ORIGINAL SCIENTIFIC PAPER

Study of the Effect of Different Groundcover Matter on the Leaf Macronutrient Content in an Integrated Apple Orchard in Eastern Hungary

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Abstract

Our paper investigated the effects of different groundcover materials on orchard nutrition. Trees of apple cv. '*Idared*'/MM.106 (*Malus domestica* Borkh.) were planted into lowland chernozem soil in the spring of 1999. 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. The P content of leaf was the highest in the control treatment both in 2005 and 2006. Leaf P increased in all treatments in 2006. Observed increase of leaf P at the control, pointed out the effect of year. In the case of applying mulch matters the measured K content of leaf was lower than the control treatment both examined years. Similarly P results it was found that the effect of year was strong in the orchard and sometimes conceals the effect of treatments. Both absolute content of nutrients and their ratios pointed out that the nutrient supply of the examined soil was not optimal. Applied treatments affected leaf macronutrient status strongly but this effect was inconsistent across treatments and hided by the effect of year.

Key words: apple, groundcover, soil and leaf analysis, macronutrients, nutrient uptake

Introduction

Although, the practise of mulching, well known to horticulture, and its importance is growing in the last few decades (Skroch and Shribbs, 1986), there are only little information about its application and its effects on orchard nutrition in Central Europe.

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

Several publications pointed out that mulching has a positive effect on the water and temperature regime of soil and it has nutritional and biological factors as well.

Nowadays the number of events of irregular weather has growing due to the global climatic change (Lakatos et al., 2005). It is very important that the productivity and the available nutrient supply of soil are improved among these climatic conditions.

Based on study of Merwin et al., (1994) and Merwin and Stiles (1994) it looks mulching is an effective tool to achieve mentioned goals mostly in organic production system where the useable nutritional tools are restricted and the consumer demands are high.

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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 between 2005 and 2006 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 both in 2005 and 2006, from all trees of each plot according to the Hungarian sampling guidelines.

The applied treatments of examined orchard part shows in Table 1.

Table 1. Treatments in orchard

Treatment	Code of treatments	Applied dosage (m^3/plot)
Control	C	-
Black foil	BF	0.5 mm thickness of a layer
Straw	S	2.475
Pine bark mulch	PBM	0.5
Cow manure	CM	1.65
Horse manure	HM	1.65
Pig manure	PM	1.65

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.

Pretreatment 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 $CaCl_2$ extractant was used according to the method described by Houba et al. (1986). 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. The humus content of soil calculated from organic carbon content of soil, which determined by dry combustion method (Nagy, 2000).

Pretreatment of plant samples

Pretreatment of the plant samples involve drying, grinding and washing. The samples were washed to remove dust and possible remains of pesticide, than firstly dried outdoors in an airy place under air temperature and then in a well-ventilated drying oven at 40 °C to avoid N losses. 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 P determine by colorimetry using phospomolybdovanadate method and K by atom emission spectrophotometry. For leaf analysis the amount of N of samples were determined with dry combustion method (Nagy, 2000).

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.

Table 2. Results of soil analysis (2005)

Method	Depth			
	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*				45.00
			mg/kg	
K ($CaCl_2$)	60.34	37.71	21.93	39.99
P ($CaCl_2$)	0.59	0.61	0.5	0.57
NO_3-N ($CaCl_2$)	13.05	8.29	5.25	8.86
NH_4-N ($CaCl_2$)	1.05	0.76	0.19	0.67
Norg ($CaCl_2$)	3.29	4.32	2.64	3.42

* - Plasticity index according to Arany (It was established in the 0-60 cm layer, only.)

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 of examined soil was in medium, while the soil N (based on the data of humus) was in the sufficient range.

However the amounts of 0.01 M $CaCl_2$ soluble N forms were low and occur mainly as nitrate. 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 (Nagy, 2004).

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 major and decreased according to depth. Significant soil N_{org} and K were explained by the high dosage of applied organic manure (60 t/ha) before planting.

Results of leaf analysis

The results of plant samplings are showed in Table 3.

Optimum growth of apple trees is associated with N contents of leaf, approximately 2.1-2.3 percent according to Hungarian standards (Papp, 1997). Our results pointed out that the N content of leaves was low in 2005 but the following year its amount was increased in all treatments (Table 3). All applied treatments increased leaf N significantly (P=5% level) both in 2005 and 2006 except BF treatment in 2005.

