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# EFFECT OF HERBICIDE FALLOW AND MULCHING IN THE TREE ROWS ON THE SOIL PROPERTIES, GROWTH, AND YIELD OF APPLES, VAR. ELSTAR

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A b s t r a c t. The subject of the present research has been to study the influence of herbicidal fallow and mulching in the tree-rows on some of the soil properties and yields of apples var. Elstar. In the experiment the following combinations of soil treatments were applied: herbicidal fallow, pine bark, black foil and non-woven polyethylene. The applied combinations of treatments affected changes in the physico-chemical and chemical soil properties. These properties varied in the quantity and quality of organic material and intensity of nutrient leaching. The results obtained showed that mulching was a simple treatment that improved yields. In growing var. Elstar apples, mulching with pine bark yielded positive production effects.

K e y w o r d s: herbicidal fallow, mulching, soil properties, apple yielding.

## INTRODUCTION

One of the agrotechnical treatment in horticulture that decides on the tree growth and yields, are the treatments related to the soil. Systems used in horticulture to maintain soils in the orchards influence supply of nutrients and water to the trees [3,7,8,10,12].

In Poland, herbicidal fallow has been the main soil treatment method in intensive dwarf orchards. Long-term application of herbicide to the soil can pollute the environment. For that reason and also because of the increasing demand for healthy food, orchard growers have to look for alternative ways of soil treatment than herbicides. More and more often, weeds that compete with the trees for water and nutrients, are controlled by soil mulching with various materials [2,3,6,8-10,12].

The aim of the present study was to examine the effect of herbicidal fallow

and mulching in the tree rows on some of the soil properties together with growth and yielding of apples var. Elstar.

## MATERIALS AND METHODS

The present studies were carried out in the Research and Didactic Station of the Agricultural University in Wrocław. The experiment was founded in 1992 on the podzolic soil originating from medium loam. After phosphorus-potassium fertilisation had been applied during ploughing at the dose of 87 kg/ha of P and 166 kg/ha of K, apple trees var. Elstar were planted on the M26 substrate, with the spacing of 3.5x2 m. In the inter-rows, grass was sown, and in the tree rows in the zone with the width of 1.3 m, the following combinations of soil treatment were applied: herbicidal fallow, pine bark mulching, black foil and non-woven polyethylene. During the experiment, fertilisation was limited only to the yearly nitrogen applications. Decomposing pine bark was supplemented in the third experimental year. Soil samples for laboratory determinations were collected in the spring of 1998 from the depth of 5-15 cm.

The following parameters were determined in the soil material:

- C-organic by the CS-MAT 5500 apparatus,
- total N by the Kjeldahl's method,
- P and K content by the Egner-Riehm's method,
- Mg content by the Schachschabel's method,
- Cu, Zn, Mn, and Fe soluble in 1 M HCl by the AAS method,
- pH in $H_2O$ and 1 M KCl,
- Hh by the Kappen's method,
- exchangeable cations of Ca, Mg, K, Na by the Pallmann's method,
- soil density by the Kopecky's method,
- water content at the pF level of 2.0, 2.5, 2.85, 4.2.

Apple yielding was determined on the basis of collected fruit from individual trees in the consecutive years of yielding. Tree growth was evaluated after vegetation season had finished on the basis of trunk diameter.

Results of the above studies were then statistically worked out on the basis of variance analysis. The t-Student's test was used to compare average values.

## RESULTS

The results obtained show that the applied soil treatment methods influence

soil properties and apple var. Elstar growth and yielding. After six years of the present experiment, soil humus content in the 5-15 layer was at the level of 5.7 - 6.7 g/kg of C-organic (Table 1). The highest content of this element was found in the objects in which mulching with pine bark was applied. It was significantly higher than in the remaining combinations of soil treatments in the tree rows. The lowest content of C-organic was found in the soil that had been mulched with non-woven polyethylene. The content of total N was not significantly varied; its highest values of 0.735 mg/kg was found in the combination with non-woven polyethylene, and the lowest in the combination with black foil. The value of C/N ration ranged from 8.5 to 14.4. Wider range was found in the object mulched with pine bark, and the lowest under non-woven polyethylene cover.

**T a b l e 1.** Some chemical properties of soils

| Treatment | C | N | S | P | K | Mg | Cu | Zn | Mn | Fe | C/N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total form | | | Available form | | | | | | | |
| | mg/kg | | | mg/100 g | | | mg/kg | | | | |
| Herbicide fallow | 7368 | 686 | 93 | 9.2 | 21.7 | 7.9 | 6.1 | 11.9 | 194 | 979 | 10.7 |
| Pine bark | 7725 | 678 | 90 | 8.7 | 18.4 | 11.4 | 4.7 | 17.5 | 167 | 1255 | 14.4 |
| Black foil | 6543 | 631 | 87 | 9.4 | 17.4 | 6.7 | 4.0 | 9.4 | 169 | 937 | 10.4 |
| Non-woven poliethylene | 6281 | 735 | 90 | 8.4 | 15.6 | 6.4 | 4.8 | 12.5 | 172 | 1001 | 8.5 |
| $LSD_{0.05}$ | 343 | 70 | 15 | 1.7 | 2.8 | 1.4 | 0.8 | 3.8 | 18 | 84 | 0.8 |

