ACTA Acta Sci. Pol., Hortorum Cultus 11(2) 2012, 71-81

INTEGRATED EVALUATION OF THE EFFECT OF ORGANIC MULCHES AND DIFFERENT MULCH LAYER ON AGROCENOSIS

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Abstract. Mulching has become increasingly common during recent decades not only in commercial horticulture. Mulching is especially important in organic farming. Crops are influenced by many factors when mulches are used. The field experiment was carried out in Aleksandras Stulginskis University (54º53'N, 23º50'E) in 2007–2009. The soil type – *Calc(ar)i – Endohypogleyic Luvisol*. Factor A – mulching: 1) without mulch; 2) straw; 3) peat; 4) sawdust; 5) grass. Factor B – thickness of mulch layer: 1) 5 cm; 2) 10 cm. The aim of this investigation was to evaluate the influence of organic mulches and different thickness of mulch layer on agrocenosis. The effect of grass mulch on vegetable agrocenosis was stronger compared with straw, peat and sawdust mulches. Mulching with 10 cm thickness of grass mulch layer had stronger effect compared with 5 cm thickness of grass mulch layer only at the 2nd and 3rd year of mulching. The condition of agrocenosis in plots without mulch declined and in plots mulched with 10 cm thickness of mulch layer improved.

Key words: straw, peat, sawdust, grass, thickness of mulch layer, soil properties.

INTRODUCTION

Mulching has become increasingly common during recent decades not only in commercial horticulture. Mulching is especially important in organic farming. Crops are influenced by many factors when mulches are used. The main advantage of organic mulches are nutrient supply In 1963 Tukey and Schoff reported increased amounts of available soil P and K under organic mulches. They suggested that the release of nutrients from decomposing mulches (rapidly and slowly decomposing) might have positive effect on the soil. The slow release of nitrogen from decomposing organic mulch is better synchronized with plant uptake than sources of inorganic nitrogen [Cherr et al.

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2006]. It was estimated that application of straw mulch [Sønsteby et al. 2004] and grass mulch [Cadavid et al. 1998] significantly increased the available phosphorus and potassium in the soil.

Mulches are important for weed control [Bilalis et al. 2002, Radics and Bognar 2004, Jodaugienė et al. 2006a, Jodaugienė et al. 2006b]. Favourable changes in field microclimate and soil temperature variations in mulched plots are estimated [Sharrat 2002]. Research findings showed that soil enzyme activities were generally higher in the mulched plots [Yang et al. 2003]. The influence of organic mulches on crop yield is unequal. Mulch can have positive or negative effects on crops apart from its impacts on weeds. Some authors reported that mulching improves plant growth, yield and yield quality [Sharma and Sharma 2003, Singh et al. 2007, Błażewicz-Woźniak et al. 2011]. Gill et al. [1996] stated greater yield increase with mulching for the early season crop. However, some mulches (straw, peat, sawdust) also may negatively affect crops by trying up soil nitrogen due to a wide C:N ratio [Johnson et al. 2004, Sønsteby et al. 2004]. By the data of Gruber et al. [2008], there was no effect of mulching with wood chips on crop yield. The experiments of Kar and Kumar [2007] showed that higher potato yield and better crop growth were observed in plots with straw mulch. Potato yields were similar in mulched and unmulched plots, but watermelon yield was higher in plots with straw mulch [Johnson et al. 2004]. Döring et al. [2005] established no positive effect of straw mulch on potato yield, but the fact that yield was not significantly affected by straw mulch is mainly attributed to the relatively low amounts of straw applied.

Indicators determining the influence of organic mulches and different thickness of mulch layer on agrocenosis mostly are analyzed separately and not integrating them into one system of evaluation. Because of that it is difficult to estimate the influence of organic mulches and different thickness of mulch layer on agrocenosis when we have many interacting indicators and to decide which of them are more and which are less important for plants and soil. Method of integrated evaluation has been chosen to overcome this problem. This method is described in the publications of Lohmann [1994] and Heyland [1998] and obviously shows variances of the individual indicators, their interactions and enables to make comprehensive evaluation of investigation results.

