Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

GROWING POTATOES WITH REDUCED TILLAGE

Georgi DIMITROV

University of Forestry, 10 Kliment Ohridski Blvd, 1797, Sofia, Bulgaria

Corresponding author email: jbfun@abv.bg

Abstract

The aim of the experiment is to study the possibility of growing potatoes with a limited number of soil cultivation, at the beginning of the vegetation. The experiment was conducted at the Vrazhdebna training field of the University of Forestry, on fluvisols. The experiment is laid out according to the growing distance of 70 x 30 cm, with the Soraya variety. The soil cultivation was carried out pre-planting, at the beginning of the experiment and consisted of cultivation at a depth of 20-25 cm and subsequent furrowing at 70 cm between the furrows. During the growing season of the plants, the weed communities in the experiment were recorded, after which the inter-row weeds were mowed. There are two variants - with one mowing and with two mowing of the weeds, with the shredded plant mass being used as mulch. The average yield from one plant with double mowing is 1.428 kg, while with the single mowed option it is 1.015 kg.

Key words*: potatoes, reduced tillage, weeds, yield.*

INTRODUCTION

Conventional intensive potato production can lead to soil erosion and moisture loss. Conservation practices such as reduced or no tillage, cover crops, or mulching are being tested as alternative methods.

Preservation of soil moisture at the beginning of the vegetation of plants and improvement of their development was achieved only by postponing the first tillage, which was carried out before the actual planting of potatoes (Griffin et al., 2009).

The influence of reduced tillage on potato yields is not unambiguous. Some authors found that potato yields when using reduced tillage did not differ from those of conventional production (Mundy et al., 1999), other authors registered a decrease in yields (Drakopoulos et al., 2018), while others found increases in yields using reduced tillage (Mosquera et al., 2019).

In no-till, different resources are used for weed control - herbicides, cover crops, or mulches, and different alternatives are being tested for organic production. Shehata et al. (2019) found that bio-degradable polyethylene mulches and so-called natural herbicides (acetic and citric acid) are a good alternative because higher yields of tubers are obtained compared to conventional production.

A variety of no-till is Strawponic, which is growing the potato tubers on the surface of the soil by covering them with straw mulch, the highest yield was obtained using an amount of 50 t/ha (Msheik et al., 2019).

Cover crops are used as living mulches. They can be cut shortly before the potatoes sprout and their residues used as mulch. The resulting potato yields are similar to or higher than conventionally produced (Boyd et al., 2001; Morse et al., 2006).

The yield and quality of potatoes are affected by the lack of moisture in the soil. Mulching potatoes helps to preserve moisture and thereby increase the yield and quality of the tubers. Waste materials such as straw or rice husks are readily available and widely used (Nowroz et al., 2021).

Mulching with grass clippings also has a positive impact on both soil and potato yields. It improves soil temperature and despite increased weed biomass, potato yields are also high (Dvořák et al., 2012).

When the grass mulch is laid immediately after planting the potatoes, the effect of reducing the weed biomass and increasing the yield and quality of the potatoes is greater compared to laying it in a later (after the second digging) phase (Dvořák et al., 2009).

On the other hand, weeds affect potato yields. Weeds that emerged a week after the potatoes and developed alongside them were found to reduce yields much more than variants where weeds emerged three weeks after the potatoes.

In the first case, yields are lower by 54%, and in the second - by 16%. Weeding affects the size and number of tubers (Nelson and Thoreson, 1981).
The purpose of the experiment is to investigate the possibility of growing potatoes with a limited number of soil treatments, as well as the possibility of using weeds as mulch.