The applied variants of mulching did not exert any significant influence on the total sulphur content. Its amount was low and ranged from 8.7-9.3 mg/100 g of the soil. Similarly, amounts of available phosphorus did not show any significant differentiation among the objects and ranged at the high content level. The amounts of available potassium found allow to classify the studied soils as medium and very rich in the above element. High potassium content ws found in the soil under herbicidal fallow. Content of available magnesium did not exceed 6 mg/100 g of the soil, which allows to classify the studies soils as rich in this element. However, significantly higher amounts of this element were found in the soils mulched with pine bark.

Soil maintenance systems resulted in high variation in the amount of the available forms of some microelements. The soils mulched with pine bark showed a significantly higher content of iron and zinc than the soils treated with other methods. Despite differences, the content of the available microelements was not

differentiated and ranged at the medium or low content level.

Simultaneously with changes in the soils fertility, its physicochemical properties changed (Table 2). The pH values in KCl ranged from 4.9 to 5.6. It indicates acidic or slightly acidic soil reaction. The lowest degree of acidification was observed in the soil under black foil, and the highest under non-woven polyethylene. Similarly, the lowest hydrolytic acidity was observed in the soils mulched with black foil. A significantly higher acidity was found in the soil mulched with non-woven polyethylene. In the sorption complex of the studied soils exchangeable calcium was predominant, followed by magnesium, potassium and sodium. The lowest content of exchangeable calcium was found in the soil covered with non-woven polyethylene, and the highest content was found in the object covered with black foil. The content of exchangeable magnesium and potassium was significantly higher in the objects mulched with pine bark and under herbicidal fallow. The applied methods of soil maintenance in the tree rows influenced soil water sorption capacity only to a low and insignificant degree. It remained at the level of about 8 cmol (+)/kg. Among them basic kations constituted 62% in the soil mulched with non-woven polyethylene and 78% in the soil under black foil. The degree of soil saturation with basic kations in the combination with black foil was significantly higher than under non-woven polyethylene.

Soil maintenance method did not exert any significant influence on the soil physical properties (Table 3). Volumetric density ranged from 1.55 to 1.62 $Mg/m^3$, which allowed to class the Ap horizons of the studied soils as compact. No significant influence of the applied growing combinations on the pF values was found, i.e. 2.0, 2.2, 2.5. Similarly, air porosity calculated according to the same pattern at the pF 2.0, and pF 2.5 did not show any significant differences.

The maintenance methods applied to the soil in the tree rows in this experiment formed conditions for the apple trees var. Elstar growth and yielding. Soil mulching in the tree rows exerted favourable influence on the apple trees growth in the object mulched with pine bark (Table 4). The increase of the tree trunk cross-section area in the period 1992-1997 was significantly higher in the above object than in the herbicidal fallow or under black foil. The results shown in Table 5, allow to conclude that the applied methods of soil maintenance are decisive for production results. In individual study years, yields were significantly differentiated except for the first years of fruiting. It influenced the amount of yield obtained. Total yield in the period 1993-1998 ranged from 58.1 to 95.2 kg/tree. The yield obtained was decidedly higher in the mulched objects. Apple trees var. Elstar yielded best on the soil covered with pine bark.

**T a b l e 2.** Some physicochemical properties of soils

| Treatment | pH | | Hydrolytic acidity (Hh) | Exchangeable cations | | | | S BC | T CEC | V BS | Ca:Mg:K:Na |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $H_2O$ | 1 M KCl | | Ca | Mg | K | Na | | | | |
| | | | | (cmol(+)/kg) | | | | | (%) | | |
| Herbicide fallow | 6.3 | 5.4 | 2.29 | 4.45 | 0.46 | 0.52 | 0.11 | 5.54 | 7.83 | 71 | 9.7:1:1.1:0.2 |
| Pine bark | 6.3 | 5.4 | 2.40 | 4.61 | 0.63 | 0.33 | 0.12 | 5.69 | 8.09 | 70 | 7.3:1:0.5:0.2 |
| Black foil | 6.4 | 5.6 | 1.77 | 5.36 | 0.40 | 0.25 | 0.14 | 6.15 | 7.92 | 78 | 13.4:1:0.6:0.4 |
| Non-woven poliethylene | 6.0 | 4.9 | 3.01 | 4.09 | 0.38 | 0.27 | 0.12 | 4.86 | 7.87 | 62 | 10.8:1:0.7:0.3 |
| $LSD_{0.05}$ | 0.3 | 0.4 | 0.69 | 0.82 | 0.07 | 0.09 | 0.02 | 0.93 | 0.50 | 9 | - |

