Investigation on mulching weed control technologies of sweet potato (*Ipomoea batatas*)

Az édesburgonya (Ipomoea batatas) mulcsolásos gyomszabályozási technológiáinak vizsgálata

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Abstract: In our experiment, we investigated the weed control efficiency of organic mulches (wheat straw and grass cuttings) and agrotextile. The mulching materials reduced weed coverage and influenced the weed flora. However, their effectiveness significantly declined after approximately 4–6 weeks, necessitating supplementary weeding to prevent substantial yield losses. Agrotextile increased the yield by 43% (likely due to its effect on soil temperature and water management favorable for sweet potatoes), while organic mulches reduced the yield by 16–23%, even with supplementary weeding. In the weedy control, yield decreased by 97.2%. Agrotextile produced a marketable yield of 84.25 t/ha, whereas organic mulches resulted in 40.98–44.54 t/ha. Based on our results, agrotextile is the most recommended option for weed control in sweet potato, considering both the labor time required for weed management and the costs. Since agrotextile can be used for multiple years, its cost is not higher than straw mulch, and its environmental impact is lower compared to disposable plastic mulches.

Keywords: *sweet potato, weed control, mulching, agrotextile*

Összefoglalás: Kísérletünkben a szerves talajtakaró anyagok (szalma és fűnyesedék) továbbá az agroszövet mulcsolás gyomszabályozási hatékonyságát vizsgáltuk. A takaróanyagok csökkentették a gyomborítottságot és befolyásolták a gyomflórát. Hatékonyságuk kb. 4-6 hét elteltével jelentősen csökken, így kiegészítő gyomlálásokra is szükség van, hogy elkerüljük a jelentősebb terméscsökkenést. A termést az agroszövet 43%-kal növelte (ehhez hozzájárulhatott az agroszövet által kialakított, a batáta számára kedvezőbb talajhőmérséklet és vízgazdálkodás is), míg a szerves mulcsok 16-23%-kal csökkentették, még kiegészítő gyomlálásokkal is, a gyomos kontrollban pedig 97,2%-kal csökkent a termés. Az agroszövet 84,25 t/ha, míg a szerves talajtakarók 40,98-44,54 t/ha értékesíthető hozamot eredményeztek. Eredményeink alapján az édesburgonya gyomszabályozására leginkább az agroszövet ajánlható, figyelembe véve a gyomszabályozáshoz szükséges kézimunka idejét és a költségeket is. Mivel az agroszövet több évig használható, költsége nem nagyobb a szalma mulcsnál, továbbá a környezeti terhelése is kisebb, mint az egyszer használatos műanyag fóliáknak.

Kulcsszavak: *édesburgonya, gyomszabályozás, mulcsolás, talajtakarás, agroszövet*

1 Introduction

Sweet potato is the world's 7th most important food crop, cultivated on approximately 9-10 million hectares. It is a tuberous root plant propagated by seedlings. Despite its name, it is not part of the *Solanaceae* family like potato, but rather belongs to *Convolvulaceae*. Consequently, it faces significantly fewer plant protection challenges compared to potatoes. However, weeds also cause serious problems in its cultivation (Pepó, 2022).

The first half of the growing season is critical, as the plant exhibits extremely low weed suppression capacity from planting until the end of July. According to Seem et al. (2003), its critical competition period spans a four-week phase between the second and sixth weeks after planting. Currently, weed control is primarily managed through manual hoeing and ridging (Pepó, 2022). To replace these methods, mulching technologies already tested on potatoes and tomatoes may prove effective (Dezső and Pásztor, 2022; 2024).

Globally, plastic mulches (e.g., agrotextile and black PE film) are widely used in various crops. However, their use generates significant amounts of hard-to-recycle waste, prompting researchers and growers to experiment with organic and biodegradable mulches as alternatives to plastics (Cirujdea et al., 2012; Miles et al., 2012). It is important to note that mulches influence the weed flora as well as several important agrotechnical parameters, such as soil moisture, soil temperature, and organic matter content of the soil (Dezső and Pásztor, 2022; 2024; Schonbeck and Evanylo, 1988a-b).

