STUDY OF THE EFFECTIVENESS OF DIFFERENT GROUNDCOVER MATTER ON MACRONUTRIENT CONTENT OF LEAF IN APPLE ORCHARD IN EAST HUNGARY

KÜLÖNBÖZŐ TALAJTAKARÓ ANYAGOK HATÉKONYSÁGÁNAK VIZSGÁLATA ALMALEVÉL MAKROELEMTARTALMÁRA KELET-MAGYARORSZÁGI ALMAÜLTETVÉNYBEN

Péter T. NAGY[1], József RACSKÓ[2]*, Zoltán SZABÓ[2], József NYÉKI[2]

[1]University of Debrecen, Centre of Agricultural Sciences, Department of Agricultural Chemistry, H-4032 Debrecen, 138 Böszörményi Street, phone: (36) 52/508-444/88090; fax: (36) 52/413-385; e-mail:nagypt@agr.unideb.hu

[2]*University of Debrecen, Centre of Agricultural Sciences, Institute for Extension and Development, H-4032 Debrecen, 138 Böszörményi Street , phone: (36) 52/508-444/88355; fax: (36) 52/526-934; e-mail: racsko@agr.unideb.hu

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ABSTRACT

This study investigated the effects of different groundcover materials on soil and plant nutrition. Trees of apple cv. 'Idared'/MM.106 (Malus domestica Borkh.) were planted into lowland chernozem soil in the spring of 1999. Applied treatments can be divided into two groups: different livestock manures and mulches. Soil strips of 150 cm width were covered either with straw, different livestock manure, black plastic foil, pine bark mulch or were without cover i.e. clean cultivation as a check. Leaf and soil samples were collected for chemical analysis. It was found that all groundcover treatments induced an increase in leaf nitrogen, sulphur and calcium. Leaf magnesium was not affected so obviously by different groundcover treatments. Leaf potassium was not affected by applying different livestock manures, except horse manure but lower in mulch treatments compared to the control. Leaf phosphorous was decreased by treatments except using horse manure. Examination of ratios of nutrients showed that there were disharmonies in the available nutrients supply of soil. The best results were obtained by applying horse manure.

KEY WORDS: apple, groundcover, soil and leaf analysis, macronutrients, nutrient uptake

ÖSSZEFOGLALÓ

A tanulmány különböző talajtakarásra használt anyagok növénytáplálásra gyakorolt hatását vizsgálja. A réti csernozjom talajra, MM. 106-os alanyon, 1999-ben telepített almaültetvény fajtája Idared. Az alkalmazott kezelések két csoportra bonthatók: különböző istállótrágyák és talajtakaró anyagok. A talajt, a fasor mentén 150 cm szélességben borítottuk szalmával, különböző istállótrágyával, fekete fóliával, fenyő mulccsal és hagytuk fedetlenül kontrollként.

Levél- és talajmintákat vettünk kémiai analízis céljából. Azt tapasztaltuk, hogy az összes talajtakarásos kezelés növelte a levél nitrogén-, kén- és kalcium-tartalmát. A különböző talajtakarásos kezelések a levél magnézium-tartalmát nem befolyásolta ennyire nyilvánvalóan.

A levél kálium-tartalmát a lótrágya kivételével a többi istállótrágya nem növelte, az egyéb talajtakaró anyagok pedig csökkentették, a kontrollhoz képest.

A lótrágyát alkalmazó kezelés kivételével, a kezelések a levél foszfor-tartalmát csökkentették. A tápelemek hányadosai rámutattak a vizsgált ültetvény tápanyag-szolgáltató képességében mutatkozó diszharmóniákra. A legjobb eredményt a lótrágyás kezelés esetén kaptuk.

KULCSSZAVAK: alma, talajtakarás, talaj és levél analízis, makroelemek, tápanyagfelvétel