Other methods of complex evaluation are being developed in the world too. One of them is method of multiple analyses. Evaluation results are presented using ordinate diagrams [Kent and Coker 1992]. Earlier described method is quite simple, obvious does not require complicated computer programs. Until now this method mainly is used in other research field, but not in horticulture science.

The aim of this investigation was to evaluate the influence of different organic mulches and different thickness of mulch layer on agrocenosis.

MATHERIAL AND METHODS

The two – factor microplot field experiment was carried out in an organic certified field in the Pomological Garden of Aleksandras Stulginskis University (54º53'N, 23º50'E) in 2007–2009. The soil type – *Calc(ar)i-Endohypogleyic Luvisol*. Soil texture:

medium clay loams on heavy clay loams and clays. Soil pH_{KCl} – 6.3, the content of total nutrients in the soil: 141.3 mg kg^{-1} of phosphorus, 142.8 mg kg^{-1} of potassium. Treatments: 1) without mulching; 2) straw (chopped wheat straw); 3) peat (medium decomposed fen peat); 4) sawdust (from different tree species); 5) grass (regularly cut, from grass-plots).

Individual plot size was 2×6 m, with each plot replicated 4 times. In 2007 in each plot were grown *Brassica oleracea* L. variety 'Kamennaja golovka' in raws with space 0.5 m, 2008 – *Solanum tuberosum* L. variety 'Anabela' in raws with space 0.7 m, 2009 – *Phaseolus vulgaris* L. variety 'Igoloneska' with space 0.5 m.

The different organic materials were used for mulching: chopped wheat straw; regularly cut grass from grass-plots; sawdust from different tree species; medium decomposed fen peat. Mulch was spread manually in a 5 cm and 10 cm thick layer shortly after sowing (planting). Remains of mulch were inserted into the soil by ploughing after harvesting in autumn.

Weed sprouts were countered and removed every 10 days from 10 June until 10 November on four 0.2 × 0.5 m squares in each plot. Sumarized data of weed number during period from 10 June until 10 November are given in this paper. Soil for analyses was sampled from each plot after harvest. Soil samples were taken from the plough layer (0–25 cm) using an auger 2 cm in diameter. A composite sample of 10–15 drillings was taken from each plot. Available phosphorus in the soil was determined by the Egner-Riem-Domingo (A–L) method. The amounts of total nitrogen in the soil was determined by Kjeldahl method. Soil biological activity was established by activity of soil hydrolytic enzymes urease and saccharase. The criteria for choosing enzyme assays were based on their importance in nutrient cycling and organic matter decomposition and the simplicity of the assay. Analyses of soil enzyme activity were done as follows: urease – by Hofman and Schmid, saccharase – by Hofman and Seegerer methods, modified by Chunderova [1973].

Method of integrated evaluation [Lohmann 1994, Heyland 1998]. The following investigations and calculations were carried out: 1. Values of various indicators determined; 2. Evaluation points (EP) of various indicators, expressed in different units of measurement, calculated aiming to put the data to unified scale. Evaluation point 1 corresponds to the worst or minimal value, point 9 – to the best or maximal value. Evaluation points of all other data of the same indicator are calculated according to the following formula: $EP_i = (X_i - X_{min}) \times (X_{max} - X_{min})^{-1} \times 8 + 1$ (EP_i – evaluation point of a certain value of corresponding indicator; X_i – value of a certain indicator; X_{max} – maximal value of corresponding indicator; X_{min} – minimal value of corresponding indicator) [Weinschenk et al. 1992]; 3. After these calculations evaluation points were marked in a network diagram with the radius scaled from 1 to 9; 4. Medium value of evaluation points, i.e. evaluation threshold (ET), which is equal to 5 points and differentiate positive and negative assessment, is also depicted on the scale. Efficiency of the treatment application is indicated by the area, limited by values of all evaluation points; 5. Integrated evaluation index (IEI), consisting from average of evaluation points, its standard deviation and standard deviation of the average of the evaluation points, which are below the ET.