In Hungary, sweet potato cultivation is gaining popularity in both large and small farms, as well as in home gardens, utilizing diverse production technologies, including black PE film mulching (INTERNET1; Kohut, 2023; Takácsné and Rubóczki, 2019).

2 Materials and Methods

The experiment was established in 2024 at the Dezső family farm in Nemespátró, Zala County, Hungary. Planting took place on May 22, with a row spacing of 70 cm and a plant spacing of 45 cm, using “Orange” variety and applying drip irrigation. Only biological pesticides (preparation of *Trichoderma asperellum* and *Beauveria bassiana* separately) were used.

For the experiment, 4 rows were designated, each 18 m long, divided into 8 treatments in a non-randomized arrangement (Figure 1). Each treatment was set up on a 9 m section, within which 4 plots were marked for data collection. The applied treatments were as follows: **C:** Weed-free control; **A:** Agrotextile mulch + 2 weeding; **S:** Straw mulch + 2 weeding; **G**: Grass cuttings mulch + 2 weeding; **WC:** Weedy control; **WA:** Agrotextile mulch without supplementary weeding; **WS**: Straw mulch without supplementary weeding; **WG**: Grass clippings mulch without supplementary weeding.

To assess the effectiveness of the treatments, weed surveys were conducted 4 times during the vegetation period (June 11, June 29, July 29, and October 1) using the Balázs-Ujvárosi method in 70 × 70 cm sampling areas. The impact of the mulching materials and weeds on soil temperature and soil moisture was measured using a specialized soil thermometer with a functionality to measure soil moisture on a 5-point scale. The temperature measurements had an accuracy of 1 °C. These measurements were conducted 3 times (June 14, June 19, and August 24). The growth of the plants was also monitored. At the beginning of the vegetation period, the length of the longest shoot was measured twice (June 13 and June 30). During the later surveys (July 29 and September 1), the ground cover by the plants was assessed. At the end of the vegetation period - during harvest (October 12) yield per plant was measured, and quality parameters (average tuber weight, proportion of damaged tubers, and marketable yield) were examined. The labor required for the application, maintenance, and weeding of the mulching materials was recorded, and the associated costs were quantified.

Data analysis was performed using MS Excel and IBM SPSS 27 software. The statistical methods applied included ANOVA, Welch test, Kruskal-Wallis test, and related post-hoc tests. Correlation and regression analyses were also conducted to examine the relationship between yield and weed coverage.

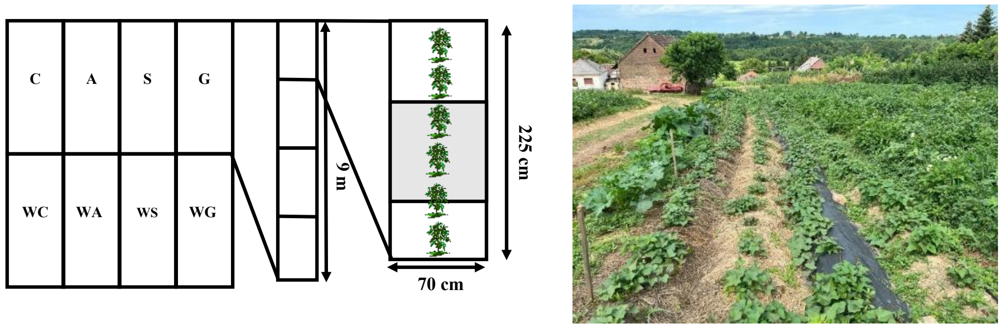

Figure 1. *Left: The design of the experiment Right: The experiment on June 20. 2024 (Dezső Dániel)*

3 Results/ Results and Discussion

3.1 Time requirement and cost of weed controll technologies

The most time-intensive treatment was the four weedings in Treatment C, requiring a total of 110 minutes (20–40 minutes per weeding). The use of mulch materials reduced the time needed for weed control by 65–82%. WA and WG required 28 minutes, WS alone required 20 minutes, straw (S) required 30 minutes, agrotextile (A) required 32 minutes, and grass clippings (G) required 39 minutes. In Treatment A, less time was needed for weeding compared to S and G (1–3 minutes versus 4–7 minutes per weeding) due to lower weed cover. The preparation and season-end removal of agrotextile required the most time in Treatment A. Significant advantage of organic mulches (S and G) is that they do not require removal, although collecting the mulch, especially in the case of G, demands substantial time (Figure 2).