MATERIALS AND METHODS

The research was conducted in 2023 under field conditions in the educational and experimental base of the University of Forestry, Sofia (42°70'76.1"N, 23°43'73.1"E) on alluvial-meadow soils. The groundwater level is high, on average 1.5-3 m from the surface. The content of humus in the layer 0-25 cm is 1.21%, and in the subsoil 25-50cm - 1.04%, the pH of the soil reaction in the arable soil layer (arable soil) is 6.8, and in the subsoil layer (subsoil) is 6.4, which is the optimal range for normal plant development.
The total area of the study is 700 m^2, divided into two equal parts of 350 m^2 each, in which the two tested options are located: variant A – with two mowing of the weed mass during the growing season; variant B – with one mowing at the end of vegetation. The used variety is "Soraya" with an average seed fraction of 35/55 mm and an average weight of 65 g, as it shows good quality indicators for the climatic region. The predecessor crop is cabbage (*Brassica oleracea* L. var. *capitata*), which is suitable for a potato crop. One pre-planting treatment was done at a depth of 20-25 cm and subsequent furrowing at 70 cm between the furrows on 09.05.2023. Planting was done on 10.05.2023 in strips with a depth of 10 cm, inter-row distance - 70 cm, and intra-row distance - 30 cm. No pre-planting or post-planting chemical preparations were introduced.
On 14.07.2023, in one-half of the experimental area (350 square meters), in a phase in which the vegetative mass grows, the generative organs of the potatoes form and grow, the first mowing of the weed vegetation, which overtakes the potatoes in its development, was carried out. The chopped plant mass from the weeds is left in the corresponding half of the area to mulch and enhance the accumulation of organic matter in the soil.
On 15.08.2023 a second mowing was carried out in the first half of the experimental area, and again the organic residues of the weed species were left for mulching.
In the last phase of development in which the potatoes are located, namely when they stop growing and forming tubers in the soil, weed vegetation was mowed in the second half of the experimental area and harvesting of potatoes was started in both halves of the area at the beginning of October 2023.
From each variant, 20 plants were randomly marked and collected. Average weight of tubers per plant and average weight per tuber were measured. The absolute dry mass was calculated in percentages and by variants. The percentage of sugars in the tubers was recorded with a refractometer. Statistical analysis was performed using ANOVA

RESULTS AND DISCUSSIONS

The meteorological situation during the experimental period (May-September) is characterized by more moderate temperatures at the beginning and higher in July and August. Lower temperatures (8°C) were recorded after planting the tubers, and the average monthly temperature from that point until the end of May was 14.3°C. Although in the third ten days of June, the average daily temperature rose above 20°C, the monthly average was 18.8°C. The highest average monthly temperatures are July (23.2°C) and August (22.7°C) (Figure 1).
The month of May is characterized by relatively frequent rainfall - there are 22 days of recorded rainfall, with a total amount of 70.2 mm. Although the total amount of precipitation in June was 161.4 mm, half of it (81.7 mm) fell on two days in the middle of the month, and the total number of rainy days was 15. July is the driest month, with only 6 rainy days and a total amount of precipitation of 11.8 mm, followed by the month of August with 8 rainy days (24.2 mm). In the month of September, the amount of precipitation increases almost twice (45.6 mm), compared to that in August, and the rainy days are collected at the beginning (4-6.9.2023) and in the middle of the month (16-20.09.2023) (Figure 2).

