes about walnut mulch (Ercisli et al. 2005) by showing that walnut leaf mulch is clearly a better mulch for potatoes than straw and no worse than mixed leaf mulch. Petrikovszki (2022) also found that the yield of the walnut leaf mulched plots exceeded those of the straw and control plots.

In the mulched plots, the number of damaged tubers did not change with the increase in total yield. So, mulching positively affected potato yield but did not increase the weight of damaged tubers.

The method of sowing on the soil's surface increased the number of green tubers in some treatments, but a more careful application of mulch could easily avoid this. However, the method did reduce the number of cut tubers, which is important because damage during storage can be an entry point for many pathogens (e.g. *Fusarium* species). We also found that by sowing the tuber on the soil's surface, the labour required for planting and harvesting can

https://doi.org/10.17221/353/2023-PSE

be saved without reducing the quantity or quality of the potato crop. This is consistent with the results of Sarangi et al. (2020).

Based on our studies, we therefore recommend using organic mulches, especially compost, walnut and mixed leaf mulches in potato production, as they increase yield but do not increase the weight of damaged tubers. By avoiding sowing in the soil and using a suitable mulch thickness (20 cm or more), and we will replace it if necessary, we can reduce planting and harvesting work without damaging the tubers or reducing the yield.

REFERENCES

Adamchuk V., Prysyazhnyi V., Ivanovs S., Bulgakov V. (2016): Investigations in technological method of growing potatoes under mulch of straw and its effect on the yield. Engineering for Rural Development, 5: 1098–1103.

Chang L., Han F., Chai S., Cheng H., Yang D., Chen Y. (2020): Straw strip mulching affects soil moisture and temperature for potato yield in semiarid regions. Agronomy Journal, 112: 1126–1139.

Coder K.D. (1983): Seasonal changes of juglone potential in leaves of black walnut (*Juglans nigra* L.). Journal of Chemical Ecology, 9: 1203–1212.

Dövényi Z., Ambrózy P., Juhász Á., Marosi S., Mezősi G., Michalkó G., Tiner T. (2008): Inventory of Microregions in Hungary. Budapest, OTKA Research Reports.

Dudás P., Gedeon Cs., Menyhárt L., Ambrus G., Tóth F. (2016): The effect of mulching on the abundance and diversity of ground beetle assemblages in two hungarian potato fields. Columella, 3: 45–53.

Dvořák P., Tomášek J., Hamouz K. (2010): Cultivation of organic potatoes with the use of mulching materials. Zeszyty Problemowe Postqpow Nauk Rolniczych, 557: 95–102.

Ercisli S., Esitken A., Turkkal C., Orhan E. (2005): The allelopathic effects of juglone and walnut leaf extracts on yield, growth, chemical and PNE compositions of strawberry cv. Fern. Plant, Soil and Environment, 51: 283–287.

Fan S., Wang D., Zhang J., Bai J., Liu W., Zhixia M., Huiyuan P. (2011): Effects of different cultivation techniques on soil temperature, moisture and potato yield. Transactions of the Chinese Society of Agricultural Engineering, 27: 216–221.

Gent M.P.N., LaMondia J.A., Ferrandino F.J., Elmer W.H., Stoner K.A. (1999): The influence of compost amendment or straw mulch on the reduction of gas exchange in potato by *Verticillium dahliae* and *Pratylenchus penetrans*. Plant Disease, 83: 371–376.

Hou X., Li R. (2019): Interactive effects of autumn tillage with mulching on soil temperature, productivity and water use efficiency of rainfed potato in loess plateau of China. Agricultural Water Management, 224: 105747.

Kar G., Kumar A. (2007): Effects of irrigation and straw mulch on water use and tuber yield of potato in eastern India. Agricultural Water Management, 94: 109–116.

Kirchner S.M., Hiltunen L.H., Santala J., Döring T.F., Ketola J., Kankaala A., Virtanen E., Valkonen J.P.T. (2014): Comparison of straw mulch, insecticides, mineral oil, and birch extract for control of transmission of potato virus Y in seed potato crops. Potato Research, 57: 59–75.

Král M., Dvořák P., Capouchová I. (2019): The straw as mulch and compost as a tool for mitigationof drought impacts in the potatoes cultivation. Plant, Soil and Environment, 65: 530–535.

Láng I., Csete L., Jolánkai M. (2007): Global climate change: domestic effects and responses (The VAHAVA Report). Agrokémia és Talajtan, 56: 199–202.

LaMondia J.A., Gent M.P.N., Ferrandino F.J., Elmer W.H., Stoner K.A. (1999): Effect of compost amendment or straw mulch on potato early dying disease. Plant Disease, 83: 361–366.

Majumder D.A.N., Nath S.C., Kabir M.A., Majumder S. (2016): Short communication: effect of mulching materials on minituber production of potato from *in vitro* plantlets. Nusant Ara Bios Cience, 8: 123–127.

Momirovic N.M., Mišovic M.M., Brocic Z.A. (1997): Effect of organic mulch application on the yield of potato seed crop. Acta Horticulturae (ISHS), 462: 291–296.

Nowroz F., Roy T.S., Haque M.T., Ferdous J., Noor R., Mondal G.C. (2021): Yield and grading of potato (*Solanum tuberosum* L.) as influenced by different mulch materials. Agrotechniques in Industrial Crops, 1: 1–10.

Petrikovszki R. (2022): Effect of different mulching materials on *Meloidogyne incognita* and beneficial nematodes. Ph.D. dissertation. Gödöllő, MATE. Accessible at: https://doktori.hu/ index.php?menuid=192&sz_ID=26918&lang=EN

Sarangi S.K., Maji B., Sharma P.C., Digar S., Mahanta K.K., Burman D., Mandal U.K., Manda S., Mainuddin M. (2020): Potato (*Solanum tuberosum* L.) cultivation by zero tillage and paddy straw mulching in the saline soils of the ganges delta. Potato Research, 64: 277–305.

Saucke H., Döring T.F. (2004): Potato virus Y reduction by straw mulch in organic potatoes. Annals of Applied Biology, 144: 347–355.

Wang L., Coulter J.A., Palta J.A., Xie J., Luo Z., Li L., Carberry P., Li Q., Deng X. (2019): Mulching-induced changes in tuber yield and nitrogen use effciency in potato in China: a meta-analysis. Agronomy, 9: 793.

Received: August 27, 2023
Accepted: October 26, 2023
Published online: January 3, 2023