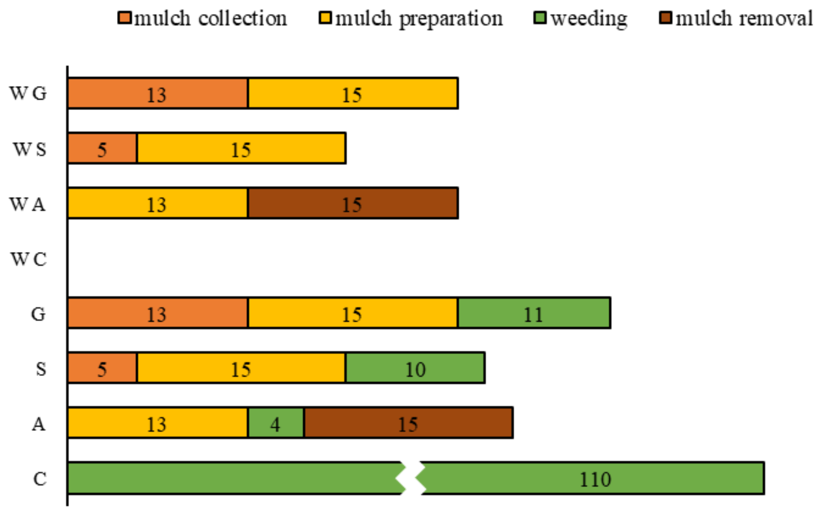

Figure 2 *Time requirement of weed controll in different treatments (min/10 m²) C-Weeded Control, A-Agrotextile, S-Stew, G-grass cuttings, WC-Weedy Control, WA-Weedy Agrotextile, WS-Weedy stew, WG-Weedy grass cuttings*

Grass clippings can be sourced for free from public areas or farmyards; however, mulching a 1.000 m² area requires a very large supply and/or tall grass. The cost of straw in 2024 was 65.000 HUF/1,000 m² (10 large round bales), while agrotextile costs ranged from 224.000 to

263.000 HUF/1,000 m². Agrotextile offers the advantage of being reusable for several years (at least 4 years which is the payback period compared to stew), based on our experience.

3.2 Evaluation of weed infestation and coverage

We found 21 weed species in the experiment across the vegetation period (Table 1). Most of the weeds in the experimental area were summer annuals (T4 species), such as *Amaranthus* spp., *Chenopodium album*, *Echinochloa crus-galli*, and *Ambrosia artemisiifolia*, the perennial *Convolvulus arvensis* was also prevalent.

Table 1 Weed species found in the experiment, ranking based on the average canopy across the vegetation period C-Weeded Control, A-Agrotextile, S-Stew, G-grass cuttings, WC-Weedy Control, WA-Weedy Agrotextile, WS-Weedy stew, WG-Weedy grass cuttings