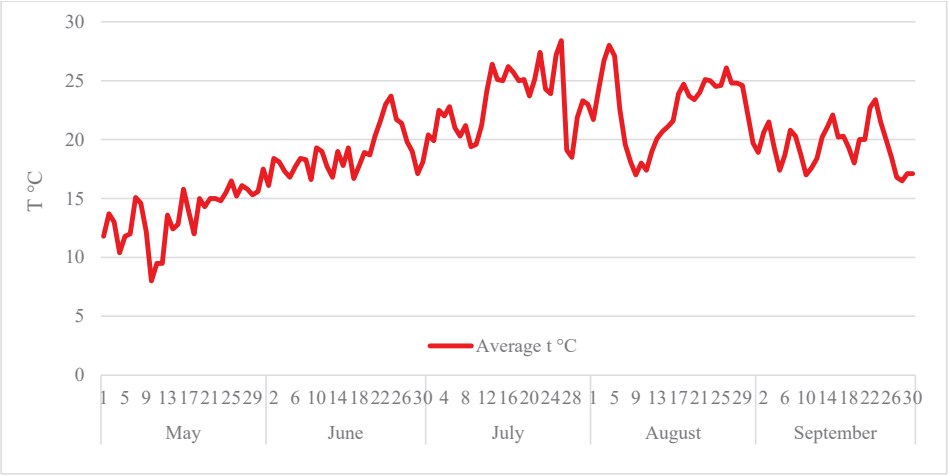

Figure 1. Average daily temperature during the experimental period

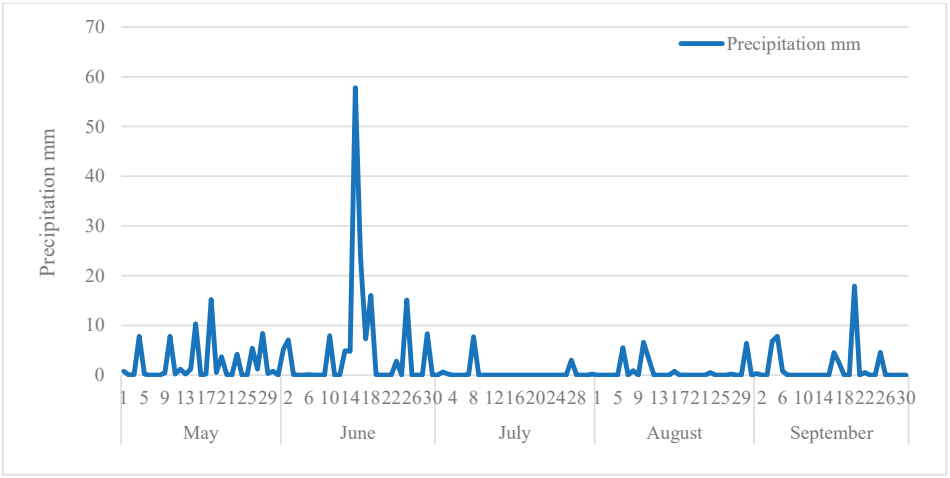

Figure 2. Daily precipitation during the experimental period

One month after planting the potatoes (June 14, 2023), the degree of weeding and the species diversity of the weeds were recorded.

The degree of weeding is between 65-70% of the area. A wide variety of wheat and broadleaf weeds are present, of which the most prevalent are: white goosefoot (*Chenopodium album* L.), meadow and sheep's fescue (*Festuca pratensis* L. & *Festuca ovina* L.), green field speedwell (*Veronica agrestis* L.), shepherd's purse (*Capsella bursa pastoris* L.), pigweed (*Amaranthus retroflexus* L.).

The number of other types of weeds reported throughout the area is not large and therefore they are summarized in one group, which represents about 32% of the total weed diversity of the experimental area (Table 1).

Table 1. The percentage ratio of weed species

Species	%
Chenopodium album L. (white goosefoot)	14
Festuca pratensis L. *(meadow fescue)*	12
Festuca ovina L. *(sheep's fescue)*	12
Veronica agrestis L. *(green field speedwell)*	10
Capsella bursa pastoris L. *(shepard's purse)*	10
Amaranthus retroflexus L. *(pigweed)*	10
Thlapsi arvence L., *Lepidium ruderale* L., *Lepidium campestre* L., *Galium tricorne* L., *Lathyrus hirsutus* L., *Spergula linicola* L., *Chenopodium poluspermum* L., *Setaria viridis* L., *Polygonum convolvulus* L., *Echinochloa crus galli* L., *Anthemis arvensis* L.	32

Approximately one month (14.07.2023) after the weeds were counted and after an analysis of the species present was made, they were mowed in variant A. Mowing was done with a trimmer in the inter-rows, and in-rows were removed manually, carefully. The grass clipping was left as mulching material.
One month later (15.08.2023) the mowing of newly grown weeds was repeated. After approximately one more month, (19.09.2023), a full mowing was done on both variants to prepare the areas for harvest.
At the end of the growing season, the yield of tubers per plant was recorded, and the average yield in variant A was higher than that of variant B (Figure 3).

