EFFECT OF LIVING MULCHES ON SELECTED SOIL STRUCTURE INDICATORS IN EGGPLANT CULTIVATION

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Received: September 10, 2012; Accepted: January 28, 2013

Summary

Conducted research involved evaluation of selected soil properties in eggplant cultivation with the use of living mulches from white clover and perennial ryegrass. The mulching species were sown three weeks before eggplant planting, in the term of planting and three weeks after planting this vegetable. In half of August there was assessed stability of soil aggregates on the basis of the following indicators of: cloddiness (B), misting (S), structure (W) of the soil and mean weighed diameter of aggregates - the dry method (MWDa), as well as water stability (ΔMWD) and waterproof (Wod) index of soil aggregates and mean weighed diameter of aggregates - the wet method (MWDg). Cover plants did significantly decrease soil cloddiness indicator, while the earliest term of their sowing contributed to lowering of that parameter values by nearly 1/3 in relation to the data obtained for mechanically treated plots. Indicator of misting of the soil and soil structure index was higher for the soil of inter–rows covered with living mulches. It was noticed that longer term of covering inter–rows with white clover and perennial ryegrass improved soil structure. Living mulches improved mean weighed diameter of aggregates, determined according to the wet method, as well as indicator of aggregates waterproof and water stability index. After sowing white clover or perennial ryegrass three weeks before eggplant planting, mean weighed diameter of aggregates, measured with the use of the wet method, was higher by 29.0% and by 18.3% than the one characterizing the object with the last term of sowing and it was higher by 31.4% and 17.1% than the value determined for mechanically treated inter–rows. ΔMWD indicator for the soil covered with white clover and with perennial ryegrass was, average, by 15.5% and 34.7% higher than the data featuring mechanical treatment. For Wod index those differences amounted 18.8% and 9.7% respectively.

key words: living mulches, Solanum melongena L., stability of soil aggregates, soil aggregates waterproof

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INTRODUCTION

Integrated agriculture consist in combining economic, ecological and social goals in a coherent system of management. In this system, a special attention is paid to soil protection which depends on preventing erosion, improvement of soil richness, reduction in leaching out nutrient components, as well as improvement in air-water conditions and soil structure. High specialization in plant and animal production brought about considerable deficit of the most valuable fertilizer – farmyard manure. Therefore, there has occurred a need of searching for new sources of organic matter origin, which mainly involved cover plants, including living mulches. After vegetable harvest, they can be ploughed in or left in the field as the mulch. This type of cultivation can significantly affect on mitigation of soil sickness through acting as a protective and anti-erosion agent, on reduction in pests population through increasing the number of their natural enemies, as well as reduction in weeds infestation. As it has been proved by long-term study, appropriately maintained cultivation of vegetables with living mulches, in spite of high competitiveness between them, can provide advantageous effects involving satisfactory yield of vegetables and protection of the environment vegetables are cultivated in (Admaczewska-Sowińska 2004, 2008, Adamczewska-Sowińska & Kołota 2008, 2009).

An important trait enabling competitiveness between weeds and living mulches is fast growing of the latter ones, as well as good covering of soil surface just from the very beginning of growing period. The results of research by Jędrszczyk et al. (2005), Wanic et al. (2005), Araki & Tamura (2008) Jędrszczyk & Poniedziałek (2009), Gibson et al. (2011), point to advantageous effects living mulches applied in cultivation of sweet corn, common cabbage, asparagus and tomato.

Living mulches also feature the function of masking cultivated plants, which makes it more difficult to find by pests and which, in turn, also become food for their natural enemies (Nyoike & Liburd 2010). Yet reduction in pests numbers on vegetables in the conditions of intercropping is changeable and depends on numerous factors (Legutowska & Klepacka 2001, Nyoike et al. 2008, Wiech et al. 2009).

Living mulches can play an important role in the protection of soil environment through preventing its erosion (Leary & De Frank 2000) and reduction in leaching out nutrients to deeper soil layers and ground waters (Tonitto et al. 2006, Kankanen & Eriksson 2007, Sturite et al. 2007). Abdul Baki et al. (2002), Sainju et al. (2002), Thomsen & Christensen (2004) claim that living mulches have a significant impact on the increase in the content of organic matter in the soil, or at least, maintain its current level. Błażewicz-Woźniak & Mitura (2004) and Adamczewska-Sowińska & Kołota (2009) regard living mulches as an important, secondary source of major macro- and microelements in the soil.