The lowest N content was measured in the control and the BF treatments both in 2005 and 2006. The higher values were obtained applying livestock manures.

According to our results the N content of leaves was deficient in the control and applying black foil and it was in the low in the rest treatments (Papp, 1997). The observed increase of leaf N can be explained by that the manures and mulches contain nutrients that increase available N content of soil. The markedly increase detected in 2006 may be explained the delayed effect of success of nutrients from various organic fertilizers and mulches. Slightly increase of leaf N observed at BF treatment compared to the control confirmed this conception (Table 3.).

The P content of leaf was the highest in the control treatment both in 2005 and 2006.

All treatments decreased leaf P significantly except applying horse manure in 2005. The P content of leaf was low in the control and HM treatment but in deficient range in the other treatments in 2005. Leaf P increased in all treatments in 2006. Observed increase at the control pointed out the effect of year. Our results are contrast with earlier studies Lakatos et al., (2001) and Lang et al., (2001) demonstrated that the P level of leaf was not showed markedly increase applying different groundcover management.

In the case of applying mulch matters (BF, S, PBM) the measured K content of leaf was lower than the control treatment both examined years (Table 3). It follows from that the livestock manures regarded as excellent K sources. According to our results the K content of leaf was deficient in the face of all treatments.

From obtained it was evident that cow and horse manure increased the K content of leaf with highest efficiency. Similarly P results it was found that the effect of year was strong in the orchard and sometimes conceals the effect of treatments.

Table 3. Results of leaf analysis (2005-2006)

	N		P		K	
			mg/kg of dry matter			
	2005	2006	2005	2006	2005	2006
Control	1.63	1.73	0.14	0.25	0.68	1.30
Black foil	1.67	1.88	0.09	0.22	0.55	1.02
Straw	1.83	2.04	0.07	0.14	0.55	1.11
Pine bark mulch	1.76	2.23	0.08	0.19	0.55	1.20
Cow manure	1.95	2.36	0.06	0.13	0.68	1.30
Horse manure	1.74	2.53	0.14	0.14	0.82	0.93
Pig manure	1.82	2.49	0.08	0.14	0.68	0.83
Mean	1.77	2.18	0.10	0.17	0.64	1.10
SD	0.11	0.31	0.03	0.05	0.10	0.18
$LSD_{5\%}$	0.08	0.23	0.02	0.03	0.08	0.13

Binary macronutrient ratios

Besides the absolute element content, the ratio of the different elements was also determined according to Papp (1997), 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/P and P/K) were calculated (Table 4). The ratio of N/K varied from 1.33 to 3.33 depending on the treatment and year (Table 4). The obtained means (2.80 and 2.06) were higher compared to the optimal value (1.5). Mostly higher ratios were obtained in year of application than the following year.

The obtained ratio of N/P varied between wide extremes, from 6.97 to 32.50 also depending on the treatments. The mean value was higher (2005), and lower (2006) than the optimal value (14.38). The major deviation between data of 2005 and 2006 is due to the significant increasing of leaf P in 2006. The ratio of P/K varied between 0.09 and 0.22. The obtained means (0.15 and 0.16) were near optimal value (0.12). Obtained means were near each other as well due to the increasing degree of leaf P and K was the same between 2005 and 2006.

Table 4. Ratios of different macronutrients (2005, 2006)

	N/K 2005	N/K 2006	N/P 2005	N/P 2006	P/K 2005	P/K 2006
Control	2.40	1.33	11.64	6.97	0.21	0.19
Black foil	3.04	1.85	18.56	8.36	0.16	0.22
Straw	3.33	1.84	26.14	14.10	0.13	0.13
Pine bark mulch	3.20	1.85	22.00	11.70	0.15	0.16
Cow manure	2.87	1.82	32.50	17.75	0.09	0.10
Horse manure	2.12	2.73	12.43	18.02	0.17	0.15
Pig manure	2.68	2.99	22.75	17.73	0.12	0.17
Mean	2.80	2.06	20.86	13.52	0.15	0.16
Optimal value	1.77	1.77	14.38	14.38	0.12	0.12

Both absolute content of nutrients and their ratios pointed out that the nutrient supply of the examined soil was not optimal. Applied treatments affected leaf macronutrient status strongly but this effect was inconsistent across treatments and hided by the effect of year.

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