RESULTS AND DISCUSSION

During the vegetation period grass mulch, due to low C:N ratio, rapidly mineralizes and releases plant readily available nutrients [Praveen-Kumar et al. 2003]. As a result, in 2007, the highest cabbage yield assessment score was established when mulching with 5 cm and 10 cm thick grass mulch layer (fig. 1). In not mulched soil or the soil applied with straw, peat and sawdust mulches cabbage yield was lower – assessment scores did not rise above the assessment limit (5 scores). These results of negative influence of some mulches on crop yield are in agreement with reports of Singh et al. [2007], Döring et al. [2005].

Estimation of soil agrochemical properties revealed that total nitrogen assessment score rose above the assessment limit only for the plots applied with 5 cm thick straw mulch layer. Sønsteby et al. [2004] established significant negative effect of bark mulch on soil nitrate and ammonium content in the two first year of experiment. Bark and sawdust mulch have C:N ratio grater than 150. The highest available phosphorus and potassium assessment scores were recorded for the grass mulched plots, since phosphorus and potassium released during grass mulch mineralization process did not leach into deeper soil layers and are accumulated at the surface. The available potassium assessment score rose above the assessment limit also in the plots applied with 5 cm thick straw mulch layer, however it did not match grass mulch. In the not mulched plots or plots applied with the other organic mulches the assessment scores of the latter indicators were below the assessment level.

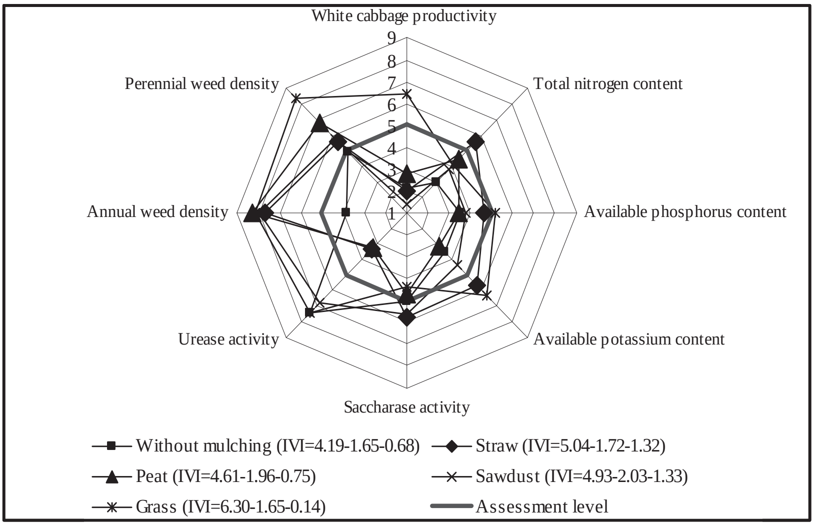
By the data of Souza Andrade et al. [2003], soil surface mulching promotes soil biological activity and crop development. Soil enzyme activity evaluation showed that in the not mulched plots or those applied with various organic mulches saccharase activity assessment scores were very close to the assessment limit. The highest urease activity assessment scores were determined both in the not mulched and grass mulched plots and in the plots applied with a 5 cm thick sawdust mulch layer. For the plots applied with 5 cm thick straw and peat mulches and with 10 cm thick sawdust mulch, the assessment score of the latter indicator was below the assessment limit.

Assessment of weed incidence in the cabbage crop showed that assessment scores of annual and perennial weeds did not rise above the assessment level only for the not mulched plots. Under the effect of all organic mulches applied, the assessment scores of annual weed number were far behind the assessment limit. The highest assessment scores of perennial weed number were established for the grass mulched plots. Under the effect of the other organic mulches applied, the assessment scores of the latter indicator were above the assessment limit, however, did not match grass mulch.