Apart from the improvement in soil chemical properties, this element of soil cultivation technology also
influences on its physical and biological properties (Kęśik et al. 2007, Majchrzak & Skrzypczak 2007, Pabin et al. 2007). Plant mulches and living mulches also generally improve indicators of soil structure (Błażewicz-Woźniak 2002, Wojciechowski et al. 2004, Kęśik & Błażewicz-Woźniak 2008, Jędrszczyk & Poniedziałek 2009), although reports in this field have not been univocal and sufficient so far. Thus basic aim of this research was determination of the effect of living mulches, sown in different terms, on selected indicators of soil structure in eggplant cultivation.

MATERIALS AND METHODS

One-factorial experiment was conducted in the years 2010-2011, in Research-Development Station belonging to the Department of Horticulture at Wroclaw University of Environmental and Life Sciences. It involved the assessment of selected soil properties in integrated cultivation of eggplant with living mulches. The experiment was established according to the method of randomized blocks, in three replications. Living mulches – white clover Trifolium repens L. (k) and perennial ryegrass Lolium perenne L. (z) were sown three weeks before eggplant planting (I), during its planting (II) and three weeks after its planting (III). As a control object there served traditional maintaining inter – rows, with periodical mechanical weeding.

The experiment was established on degraded black earth, originating from slightly sandy light loam, lying on medium loam, of humus content 1.8%, classified to III a soil class. Eggplant seedlings were planted in the field on 20th May, in 80 x 50 cm spacing. Between plants rows there were sown seeds of living mulches in 20 cm - strips.

Selected soil properties were assessed in full growing period, in half of August, for 0-20 cm layer. Evaluation of stability of soil aggregates was done following the method of dry and wet separation in Bakszajew apparatus. Soil samples, collected from each plot, after obtaining their air-dry state, underwent screening with the use of screen set of mesh diameters: 0.25, 0.5, 1, 3, 5, 7, 10 mm. There was also determined percentage share of each aggregate fraction. On the basis of obtained results there were calculated indicators of soil cloddiness (B), soil misting and soil structure (W), as well as mean weighed diameter of aggregates (MWDa), using the dry method.

Evaluation of aggregates waterproof was done using Bakszajew apparatus, by wet screening of soil samples on screen set of mesh diameters: 0.25, 0.5, 1, 3, 5, 7, 10 mm. Then there was calculated mean weighed diameter of aggregate, with the use of wet method, as well as indicator (ΔMWD) and water stability index (Wod) of soil aggregates.

Examination results were subjected to statistical analysis by Tukey method at significance level α=0.05.

RESULTS AND DISCUSSION

In the initial stage of cultivated plant growth such soil parameters as soil cloddiness and soil misting can be
of the highest importance. Clumps and clods make seeds germination difficult, while considerable dispersion facilitates the occurrence of soil crust, which prevents, among others, optimal exchange of gases between the soil and the atmosphere (Kordas & Zimny 1998, Rasmussen 1999). In research by the author it was possible to state that application of living mulches did significantly affect on soil clumping process (Fig. 1).

Fig. 1. Index of cloddiness of the soil (B) depending on kind and sowing term of living mulch, mean for 2010-2011

Cover plants diminished cloddiness indicator to a high degree, especially when sown in the earliest term. The sowing of inter – rows with white clover or perennial ryegrass, which took place three weeks before eggplant planting decreased that parameter by nearly 1/3 in relation to that featuring plots with mechanical treatments. However, there was not determined statistically significant soil misting as dependent on the examined factor, although it was noticed that its indicator was of a higher value (average by 33%) for inter – rows covered with living mulches (Fig. 2). Błażewicz-Woźniak (2002) and Wojciechowski et al. (2004) also proved that soil mulching increased its dispersion, which mainly resulted from smaller degree of soil clumping.
Living mulches did beneficially influence on soil structure, whose indicator of covering inter-rows with white clover, regardless the term of its sowing, was by 55.6% higher, and when sown with perennial ryegrass, its value was higher by 25.3% than in traditional cultivation (Fig. 3). Highly efficient, soil structure forming role of the Fabaceae was also reported by Wojciechowski (2009) and Wojciechowski et al. (2004). Wojciechowski and Sowiński (2011), assessing the structure of fallow soil, proved highly advantageous effect of sowing this kind of soil with eastern goat rue (Galega orientalis Lam). In that way the mentioned authors proved that Fabaceae plant had more intensive impact on the improvement in soil structure indicators than long-term sodding fallow land with grasses. However, Błażewicz-Woźniak (2002) claimed that cover plant species did not significantly affect on the mentioned soil property, while Zawieja and Wojciechowski (2007) proved that the structure of fallow soil covered with red clover was much worse than that of self-sufficient or treated with herbicides soil. The term of sowing cover plants did not markedly influenced on soil structure, although it was observed that longer period of covering inter-rows with white clover and perennial ryegrass resulted in soil structure improvement. Błażewicz-Woźniak (2002) reported that structure indicators, regardless the species of a mulching plant, were of higher values at the beginning of growing period of main yield than in its full growing period.