DETAILED ABSTRACT IN HUNGARIAN

A talajtakarás gyakorlata - jól ismert a kertészetben - talán olyan idős, mint a mezőgazdaság maga. A talajtakarást, előnyei miatt, általánosan használják ökológiai és integrált gyümölcsösökben szerte a világon. A talajtakaró anyagok nem csak az evaporációs folyamatok szabályozásában és a gyomirtásban játszanak szerepet, hanem számos, a talajban lejátszódó folyamatban. Előnyeik a gyomelnyomásban, az evaporáció és kimosódás csökkentése révén a talajnedvesség megőrzésében, az erózió csökkentésében, a vízbeszivárgás növelésében, a talaj-hőmérséklet fluktuációjának csökkentésében, az ásványi tápelemek felvehetőségének és a nitrifikációnak a növelésében, bomlásuk révén felszabaduló tápanyagok és szerves anyagok szolgáltatásában valamint a talajszerkezet megóvásában/javításában érhetők tetten. Továbbá a talajtakarásnak pozitív hatása van a növénytáplálási és biológiai faktorokra is. Egyrészt a talajtakarás a tápanyagok kioldódása révén növeli a talaj tápanyagtartalmát ugyanakkor a rendelkezésre álló tápanyag felvételi körülményeit ronthatja vagy javíthatja a talaj nedvesség- és hő-gazdálkodásának megváltoztatása révén. Másrészt növeli a gyökérsűrűséget és mennyiségét a feltalajban.

A cikk célja, hogy tanulmányozza különböző talajtakaró módszerek hatását levelek makrotápelem-tartalmára almaültetvényben.

INTRODUCTION

The practise of mulching, well known to horticulture, is perhaps as old as agriculture itself.

Mulching has used generally in organic and integrated fruit farming all over the world due to benefits of it [11]. Mulches are not only highly effective in checking evaporation and in preventing weed growth, but also have influence on several processes in the soil. The benefits are variously attributed to the suppression of weed growth, to the conservation of moisture by reducing evaporation and run off, to protection from erosion, to increased infiltration of water, to the increase or decrease of soil-temperature fluctuations, to the enhancement of mineral nutrient availability, to the enhancement of nitrification, to additional nutrients and organic matter derived from a decomposing mulch, or to the preservation or improvement of soil structure [4].

Moreover, mulching has a positive effect on nutritional and biological factors as well.

On the one hand mulching produces an increase in the nutrient content of the soil by leaching of nutrients from the mulch, but at the same time the entire condition of nutrient availability may be modified for better or worse by changes induced by the mulch in the moisture and temperature regimes of the soil. On the other hand applying mulches increases root length density and brought the roots closer to the surface [5].

The aim of present paper is to study the effect of different groundcover methods on macronutrient contents of leaf in apple orchard.

MATERIAL AND METHODS

The experiment was carried out at the orchard of TEDEJ Rt. at Hajdúnánás-Tedej, in Eastern Hungary. The orchard was set up on lowland chernozem soil in the Nyírség region. It was established in the autumn of 1999, using grafted on MM106 rootstocks at a spacing of 3.8 x 1.1 m Idared cultivar, which was planted in plots. Each plot consisted of 10 trees. The orchard has been treated according to the Integrated Fruit Production guidelines.

Orchard has irrigation system and applying if the weather conditions require but in 2005 the sampling site was not irrigated due to the sufficient rainfall. Soil samples were taken from three layers (0-20 cm; 20-40 cm and 40-60 cm) of each plot, at the middle of the section by using manual soil sampling equipment. Sampling was performed at the beginning of the vegetation period on April, in 2005, before applying groundcover matters. For the characterisation of the soil the most important soil parameters and nutrient status were determined.

Plant samples (leaf) were taken at the end of July, from all trees of each plot according to the Hungarian sampling guidelines [9].

The applied treatments of examined orchard part shows in Table 1. Applied treatments were divided into two groups according to origin and effect. On the one hand different livestock manures, on the other hand different mulch-matters were used.

The used different manures and mulches were applied to the surface to test the effectiveness of these materials. Layout of groundcover matter was the same all treatments. From the line of trees 0.75 m both deals all each plot. The covered area was 16.5 m^2.

Laboratory examination of soil samples

The soil samples were dried outdoors, in an airy place under air temperature in a 1-1.5 cm layer. Before grinding, samples were cleaned from plant remains and other possible dirt, and the soil was passed a 2 mm screen, homogenized and stored in plastic boxes in dry place until the examination. Besides the main characteristics of soil, the contents of macronutrients were measured by using two kinds of methods. For establishing the content of easily soluble nutrient forms of N, P and K 0.01 M $CaCl_2$

Table 1. Treatments in orchard
1. táblázat. Az ültetvényben alkalmazott kezelések

Treatment	Applied dosage (m^3/plot)
Control	-
Straw manure	2.475
Pine bark mulch	0.5
Cow manure	1.65
Horse manure	1.65
Pig manure	1.65
Black foil	0.5 mm thickness of a layer

extractant was used according to the method described by [1]. For studying the available P, and K content of soil the conventional extracting solution NH_4-lactate+acetic acid (so called AL extractant) was used according to the Hungarian standards [10]. The humus content of soil calculated from organic carbon content of soil, which determined by dry combustion method [6].