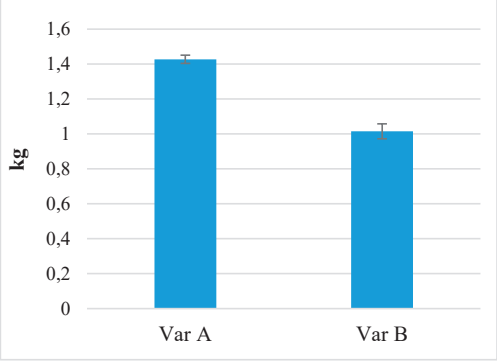

Figure 3. Average tuber weight per plant (kg). Error bars represent standard error

Data were processed with a one-way ANOVA to compare the effect of treatments on tuber yield per plant, under conditions of initial tillage combined with two mowings during the growing season (variant A) and variant B with a single mowing at the end of the growing season, before harvesting the plants. Mowing the inter-row weed vegetation and leaving the grass clipping as mulch had a significant effect on tuber yield per plant at the $p<.05$ level for the indicated conditions. [$F (1.38) = 71.22$, $p < .001$]. This result shows that the double mowing of the weeds in variant A has an effect on the yield of tubers from one plant, compared to variant B - with mowing at the end of the vegetation of the plants. In variant A, leaving plant residues from both mowings affected the yield per plant, probably due to the accumulation of organic residues of the weed species as mulch during potato development.

The mulching of variant A with the grass clipping also affected the average weight of a single potato, as again in variant B – without mowing, the potatoes were of lower weight (Figure 4).

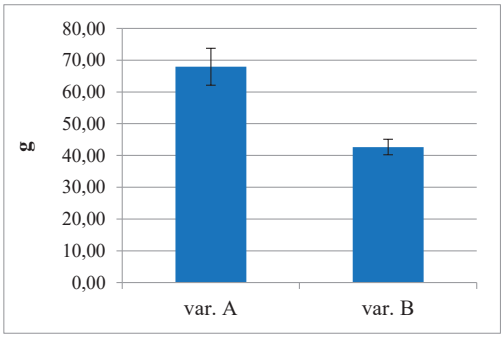

Figure 4. Average single potato tuber weight (g). Error bars represent standard error

The obtained results for the yield of potatoes, when growing them with mulching, are in agreement with the data of Dvořák et al. (2009; 2012), and Nowroz et al. (2021) for a higher yield when growing potatoes with mulching.
Similar to the average weight of individual tubers or the yield of tubers from one plant, the way of growing potatoes - by mowing the weeds during their vegetation (variant A) or once - at the end of the vegetation (variant B) also affects the content of dry matter.
One-way ANOVA test confirms that mowing in variant A also affected the average weight of a single tuber at the $p<.05$ level for the tested conditions [$F (1.58) = 16.07$, $p < .001$].
Growing potatoes with a single mowing of the weeds at the end of their growing season (variant B), besides producing smaller potatoes, they have a higher content of absolute dry matter - 26.64%. In the first option A - with mowing the weeds and laying them as mulch in the rows, the content of absolute dry matter is 20.84%.
The influence of the way of growing the plants and on the content of carbohydrates in the tubers is similar in the different variants (Figure 5).
The mean content of total sugars in potato tubers from variant A was 4.37% (SD = 0.29), while the percentage of reported average total sugar content was 5.63 in variant B - with weed cutting at the end of the growing season, and a standard deviation of 0.42. Variant B also had a higher percentage of dry matter.

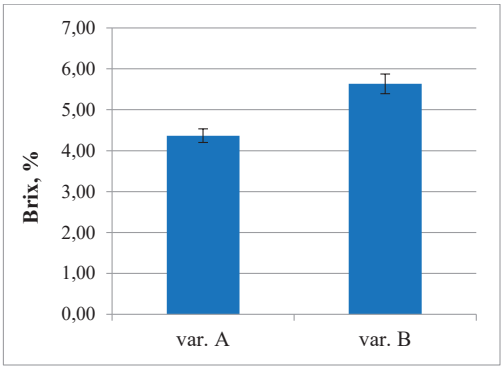

Figure 5. Content of total sugars (%) in potato tubers. Error bars represent standard error

When growing potatoes without irrigation and in drought conditions, the use of weeds as a mulching layer after their mowing during the growing season has a favorable effect on the yield and quality of the produce. This influence can be explained by the conservation of soil moisture. While mowing the weeds at the end of the growing season does not have this effect, as by then the weeds are competing with the potatoes for soil moisture. This results in smaller potatoes with an increased dry matter content, which corresponds to the results of Nelson and Thoreson (1981).