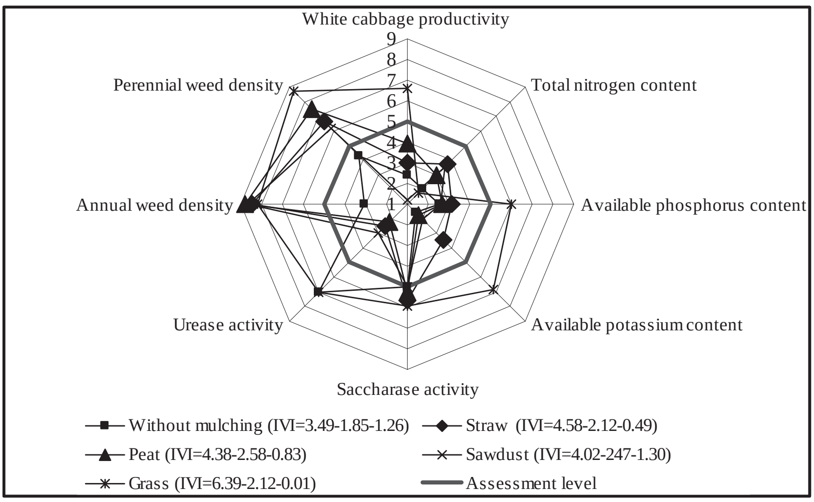
Standard deviations of the assessment scores, not passing the assessment limit, show that the highest number of minimal values, i.e. values close to 1, was established for the plots applied with 5 cm thick straw mulch and 5 and 10 cm thick sawdust mulch.

Assessment scores for various values were calculated, as well as area limited by them, and integrated assessment indexes (IAI) were determined consisting of all AS average, standard deviation and AS, not passing assessment limit's standard deviation. These findings indicate that grass mulch effect on cabbage stand was greater than that of straw, peat and sawdust mulches. Plot mulching with 5 cm thick grass layer was as effective as mulching with 10 cm thick grass layer.

5 cm mulch layer – 5 cm warstwa ściółki



10 cm mulch layer – 10 cm warstwa ściółki

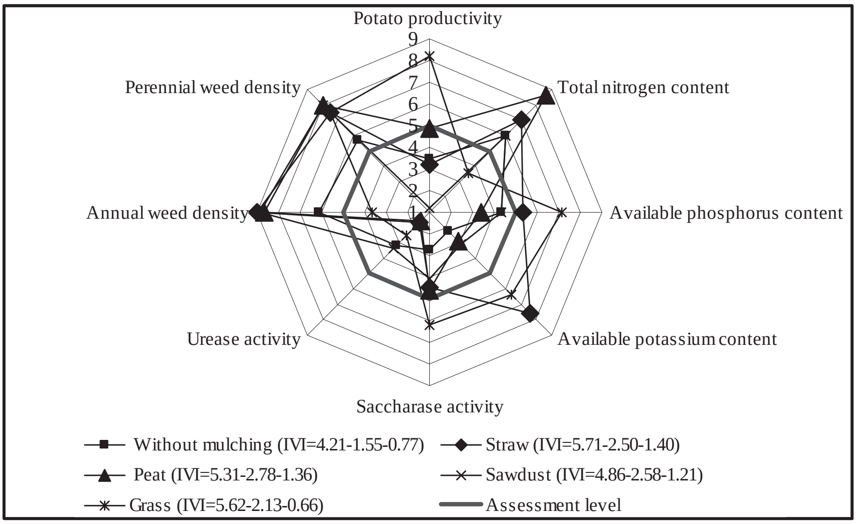


White cabbage productivity – wydajność kapusty białej; Perennial weed density – gęstość chwastów wieloletnich; Annual weed density – gęstość chwastów jednorocznych; Urease activity – działanie ureazy; Total nitrogen content – całkowita zawartość azotu; Available phosphorus content – zawartość dostępnego fosforu; Available potassium content – zawartość dostępnego potasu; Saccharase activity – aktywność β-fruktofuranozydazy; Without mulching – bez ściółki; Peat – torf; Grass – trawa; Straw – słoma; Sawdust – trociny; Assessment level – poziom oceny

