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WINTER COVER CROPS AS NITROGEN SOURCES IN ORGANIC VINEYARD

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Abstract: *The objectives of this study were to assess the effect of cover crops grown as green manure on the dynamics of mineral nitrogen in the soil under organic vineyard. Field investigations were carried out on the experimental field of the Faculty of Agriculture in Novi Sad, which is located in Sremski Karlovci, Serbia. Winter cover crops were sowed in autumn 2009 and samples of soil, where mineral forms of nitrogen were present, were taken twice during the growing season in 2010 (spring and summer). Winter forage pea (Pisum sativum L.) and oilseed rape (Brassica napus L.), used as cover crops in an organic vineyard, showed the influence on the increase of mineral nitrogen in the soil. Plowing of the green mass of forage pea led to an intensive mineralization of organic matters which consequently caused positive balance of N. On the treatment with forage pea, content of mineral N at the end of the vegetation period was higher by 60 kg N ha^{-1} in comparison to the first measuring period (spring). The treatment with oilseed rape showed no significant differences in the measuring periods. With regard to the control treatment, this treatment did not have a negative balance of nitrogen but it was considerably lower in comparison to the forage peas and it was 5.93 kg N ha^{-1}. Oilseed rape, used as a cover crop, is suitable for storing reserves of soil mineral nitrogen in winter and spring, when there is minimal need for nitrogen in the vineyard. Thus, nitrogen losses can be prevented. Apart from uptaking nitrogen from the soil, forage peas also fixate considerable amount of nitrogen from the air and additionally enriches soil with nitrogen. Cover crops use in viticulture is suitable since their vegetation partly overlaps with vineyards vegetation, thus it does not represent a problem for vine plants in the aspect of uptaking nitrogen from the soil.*

Key words: *forage pea, oilseed rape, nitrogen, organic vineyard*

INTRODUCTION

The use of cover crops is one measure that has been taken in agricultural production in order to increase environmental protection and to encourage sustainable use of natural resources. Cover crops offer many benefits to sustainable agriculture (DABNEY et al., 2001). The integration of cover crops into cropping systems brings costs and benefits, both internal and external to the farm (SNAPP et al., 2005).

Areas covered by vineyards for organic grape production in the whole Europe region have increased in the last couple of years (HÄSELI, 2000; JONIS, 2000; JOLY, 2007). A key reason for such a growing interest in organic production lies in the rising consumers' demand for organic products and in the fact that organic agriculture contributes to the environmental protection, sustainable exploitation of natural resources and human health protection (OLJAČA, 2006).

Macroelements (especially nitrogen) in the soil represent a significant problem in the organic grape production (LIND et al., 2003; ROMBOURGH, 2002). Green manure is most often used in order for the content of nourishing elements in the soil to be increased, since the application of synthetic mineral manure in organic agriculture is limited. Green manuring encompasses annual plants which achieve maximum growth and provide large green mass such as legumes (pea, forage pea, vetch, horse beans, lupines and others) and other crops (rye, oat, oilseed rape , buckwheat and other) (KORAĆ, 2008).

When a cover crop is incorporated into the soil, a substantial amount of nitrogen is usually mineralized within a few weeks. Nitrogen continues to mineralize in ensuing weeks as the organic matter decomposes (SNAPP et al., 2005). Recently, emphasis has been placed on the uptake of soil mineral N which could otherwise be leached as NO_3 into deeper soil layers and ground water (Shipley et al., 1992; Logsdon et al., 2002), lost during nitrification as NO and N_2O, or denitrified as N_2 (JENKINSON 2001).

The aim of this paper was to investigate the increase in soil nitrogen influenced by winter forage pea and oilseed rape as cover crops in organic vineyard.

MATERIAL AND METHODS

Experimental field

All the investigations were conducted in the organic vineyard which is located in Sremski Karlovci, on the experimental field for viticulture of the Faculty of Agriculture in Novi Sad. In this experimental vineyard, oilseed rape (*Brassica napus* L) and forage pea (*Pisum sativum* L.) were sowed between the rows. Sowing was conducted on November 3, 2009, and plowing was conducted at the depth of 20 cm on May 25, 2010. Regularly tilled interrows (without crops) were used as the control plots. Soil samples for chemical analysis were taken twice a year: at the beginning of the vegetation period (March 15) and a month after the plowing of cover crops (June 25). Samples were taken at three different depths: 0-15 cm, 15-30 cm and 30-60 cm.