Weed species	Life cycle[1]	Ranks in: Overall	C	A	S	G	WC	WA	WS	WG
Amaranthus blitoides	T4	1	2	3	2	2	6	4	1	2
A. retroflexus	T4	2	-	-	-	-	2	3	2	1
A. chlorostachys	T4	3	3	-	3	3	1	-	4	4
Convolvulus arvensis	G3	4	5	1	1	1	7	1	7	5
Echinochloa crus-galli	T4	5	4	-	8	6	-	-	3	3
Portulaca oleracea	T4	6	1	2	4	5	8	-	-	-
Chenopodium album	T4	7	9	-	5	-	-	2	5	8
Ambrosia artemisiifolia	T4	8	8	-	6	13	4	-	8	7
Solanum nigrum	T4	9	-	-	-	-	5	6	6	6
Galinsoga parviflora	T4	10	7	-	14	4	3	-	9	9
Digitaria sanguinalis	T4	11	6	-	9	10	10	-	-	-
Sonchus oleraceus	T4	12	12	-	-	9	9	5	-	-
Oxalis spp.	T4	13	-	-	7	-	-	-	12	-
Lolium multiflorum	T2	14	13	-	-	8	12	-	10	-
Taraxacum officinalis	H3	15	-	-	-	7	-	-	-	-
Urtica dioica	G1	16	-	-	-	-	-	-	11	-
Stellaria media	T1	17	10	-	11	12	-	-	-	-
Senecio vulgaris	T1	18	11	-	13	11	11	-	-	-
Setaria viridis	T4	19	-	-	10	-	-	-	-	-
Capsella bursa-pastoris	T1	20	-	-	-	12	-	-	-	-
Glechoma hederaceum	H1	21	-	-	12	-	-	-	-	-

[1] T3-T4: summer annual weeds; T1-T2: winter annual weeds; G1, G3, H1, H3: perennial weeds

In mulched and weeded areas (A, S, G), *C. arvensis* surpassed annuals in dominance. Table 1 shows that fewer weed species were present in mulched areas compared to WC (weed control). However, in three of the four survey periods, only Treatment A differed significantly from WC (p<0.001). On July 29 only, significantly fewer weed species were found in all mulched areas compared to WC. In Treatment G, the perennial *Taraxacum officinale* was introduced, likely via the grass clippings. Winter annuals (T1-T2 species) were more prominent in organically mulched and weeded areas, while the absence of weeding allowed summer annuals to dominate in WS and WG. Notably, no winter annual species were observed in these treatments.

Weed coverage differed significantly (p<0.001) across all four survey periods (Table 2). On June 11, all mulch materials significantly reduced weed cover. By June 29, A and WA significantly reduced weed cover compared to all other treatments. S and G showed significantly lower weed cover than C and WC. After June 29, no further weeding was performed in A, S, or G treatments, while C underwent two additional weedings. Consequently, A and C exhibited significantly lower weed cover in subsequent surveys compared to WC, WS, and WG. Organic mulches (S and G) performed similarly to WA and produced acceptable results due to the increased weed suppression from crop canopy development by the end of the vegetation.

Table 2 Weed coverage in the treatments C-Weeded Control, A-Agrotextile, S-Stew, G-grass cuttings, WC-Weedy Control, WA-Weedy Agrotextile, WS-Weedy stew, WG-Weedy grass cuttings

Time	C	A	S	G	WC	WA	WS	WG	p value[1]
June 11	78.13 b	1.12 a	13.28 a	14.06 a	90.63 b	3.90 a	14.06 a	17.19 a	<0.001
June 29	75 c	1.87 a	18.75 b	14.84 b	100 c	7.03 a	84.63 bc	81.25 bc	<0.001
July 29	4.69 a	2.89 a	21.87 ab	24.16 ab	90.68 c	29.69 b	84.38 c	87.5 c	<0.001
Oct. 1	7.81 a	9.38 a	23.44 ab	29.63 ab	83.13 c	37.5b	70.63 c	71.86 c	<0.001

[1]*Treatments labelled with the same letter are not statistically different, whereas those with different letters show significant differences; if a treatment receives multiple letters, it is not significantly different from any associated group.*

3.3 Plant growth and coverage

In our experiment, crop plants fully covered the soil by July 15, but their weed-suppressing ability was limited before then. During the first survey on June 13, Treatment A produced significantly (p=0.014) longer shoots (27.1 cm) than S and WS (19.4–19.6 cm), with no significant differences among other treatments. On June 30, A achieved significantly greater (p<0.001) shoot lengths (108.5 cm) than all other treatments (36.8–61.4 cm).