Laboratory examination of plant samples

Pretreatments of the plant samples involve drying, grinding and washing. The samples were washed to remove dust and possible remains of pesticide, than first dried outdoors in an airy place under air temperature than in a well-ventilated drying oven at 40 °C. Then the material was finely grounded and homogenized.

The dried and grounded samples should be stored in paper bags in a cool and dry place protected against direct sunlight.

The amount of Ca and Mg were determined by atom absorption spectrophotometry, P by colorimetry using phospomolybdovanadate method and K by atom emission spectrophotometry according to Hungarian standards [9].

For leaf analysis the amount of N and S of samples were determined with dry combustion method [6].

RESULTS AND DISCUSSION

Results of soil analysis

Besides conventional soil testing procedures (using AL extractant and determination of humus content) the 0.01 M $CaCl_2$ was used to give further information about the easily soluble and available nutrient forms of soil. Obtained results of soil analysis are represented in Table 2.

The pH of soil was near the neutral value. The physical category of soil was clay loam. According to results of AL solution the P- and K-supply of examined soil was in the "medium", while the N-supply was in the "sufficient" level of nutrient supply category*.

The values of measured 0.01 M $CaCl_2$ soluble N forms correspond to the type of examined soil. Presence of mineral nitrogen was mainly as nitrate-nitrogen form due to soil pH. The nitrate and ammonium content of soil was low and decreased according to depth while the soluble organic nitrogen content of soil was slightly different among examined layers. Notable that the amount of soluble organic nitrogen content of soil is commensurable with mineral N forms of soil [7]. The amount of 0.01 M $CaCl_2$ soluble phosphate fraction was low and was not change among layers. The value of 0.01 M $CaCl_2$ soluble K was significant and decreased according to depth. It is explained by the high dosage of applied organic manure (60 t/ha) before planting.

Results of leaf analysis

Optimum growth of apple trees is associated with N contents of leaf, approximately 2.1-2.3 percent according to Hungarian standards [8].

Our results pointed out that the N content of leaves was low in all treatments (Table 3).

The lowest N content was measured in the control and the black foil treatments, while the highest value was obtained applying cow manure. According to our results the N content of leaves was in the 'deficient' plant nutrient status in the control and applying black foil [8]. It was in the 'low' plant nutrient status in the rest treatments [8]. The observed slightly increase of N content of leaf can be explained by that the manures and mulches have relatively little nutrient value and the available nutrients from various organic fertilizers and mulches are very few for a single year and surface application.

The P content of leaf was the highest in the control treatment and applying horse manure. In the rest treatment it was lower 40-50% (Table 3). The P content of leaf was in the 'low' plant nutrient status in the control and

* the evaluation based on the MÉM NAK advisory system

'horse manure' treatments but in 'deficient' in the other treatments. Our results are contrast with earlier studies [2,3] demonstrated that the P level of leaf was not showed markedly increase applying different groundcover management.

In the case of applying mulches the measured K content of leaf was lower than control treatment (Table 3). It follows from that the livestock manures regarded as excellent K sources. According to our results the K content of leaf was in 'deficient' plant nutrient status in the face of all treatments [8].

Similarly P results, applying horse manure increased the K content of leaf with highest efficiency. It can be explained the higher P and K content of horse manure.

Regarding Ca content of leaves it can be established that all treatments increased the Ca content of leaf compared to the control (Table 3). This effect was statistically significant (P=5% level) except applying 'cow manure'. The highest increment was detected at 'horse manure' treatment. From results it can be established that the Ca content of leaf was in 'excess' plant nutrient status in all treatments [8]. It can be explained the type of soil, which contains significant available Ca for trees. Our results pointed out that significant increase (12-27%) can reach with use different groundcover matters.

It was found that the Mg content of leaves was significant higher in some treatments (pine bark mulch, horse and pig manure, black foil) compared to the control (Table 3). The Mg content of leaf was in 'high' plant nutrient status in these treatments. Moreover, it was found that the Mg

Table 2. Results of soil analysis
2. táblázat. A talajanalízis eredményei

	Depth			
Method	0-20	20-40	40-60	***0-60***
pH ($CaCl_2$)	7.43	7.36	7.54	***7.44***
H%	2.95	2.83	2.58	***2.79***
K_A				***45***
	mg/kg			
AL-P	164.11	89.12	42.7	***98.64***
AL-K	263.93	160.69	88.65	***171.09***
S[#] (total)	255	263	234	***250.67***
$CaCl_2$-K	60.34	37.71	21.93	***39.99***
$CaCl_2$-P	0.59	0.61	0.5	***0.57***
$CaCl_2$-NO_3-N	13.05	8.29	5.25	***8.86***
$CaCl_2$-NH_4-N	1.05	0.76	0.19	***0.67***
$CaCl_2$-Norg	3.29	4.32	2.64	***3.42***