**Table 3.** Some physical properties of soils

| Treatment | Bulk density $Mg/m^3$ | Total porosity | Water content at pF | | | Air porosity at pF | |
|---|---|---|---|---|---|---|---|
| | | | 2.0-2.85 | 2.0-4.2 | 2.5-4.2 | 2.0 | 2.5 |
| | | | (% vol.) | | | | |
| Herbicide fallow | 1.57 | 39.7 | 7.8 | 22.7 | 17.7 | 9.7 | 14.7 |
| Pine bark | 1.62 | 37.3 | 6.6 | 20.7 | 16.9 | 8.5 | 12.3 |
| Black foil | 1.59 | 38.9 | 6.9 | 22.2 | 18.0 | 8.7 | 12.4 |
| Non-woven poliethylene | 1.55 | 40.3 | 8.1 | 22.4 | 17.2 | 10.7 | 15.8 |
| $LSD_{0.05}$ | 0.04 | 1.9 | n.s. | n.s. | n.s. | n.s. | n.s. |

**Table 4.** Effect of mulching on vegetative growth of Elstar variety

| Treatment | Increment of trunk cross-section area ($cm^2$) | | | | | |
|---|---|---|---|---|---|---|
| | 1992-1993 | 1993-1994 | 1994-1995 | 1995-1996 | 1996-1997 | 1992-1997 |
| Herbicide fallow | 1.56 | 4.86 | 5.24 | 14.38 | 6.36 | 32.4 |
| Pine bark | 4.72 | 4.44 | 7.46 | 14.64 | 6.44 | 37.7 |
| Black foil | 3.99 | 4.01 | 7.61 | 13.25 | 6.44 | 32.7 |
| Non-woven poliethylene | 2.75 | 4.34 | 5.73 | 13.87 | 6.01 | 35.3 |
| $LSD_{0.05}$ | 1.15 | n.s. | 1.54 | n.s. | n.s. | 2.8 |

## DISCUSSION

High cost of founding an orchard call for big investments. That guarantees quick commencement of yielding and regular yields. Maintenance of the orchard soil is of extreme importance. The so-far obtained experimental results show that mulching applied in the tree rows plays an important role in managing soil properties. It has also been confirmed in the growth and yielding of the apple tree var. Elstar.

In the present experiment, a systematic decrease of humus content was observed in consecutive experimental years [6]. Limited inflow of organic matter especially in the combinations with black foil and non-woven polyethylene resulted in the decrease of C-organic content. Content of macro- and microelements and physico-chemical soil properties allow to achieve high yields of good quality. When the inflow of organic matter from outside is limited by black foil, a decrease in the content of nitrogen, magnesium and microelements was observed. The process of leaching that takes place under the cover of non-woven polyethylene,

**Table 5.** Effect of mulching on yield of Elstar cultivar

| Treatment | Yield (kg/tree) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1993-1998 |
| Herbicide fallow | 3.6 | 3.8 | 15.1 | 1.6 | 31.8 | 2.2 | 58.1 |
| Pine bark | 2.7 | 11.6 | 14.0 | 18.4 | 32.7 | 15.8 | 95.2 |
| Black foil | 4.0 | 13.5 | 5.5 | 17.9 | 24.8 | 12.5 | 78.2 |
| Non-woven polietylene | 3.8 | 11.3 | 13.4 | 15.4 | 27.8 | 13.8 | 85.5 |
| $LSD_{0.05}$ | n.s. | 4.6 | 2.1 | 7.9 | 2.1 | 4.2 | - |

a decrease in the content of potassium and magnesium together with an increase in the soil acidity resulting form the washing out of basic cations, was observed. The Ca:Mg:K:Na cation ratio was the most favourable in the object mulched with pine bark. According to the studies by Lipecki [7] the K:Mg ratio plays an important role in the period of young apple tree growth.

The applied mulching methods did not change soil retention abilities. Nevertheless, the actual moisture level could have been modified by the changing thermal conditions. Engel [3] quotes that black foil placed in the tree rows warms the soil up. Lipecki [7] draws attention to the role of mulching as a factor that decides on the water supply during the period of tree growth, especially during the first years after planting. In the present experiment, the best tree growth was observed when mulching with pine bark was applied, and the worst increase in the cross-section area of the trunk was observed in the case of herbicidal fallow.

Mulching influenced tree yields positively. The best effects were obtained in the combination with pine bark mulching. It could be related to the higher content of C-organic and some nutrients [3,6,11,12]. When herbicidal fallow was applied, apple trees started rotational fructification that disturbed regular yielding. The results obtained in this experiment showed that soil mulching in tree rows can be a simple treatment that improves soil fertility and eliminates rotational fructification of apple trees var. Elstar.

## CONCLUSIONS

1. The way soil in the inter-rows is maintained exerts a significant influence on the physico-chemical and chemical properties that differ in relation to their amount and the quality of the inflowing organic matter as well as intensity of

washing out components from the soil.

2. Soil mulching in orchards is a simple treatment that improves soil fertility and favours regular yields of apples var. Elstar.

3. In growing apples var. Elstar, it is favourable to mulch the soil with pine bark.

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