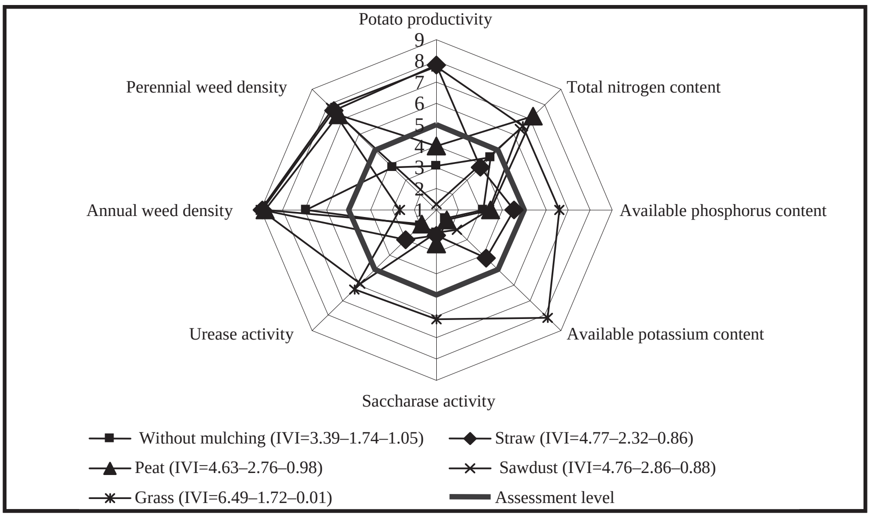
Fig. 1. Integrated evaluation of the influence of organic mulches and different thickness mulch layer on the white cabbage crop in 2007

Ryc. 1. Zintegrowana ocena wpływu ściółek organicznych i warstw ściółki o różnej grubości na plon kapusty białej w roku 2007

5 cm mulch layer – 5 cm warstwa ściółki



10 cm mulch layer – 10 cm warstwa ściółki



Potato productivity – wydajność ziemniaka; Perennial weed density – gęstość chwastów wieloletnich; Annual weed density – gęstość chwastów jednorocznych; Urease activity – działanie ureazy; Total nitrogen content – całkowita zawartość azotu; Available phosphorus content – zawartość dostępnego fosforu; Available potassium content – zawartość dostępnego potasu; Saccharase activity – aktywność β-fruktofuranozydazy; Without mulching – bez ściółki; Peat – torf; Grass – trawa; Straw – słoma; Sawdust – trociny; Assessment level – poziom oceny

Fig. 2. Integrated evaluation of the influence of organic mulches and different thickness mulch layer on the potato crop in 2008

Ryc. 2. Zintegrowana ocena wpływu ściółek organicznych i warstw ściółki o różnej grubości na plon ziemniaka w roku 2008

Research done in 2008 showed the highest potato yield assessment score to have been established in grass mulched plots (fig. 2). In the not mulched plots or plots applied with straw, peat and sawdust mulches potato yield assessment scores did not rise above the assessment limit.

The highest total nitrogen assessment score was determined for the plots applied with 5 cm thick peat mulch layer. For the plots mulched with 5 cm thick straw and sawdust layer, the total nitrogen assessment score rose above the assessment limit, however, did not match peat mulch. For the plots applied with 5 cm thick grass mulch, the total nitrogen assessment score dropped below assessment limit. For the plots mulched with 10 cm thick peat, sawdust, and grass mulch layers, the total nitrogen assessment scores were identically far from the assessment limit. For the plots mulched with 10 cm thick straw layer, the total nitrogen assessment score did not rise above the assessment level. For the not mulched plots, the total nitrogen assessment scores were close to the assessment limit. The highest available phosphorus assessment score was identified for the plots applied with both 5 cm and 10 cm thick grass mulch. In the not mulched plots and plots applied with the other organic mulches available phosphorus assessment scores were close to the assessment limit or below it. The highest available potassium assessment score was determined for the plots mulched with 10 cm thick grass layer. Slightly lower assessment scores of the latter indicator were established for the plots mulched with 5 cm thick straw and grass layers. In the not mulched plots and plots applied with peat and sawdust mulches, available potassium assessment scores were below assessment limit.