No significant differences were fund in mean weighed diameter of aggregates, according to the dry method, in relation to the examined factor, although in inter-rows, covered with a cover plant, it was slightly higher than in the case of their me-
chanical treatment (Fig. 4). Wojciechowski et al. (2004) proved that when white clover was sown into winter wheat, soil aggregates diameter (dry) was lower in comparison to cultivation without a mulching plant.

![Graph](image)

**kind and sowing term of living mulch**

Explanation like under Fig. 1

Fig. 3. Index of soil structure (W) depending on kind and sowing term of living mulch, mean for 2010-2011

![Graph](image)

**kind and sowing term of living mulch**

Explanation like under Fig. 1

Fig. 4. Mean weighted diameter of aggregates (dry) (MWDa) depending on kind and sowing term of living mulch, mean for 2010-2011

Living mulches had a significant impact on selected indicators of aggregates waterproof (Table I). Those mulches improved mean weighed diameter of aggregates, according to the wet method, as well as water stability and waterproof index. More satisfactory effect on the size of soil
aggregates was obtained due to white clover, as compared to perennial ryegrass. Indicator MWDg, determined for the soil sown with *Fabaceae* plant, was, average, by 18.1% higher than at traditional maintaining inter – rows, while after perennial ryegrass sowing that difference amounted 5.7%.

Table 1. The effect of kind and sowing term of living mulch on indicators describing wet soil structure status in eggplant cultivation, mean for 2010-2011

| Kind and sowing term of living mulch | MWDg (mm) | ΔMWD | Wod |
|-------------------------------------|-----------|-------|-----|
| white clover I*                     | 1.38      | 1.69  | 41.6|
| white clover II                     | 1.27      | 1.69  | 37.9|
| white clover III                    | 1.07      | 1.71  | 34.6|
| mean                                | 1.24      | 1.70  | **38.0**|
| perennial ryegrass I                | 1.23      | 1.96  | 38.5|
| perennial ryegrass II               | 1.06      | 2.13  | 32.7|
| perennial ryegrass III              | 1.04      | 1.84  | 34.0|
| mean                                | 1.11      | **1.98** | **35.1**|
| Control without living mulch        | 1.05      | 1.47  | 32.0|

LSD_{α=0.05} 0.08  0.07  2.17

* sowing term of living mulch: I - 3 weeks before eggplants planting, II – in the term of eggplants planting, III - 3 weeks after eggplants planting

MWDg – mean weighed diameter of aggregates (-wet)

ΔMWD – water stability index

Wod – index of waterproof

Taking into account reports by Rewut (1980), who claimed that the most advantageous soil properties characterized the soil in which the highest share belongs to aggregates of diameter from 1 to 5mm, beneficial influence of living mulches on that soil property should be appreciated. The size of aggregates in inter – rows soil, treated mechanically, ranged, average, 1.05 mm, i.e. close to limit criterion. Mean weighed diameter of aggregates, measured by the wet method, was considerably diversified according to the term of covering inter – rows with a living mulch. After sowing white clover, three weeks before eggplant planting, soil clump diameter value was by 29.0% higher than that from the object where the last sowing term was applied and by 31.4% from the diameter measured for the object with mechanical treatment of inter – rows. For perennial ryegrass the mentioned differences ranged 18.3% and 17.1% respectively, and they were statistically significant. Both species of living mulch featured highly favourable effect on indicator and water stability index of soil aggregates. Indicator ΔMWD, after sowing inter – rows with white clover or perennial ryegrass, was, average, by 15.6% and 34.7% higher than at me-
mechanical treatment. For Wod index those differences amounted 18.8% and 9.7% respectively. The changes in indicator of aggregate waterproof, related to the term of clover sowing, were insignificant, while for perennial ryegrass they featured diverse values and they were not univocal. Water stability index of soil aggregates did evidently decrease according to the delay in sowing inter – rows with living mulches. Wod index, in the conditions of sowing white clover three weeks before eggplant planting, was by 20.2% higher than after last – term sowing and by 30.0% higher than that determined for mechanically treated inter – rows. For perennial ryegrass those differences amounted 13.2% and 20.3% respectively. Jędrszczyk and Poniedziałek (2009) confirmed favourable effect of living mulches on increased number of water - stable soil aggregates, especially those of the highest diameter value, although even more advantageous effect of living mulches could be observed in the case of rye than for the Fabaceae.