Weather conditions

The long term average annual air temperature of the area is 11.2° C, the average monthly minimum temperature is in January and it is -0.5° C, and the average monthly maximum is in July with 25.7° C. The average annual rainfall in the area is 624 mm. The average monthly temperatures and amount of precipitation during the experiment are presented in Figure 1.

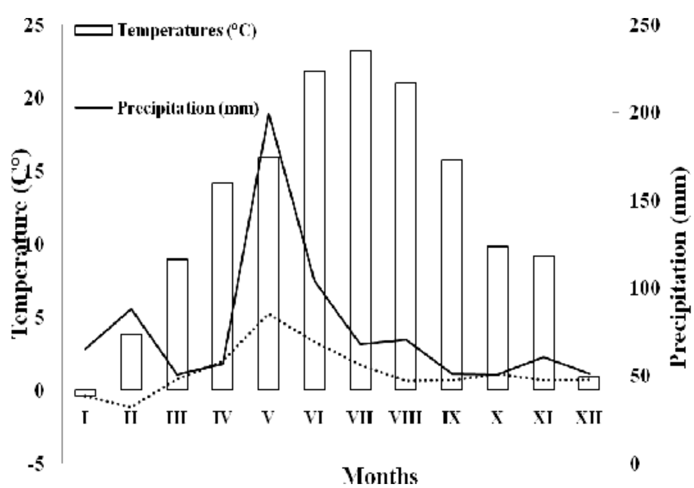

Figure 1. Total monthly precipitation and monthly air temperature for hydrological year 2010.

Measurements and analytical determination

Soil pH was determined in a suspension of soil and H_2O, by *METREL*, MA 3657 pH meter. $CaCO_3$ content was determined volumetrically, by a Scheibler calcimeter. The total N and C contents were determined by CHNS analyzer (ELEMENTAR, Vario EL, Elementar Analysensysteme GmbH, Hanau, Germany). Humus content was determined by oxidizing organic matter with potassium bichromate (SIMAKOV and TSYPLENKOV, 1969). Available P and K contents were determined using the AL method (ENGER et al., 1960). Mineral N in the soil was extracted with 2 M KCl (1:4, soil to solution ratio, weight basis) and determined by steam distillation (BREMNER, 1965). The basic chemical properties of the soil are listed in Table 1.

Table 1

Chemical properties of soil before experiment setting

Depth	pH		% $CaCO_3$	% humus	% N	mg P_2O_5 $100g^{-1}$	mg K_2O $100g^{-1}$
	H_2O	KCl					
0-30	7,6	7,0	4,59	3,12	0,16	21,9	22,1
30-60	7,8	7,0	5,42	2,96	0,15	14,3	21,0

The content of mineral N (Nmin) in the soil was measured twice in the course of the growing season, at the beginning of vegetation (spring) and a month after the plowing (summer). Nitrogen balance was calculated according to the formula (1):

$$N_I - N_{II} = N_B \quad (1)$$

where N_I is the content of mineral nitrogen in 0-60 cm deep soli layer at the beginning of vegetation; N_{II} is the content of mineral nitrogen in 0-60 cm deep soil layer a month after the plowing of cover crops, and N_B is nitrogen balance.

RESULTS AND DISCUSSIONS

Content of mineral nitrogen in the control treatment was significantly different between two measuring periods. After the plowing, considerably low level of nitrogen was measured in all three layers in comparison to the first measuring period (Figure 2), which showed the negative balance of nitrogen during the vine vegetation. When nitrogen was uptaken by the vine and moved and leached into deeper layers due to large amount of precipitation in that period (Figure 1), the content of mineral nitrogen on the control plots was lower in the second measuring period in comparison to the first one, and it was 117 kg N ha^{-1} (Figure 3).