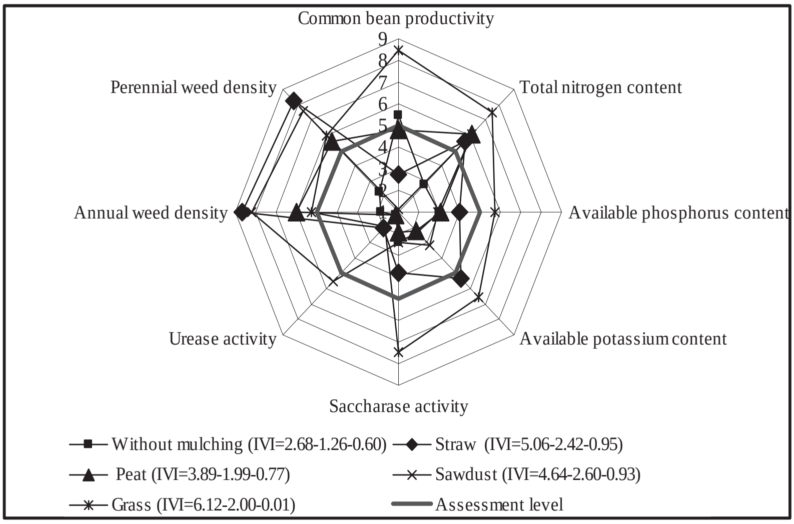
Assessment scores of the soil enzyme saccharase rose above assessment limit only for the grass mulched plots, and those of urease only for the plots applied with 10 cm thick grass and sawdust mulches. For the not mulched plots or plots applied with straw and peat mulches the assessment scores of the above mentioned soil enzymes were below assessment limit. Results of other researches opposite this – the plots with addition of straw had higher values of enzymatic activity [Garcia-Orenes et al. 2010].

Potato crop weed incidence evaluation showed that assessment scores of annual weed number did not rise above the assessment limit only in the grass-mulched plots. This can be explained by the fact that many annual meadow grass seeds were introduced into the soil with grass mulch. Under the effect of all organic mulches used, the assessment scores of perennial weed number rose above the assessment limit. For not mulched plots, the assessment scores of the latter indicator were close to assessment limit or below it.

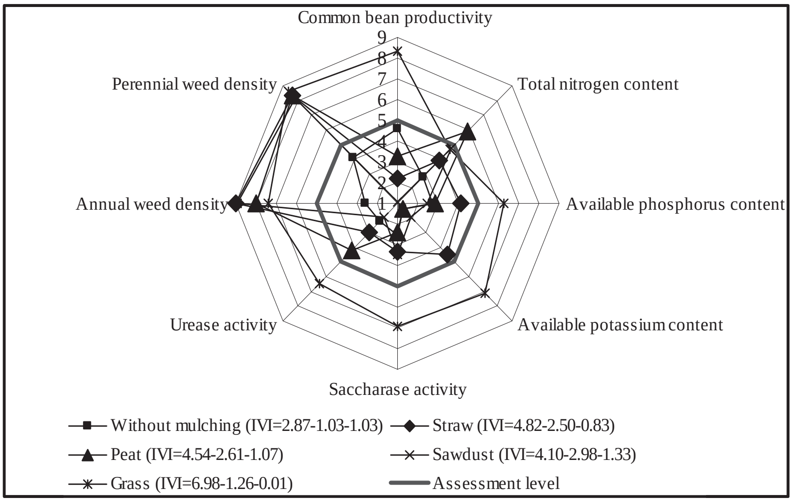
Standard deviations of the assessment scores not passing the assessment limit, showed the highest number of minimal values, i.e. values close to 1, for the plots applied with 5 cm thick peat and straw mulches. The calculated assessment points of various values, area limited by them, and integrated assessment indexes indicate that grass mulch effect on potato crop was higher than that of straw, peat and sawdust. Plot mulching with 10 cm thick grass layer was more effective than mulching with 5 cm thick grass layer.

In 2009, the highest bean yield assessment score was established in the grass-mulched plots (fig. 3). For the not mulched plots and plots applied with straw, peat and sawdust mulches, bean yield assessment scores were close to the assessment level or below it. The

5 cm mulch layer – 5 cm warstwa ściółki



10 cm mulch layer – 10 cm warstwa ściółki



Common bean productivity – wydajność fasoli zwyczajnej; Perennial weed density – gęstość chwastów wieloletnich; Annual weed density – gęstość chwastów jednorocznych; Urease activity – działanie ureazy; Total nitrogen content – całkowita zawartość azotu; Available phosphorus content – zawartość dostępnego fosforu; Available potassium content – zawartość dostępnego potasu; Saccharase activity – aktywność β-fruktofuranozydazy; Without mulching – bez ściółki; Peat – torf; Grass – trawa; Straw – słoma; Sawdust – trociny; Assessment level – poziom oceny