On July 29, all treatments except C exhibited significantly smaller plant cover than A (97.5%). While it was 87.5% in C and 72.5% in S and G. WA achieved 45% cover, significantly different than all other treatments, while WC, WS, and WG produced only 8.75–15% cover. By October 1, A, C, S, and G resulted in significantly greater (p< 0.001) plant cover (71.25–90%) compared to unweeded treatments (13.75–42.5%).

3.4 Soil Temperature and moisture

On June 14, Treatments A and C resulted in significantly higher (p < 0.001) soil temperatures (23.5 and 23.8 °C respectively) than other treatments (20.6–21.3 °C). Figure 3 illustrates daily soil temperature variations, showing more stable curves for organic mulches (S and G) compared to A and C, where afternoon temperatures rose to 30.5 °C. By contrast, temperatures in S and G treatments peaked at 24.5 °C. On June 29, C produced significantly higher soil temperatures than A and all other treatments. By August 24, no significant differences were

observed among treatments (p=70.245), as crop and weed cover had developed fully, overshadowing the effect of mulch type on soil heat dynamics.
No differences in soil moisture were observed in the first two measurements (June 14 and June 30). However, on August 24, C exhibited significantly lower soil moisture (p=0.011) than G and WC, while other treatments showed no significant differences.

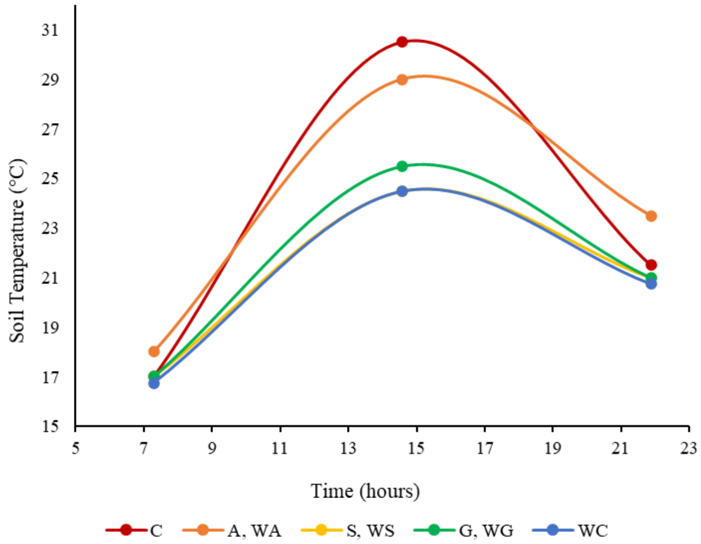

Figure 3 *The daily variation of soil temperature on June 14 in different treatments C-Weeded Control, A-Agrotextile, S-Stew, G-grass cuttings, WC-Weedy Control, WA-Weedy Agrotextile, WS-Weedy stew, WG-Weedy grass cuttings*

3.5 Assessment of yield and its connection with weed coverage

Treatment A produced the highest total yield, significantly exceeding all other treatments except C (p<0.001). S and G resulted in 16.4% and 23.3% lower yields than C, respectively, while agrotextile increased yield by 43.2%. Treatments without weeding exhibited yield reductions of 59.3–97.2%. The average tuber weight was highest in Treatment A, with acceptable values were recorded in C, S and G. Unweeded treatments (WC, WA, WS, WG) produced smaller tubers. The number of tuber per plant was significantly (p<0.001) highest in C, S and G smaller in WG, with no significant difference in A and WA and the smallest in WS and WC. Therefore, the use of agrotextile primarily increased the weight of the tubers rather than their number.
Pest damage (caused by wireworms and snails) affected 10–33% of the tubers, with no significant differences among treatments (p=0.159). Damaged tubers were still marketable as second-grade products. Treatment A resulted in the highest marketable yield, followed by significantly lower but acceptable values in C, S, and G. WA did not significantly differ from these, while WS and WG yielded much less, and WC produced no marketable yield (tubers were too small, averaging 23 g/tuber). The yield was also converted to a per-hectare basis; however, these data are for informational purposes only, allowing readers to compare the average yields of other crops. The gross production value was calculated per 1,000 m^2, with the highest value recorded in treatment A. All treatments without weeding produced significantly lower values, while treatments C, S, and G did not differ significantly from any treatment.
Yield showed a strong negative correlation with weed cover during the last three surveys, with correlation coefficients of -0.640, -0.890, and -0.899 (p<0.001). A linear regression model revealed that weed cover on October 1 most strongly predicted yield (p<0.001). The regression equation ($y=2356-28.44*x$) indicates that every 1% increase in weed cover reduces yield by 1.21% or 0.69 t/ha.