CONCLUSIONS

1. Living mulches influence on decreased soil clumping. Sowing inter – rows with white clover or perennial ryegrass three weeks before eggplant planting diminished the value of that parameter nearly by 1/3 in relation to that determined for mechanically treated plots.

2. Cover plants favourably affected soil structure. Its indicator, for white clover mulch, regardless the term of its sowing, was by 55.6% higher, while for perennial ryegrass it was higher by 25.3% than that obtained for traditional cultivation.

3. Soil misting and mean weighed diameter of aggregates, measured according to the dry method, did not depend on plant species and the term of living mulches sowing.

4. More favourable effect on mean weighed diameter of aggregates, determined according to the wet method, featured white clover in comparison to perennial ryegrass. White clover sowing three weeks before eggplant planting provided for the increase in the diameter of aggregates by 29.0%, as compared to the one obtained for last - term sowing and by 31.4% for mechanically treated inter - rows. For perennial ryegrass that difference amounted 18.3% and 17.1% respectively.

5. Both species of living mulches had a positive impact on water stability index and waterproof index. ΔMWD index, after sowing inter – rows with white clover, was, average, by 15.5% higher and after sowing with perennial ryegrass - by 34.7% higher than the one determined for mechanically treated plots. For Wod index those differences amounted 18.8% and 9.7% respectively.

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Streszczenie
Przeprowadzone badania obejmowały ocenę wybranych właściwości gleby w uprawie oberżyny z zastosowaniem żywych ściełók z koniczyny białej i życicy trwałej, wysiewanych na trzy tygodnie przed sadzeniem roślin, w terminie ich sadzenia oraz trzy tygodnie po ich posadzeniu. W połowie sierpnia oceniono trwałość agregatów glebowych na podstawie wskaźników: zbrylenia (B), rozpylenia (S), struktury (W) gleby oraz średniej ważonej średnicy agregatu - na sucho (MWDa), a także ich wodoodporność na podstawie wskaźnika (ΔMWD) i współczynnika wodoodporności (Wod) agregatu oraz średniej ważonej średnicy agregatu - na mokro (MWDg). Rośliny okrywowe w sposób istotny zmniejszały wskaźnik zbrylenia gleby, a najwcześniejszy termin ich wysiewu przyczynił się do zmniejszenia tego parametru blisko o 1/3 w stosunku do wykazanego na połetkach z mechaniczną pielęgnacją. Wskaźnik rozpylenia oraz wskaźnik struktury gleby był większy dla gleby międzyrzędzi okrytych żywymi ściełkami. Obserwowano, że dłuższy okres pokrycia międzyrzędzi koniczyną białą i życicą trwałą poprawiał strukturę gleby. Żywe ściełki poprawiały średnią ważoną średnicę agregatu na mokro oraz wskaźnik i współczynnik wodoodporności. Po wysiewie koniżyny białej lub życicy trwałej trzy tygodnie przed posadzeniem oberżyny średnia ważona średnica agregatu na mokro była większa o 29.0% i 18.3% niż w obiekcie z ostatnim terminem siewu oraz o 31.4% i 17.1% od wykazanej przy mechanicznej pielęgnacji międzyrzędzi. Wskaźnik ΔMWD dla gleby pokrytej koniczyną białą oraz życicą trwałą był średnio o 15.5% i 34.7% większy niż przy pielęgnacji mechanicznej. Dla współczynnika Wod różnice te wyniosły odpowiednio 18.8% i 9.7%.