[#]- determined by dry combustion method

Table 3. Results of leaf analysis
3. táblázat. A levélanalízis eredményei

	N	**P**	**K**	**Ca**	**Mg**	**S**
Treatments			**g/100g**			
Control	*1.63*	*0.14*	*0.68*	*2.16*	*0.34*	*0.23*
Straw manure	1.83	0.07	0.55	2.62	0.33	0.29
Pine bark mulch	1.76	0.08	0.55	2.61	0.44	0.32
Cow manure	1.95	0.06	0.68	2.18	0.33	0.46
Horse manure	1.74	0.14	0.82	2.74	0.40	0.32
Pig manure	1.82	0.08	0.68	2.58	0.39	0.33
Black foil	1.67	0.09	0.55	2.42	0.44	0.31
Mean	**1.77**	**0.10**	**0.64**	**2.47**	**0.38**	**0.32**
SD	**0.11**	**0.03**	**0.10**	**0.23**	**0.05**	**0.07**
LSD5%	**0.08**	**0.02**	**0.08**	**0.17**	**0.04**	**0.05**

Table 4. Ratios of different macronutrients
4. táblázat. Makro-tápelemek arányai

	N/K	N/Ca	K/Mg	K/Ca	Ca/Mg
Control	*2.39*	*0.75*	*2.00*	*0.32*	*6.33*
Straw manure	3.36	0.70	1.68	0.21	8.05
Pine mulch	3.23	0.67	1.25	0.21	5.97
Cow manure	2.86	0.90	2.06	0.31	6.59
Horse manure	2.13	0.63	2.03	0.30	6.79
Pig manure	2.67	0.71	1.75	0.26	6.61
Black foil	3.06	0.69	1.25	0.23	5.56
Mean	**2.81**	**0.72**	**1.72**	**0.26**	**6.56**
Optimal value	*~1.5*	*~1.5*	*~6.0*	*~1.0*	*~5.0*

content of leaf was not increased by applying straw and cow manure. In these treatments and the control the Mg of leaf was in 'sufficient' plant nutrient status [8].

The S content of leaves was in 'excess' plant nutrient status according to [12].

It can be established that all applied treatments increased the S content of apple leaf, especially treating with cow manure (Table 3). As can see in table 3, the S content of leaf was higher near 30% in most applied groundcover treatments, except cow manure treatment, where the S-content was twice as much than the control. The S content ranges between 0.29 and 0.46 in treated plots while it was 0.23 in the control.

Binary macronutrient ratios

Besides the absolute element content, the ratio of the different elements was also determined according to [8] because our assumption is that these ratios can provide a better indication of nutritional status than conventional sufficiency range approaches. It has been suggested that using these ratios minimize the effects of dilution or concentration due to dry matter and age factors and better evaluates possible nutritional interactions.

The most frequently used ratios (N/K, N/Ca, K/Mg, K/Ca and Ca/Mg) were calculated (Table 4). The ratio of N/K varied from 2.13 to 3.36 depending on the treatment (Table 4). The obtained mean (2.81) was high compared to the optimal value (1.5). Higher ratios were obtained in mulching treatments than in treatments used manures. Results can be explained the K supply of manures.

The obtained ratio of N/Ca varied from 0.67 to 0.90 also depending on the treatments. The mean value (0.72) was lower than the optimal value (1.5) due to the low N content.

The ratio of K/Mg varied between 1.25 and 2.06. The obtained mean (1.72) falls short of the optimal value (6.0) due to the above-mentioned low K content of leaf.

The ratio of K/Ca varied from 0.21 to 0.32. The mean value (0.26) was behind the optimal value (0.87) which was caused by the low K content.

The obtained N/K, K/Mg and K/Ca values can be explained by the deficiency of K.

The ratio of Ca/Mg varied between 5.56 and 8.05. According to the literature data, the optimal value is near to 5.0 [8]. Obtained average (6.56) can be explained by the above-mentioned tendencies.

Both absolute content of nutrients and their ratios pointed out that the nutrient supply of the examined soil was not optimal. There was a disharmony in the available nutrients supply of soil in spite of the sufficient nutrient capacity of soil. Furthermore, our results confirmed that the applied treatments can be divided into two groups.

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