Fig. 3. Integrated evaluation of the influence of organic mulches and different thickness mulch layer on the common bean crop in 2009

Ryc. 3. Zintegrowana ocena wpływu ściółek organicznych i warstw ściółki o róznej grubości na plon fasoli zwyczajnej w roku 2009 highest total nitrogen assessment score was recorded for the plots applied with 5 cm thick grass mulch layer. For the plots applied with 5 cm thick straw, peat and sawdust mulches the total nitrogen assessment scores rose above assessment limit, however, did not match grass mulch. For the plots applied with 10 cm thick layer of organic mulches, the total nitrogen assessment scores were slightly above the assessment limit or below it. The highest available phosphorus and potassium assessment scores were established for grass mulched plots. For not mulched plots and plots mulched with the other organic mulches the assessment points of the latter indicators were close to the assessment limit or dropped far below it.

The assessment scores of soil enzyme saccharase rose above the assessment limit only for the grass mulched plots, and those of soil enzyme urease only for the plots applied with 5 cm thick sawdust and 10 cm thick grass mulch layers. For the not mulched plots and plots applied with straw and peat mulches the assessment scores of the above-mentioned enzymes did not rise above the assessment limit.

Evaluation of weed incidence in common bean stand showed that the assessment scores of annual and perennial weed number did not rise above the assessment limit only for the not mulched plots. Under the effect of all organic mulches applied, the assessment scores of annual and perennial weed number were slightly above the assessment limit or far below it, especially for the plots mulched with 10 cm thick layer.

Standard deviations of the assessment scores not passing assessment limit show that the highest number of minimal values, i.e. values close to 1, was identified for the plots applied with 10 cm thick sawdust mulch layer.

The calculated assessment scores of various values, the area limited by them, and integrated assessment indexes show that grass mulch effect on bean stand was higher than that of straw, peat and sawdust mulches. In the plots mulched with 10 cm thick grass layer, the obtained effect was higher than in the plots mulched with 5 cm thick grass mulch.

CONCLUSIONS

1. According to the integrated assessment indicators, grass mulch effect on various crops stands was higher than that of straw, peat and sawdust mulches, due to the rapid grass mulch mineralization during the growing season.

2. The highest cabbage, potato, common bean yield assessment scores and the highest assessment scores of perennial weed number were established for the plots mulched with grass.

3. Mulching with 10 cm thick grass layer was more effective compared with 5 cm thick grass layer.

4. The crop condition in the plots not applied with mulches for a three successive years deteriorated.

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ZINTEGROWANA OCENA WPŁYWU ŚCIÓŁEK ORGANICZNYCH ORAZ RÓŻNYCH WARSTW ŚCIÓŁKI NA AGROCENOZĘ

Streszczenie. W ostatnich dziesięcioleciach popularnośc ściółkowania wzrasta nie tylko w ogrodnictwie handlowym. W rolnictwie organicznym jest ono szczególnie ważne. Gdy używa się ściółek, na plon wpływa wiele czynników. Doświadczenie polowe przeprowadzono w Uniwersytecie Aleksandras Stulginskis (54º53'N, 23º50'E) w latach 2007–2009. Typ gleby – *Calc(ar)i – Endohypogleyic Luvisol*. Czynnik A – ściółkowanie: 1) bez ściółki; 2) słoma; 3) torf; 4) trociny; 5) trawa. Czynnik B – grubość warstwy ściółki: 1) 5 cm; 2) 10 cm. Celem niniejszego badania była ocena wpływu ściółek organicznych oraz różnej grubości warstwy ściółki na agrocenozę. Wpływ ściółki z trawy na agrocenozę warzyw był silniejszy w porównaniu ze ściółkami ze słomy, torfu oraz trocin. Ściółkowanie 10 cm warstwą trawy miało wpływ silniejszy w porównaniu z 5 cm warstwą trawy jedynie w 2. i 3. roku ściółkowania. Warunki agrocenozy na działkach bez ściółki pogarszały się, a na działkach z 10 cm warstwą ściółki – poprawiały się.

Słowa kluczowe: słoma, torf, trociny, trawa, grubość warstwy ściółki, właściwości gleby

Accepted for print – Zaakceptowano do druku: 3.01.2012