CONCLUSIONS

When growing potatoes without tilling the soil during their growing season and only with two mowing of the weeds in the rows, an average of 1.4 kg of potatoes per plant was obtained, with the average size of the tubers being about 68 g.
When weeds are left during the growing season and mowed at the end of the growing season, shortly before harvest, their influence is stronger, the potatoes are smaller (on average about 43 g) and the yield per plant is lower - approximately about a kilogram of a plant.
For small areas in urban and suburban conditions, growing potatoes without cultivation during the growing season and only with the initial preparation for planting is a good alternative. In this way, funds are saved, and by using the grass clippings from the weeds as a mulching layer, the environment for growing potatoes is improved - additional organic matter is added, the soil is protected from overheating and the moisture in it is preserved. To quantitatively substantiate these observations, it is necessary to deepen the research in this direction.

ACKNOWLEDGEMENTS

This research work was carried out with financial support from Project SRC No. B-1217/27.04.2022 (2022-2023). The project title: "Comparative study of technologies for growing vegetables and spices in urban conditions" to the Scientific Research Sector of the University of Forestry.

REFERENCES

Boyd, N. S., Gordon, R., Asiedu, S. K., Martin, R. C. (2001). The effects of living mulches on tuber yield of potato (Solanum tuberosum L.). *Biological agriculture & horticulture*, *18*(3), 203-220.

Drakopoulos, D., Scholberg, J. M., Lantinga, E. A. (2018). Influence of reduced tillage and fertilization regime on soil quality indicators in an organic potato production system. *Biological Agriculture & Horticulture*, *34*(2), 132-140.

Dvorak, P., Hajslova, J., Hamouz, K., Schulzová, V., Kuchtová, P., Tomasek, J. (2009). Influence of grass mulch application on tubers size and yield of ware potatoes. *Lucrări Ştiinţifice, Seria Agronomie*, *51*, 121-125.

Dvořák, P., Tomášek, J., Kuchtová, P., Hamouz, K., Hajšlová, J., Schulzová, V. (2012). Effect of mulching materials on potato production in different soil-climatic conditions. *Romanian Agricultural Research*, *29*, 201-209.

Griffin, T. S., Larkin, R. P., & Honeycutt, C. W. (2009). Delayed tillage and cover crop effects in potato systems. *American Journal of Potato Research*, *86*, 79-87

Msheik, A., Haidar, M., Jaafar, H. (2019). Strawponic for No-Till Potato Production. American Journal of Plant Sciences, 10(12), 2159-2169.

Morse, R., LaForce, W., Dungannon, V. A., Fannon, J., Duffield, V. A. (2006). Using high-residue cover crop mulch for weed management in organic no-till potato production systems. *Organic Farming Research Foundation Web page: http://ofrf.org/funded/reports/morse_03s18. pdf accessed*, *4*(22), 09

Mosquera, V. B., Delgado, J. A., Alwang, J. R., López, L. E., Ayala, Y. C., Andrade, J. D., D'Adamo, R. (2019). Conservation agriculture increases yields and economic returns of potato, forage, and grain systems of the Andes. *Agronomy Journal*, *111*(6), 2747-2753.

Mundy, C., Creamer, N. G., Wilson, L. G., Crozier, C. R., Morse, R. D. (1999). Soil physical properties and potato yield in no-till, subsurface-till, and conventional-till systems. *HortTechnology*, *9*(2), 240-247.

Nelson, D. C., Thoreson, M. C. (1981). Competition between potatoes (*Solanum tuberosum*) and weeds. *Weed Science*, *29*(6), 672-677.

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), 1-10.

Shehata, S. A., Abouziena, H. F., Abdelgawad, K. F., Elkhawaga, F. A. (2019). Weed control efficacy, growth and yield of potato (*Solanum tuberosum* L.) as affected by alternative weed control methods. *Potato Research*, *62*, 139-155