Table 3 Yield and qualitative parameters significant difference C-Weeded Control, A-Agrotextile, S-Stew, G-grass cuttings, WC-Weedy Control, WA-Weedy Agrotextile, WS-Weedy stew, WG-Weedy grass cuttings p<0.001 in every parameter (label letters as described in Table 2)

	C	A	S	G	WC	WA	WS	WG
total yield / plant [g]	1988 ab	2847 a	1662 b	1525 b	55 c	810 bc	261 bc	308 bc
avg. tuber waight [g]	243 b	425 a	193 b	192 bc	23 c	114bc	84 bc	82 bc
tuber/plant	10.13 a	7.5 ab	9.25 a	8.63 a	2.06 c	7.69 ab	3.25 bc	4 b
yield loss [%][1]	-	+43.2	16.4	23.3	97.2	59.3	86.9	84.5
marketable yield [g/plant] [2]	1789 b	2654 a	1403 b	1291 b	0 c	636 bc	159 c	203 c
marketable yield [t/ha] [2]	56.79 b	84.25 a	44.54 b	40.98 b	0 c	20.19 bc	5.05 c	6.44 c
gros income (HUF) [2]	3.041 ab	4.698 a	2.587 ab	2.339 ab	0 b	1.082 b	276 b	368 b

[1] Based on C (Controll)

[2] First grade (I.) + Second grade (II.)-damaged by wireworms and slugs (about 10-33%); net prices: II.: 450 HUF/kg, I.: 600 Ft/kg; gros income in thousend HUF/1000 m^2

4 Discussion

The mulch materials significantly influenced weed coverage and weed flora, consistent with our previous research (Dezső and Pásztor, 2022; 2024). Additionally, they affected soil temperature, as seen in studies by Schonbeck and Evanylo (1988a) and Dezső and Pásztor (2024). However, their impact on soil moisture could not be demonstrated, probably due to continuous irrigation and the inaccuracy of the measuring instrument.

Strew and grass cuttings mulch resulted in acceptable yield loss compared to the weeded control but only with addition weeding, without weeding organic mulch does not have enough weed suppression ability as described in Dezső and Pásztor (2022). Agrotextile, however, resulted in significantly higher yields compared to the control treatment, likely due to improved water retention (besides the better weed suppression than only weeding) which warrants further investigation. The use of agrotextile is most recommended, as it produced significantly higher yields than organic mulches, required no substantially greater labor time, and, if used for at least four years, its costs are not higher than straw. However, it is made of plastic like other films that are highly polluting (Miles et al., 2012), it generates much less waste at the end of its usage. Nevertheless, microplastic pollution remains a concern. Although organic mulches can increase soil humus content according to Schonbeck and Evanylo (1988b), removing them from their source areas may decrease humus levels. Our current research did not address soil organic matter content or microplastic pollution, both of which merit further study. Another drawback of agrotextile is the time required for its removal. Moreover, the increased average tuber weight observed in our study may not always be advantageous as we harvested many tubers weighted 1 kg or larger witch are not always desirable in the market.

In the experiment, a relatively high proportion of tubers were damaged by terrestrial pests, however we used *Beauveria bassiana* preparations. Since currently this is the only other major pest issue in sweet potato cultivation, it would be worthwhile to conduct experiments on pest control strategies, focusing on optimizing the application of biological methods, exploring chemical alternatives, and determining their effectiveness.

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