On the forage pea plots, the content of mineral N in the surface layer was considerably higher in the second measuring period in comparison to the first one, while in the other layers there was no significant difference between two measuring periods (Figure 2). At the end of the vegetation period, total content of mineral N in all three layers was higher by 60 kg N ha^{-1} in comparison to the first measuring period. Plowing of the green mass of legume plants led to an intensive mineralization of organic matters which consequently caused positive balance of N in the treatment with forage peas (BOLDRINI et al., 2006), (MANOJLOVIĆ et al., 2007). Not only did this treatment reduce losses but it also caused soil to be considerably enriched with nitrogen by its fixation from the air.

The treatment with oilseed rape showed no significant differences in the measuring periods in any layers (Figure 2). With regard to the control treatment, this treatment did not have a negative balance of nitrogen but it was considerably lower in comparison to the forage peas and it was + 5.93 kg N ha^{-1} (Figure 3).

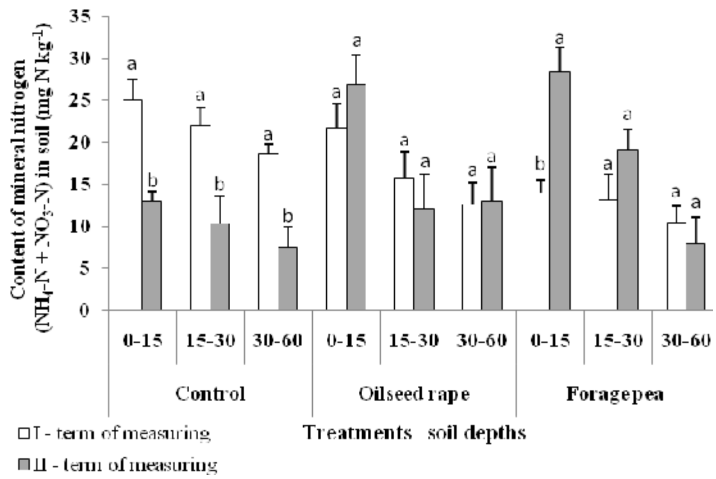

Figure 2. Content of mineral nitrogen in soil layer before and after the plowing of cover crops

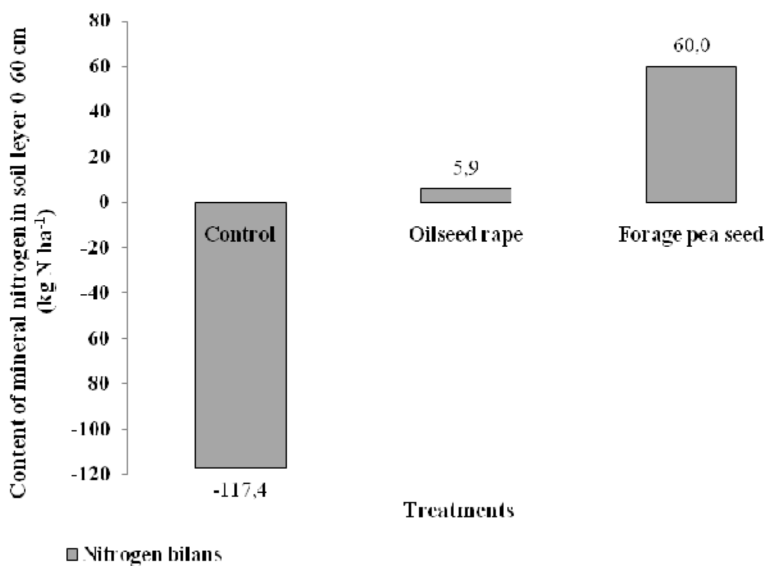

Figure 3. Soil mineral nitrogen balance

Lower content of nitrogen in soil in this treatment, unlike the treatment with forage peas, could be explained by the fact that green mass of oilseed rape had lower content of N and inadequate C/N ratio than forage peas (JUSTES et al., 1999). Therefore, it can be assumed that total amount of nitrogen was lower and mineralization was difficult to achieve after plowing in comparison to the forage peas. Also, unlike the forage peas, oilseed rape is not a legume plant and it cannot fixate nitrogen from the air. Therefore, oilseed rape could use mineral nitrogen only from the soil which produced the low content of nitrogen in the second measuring period in comparison to the treatment with forage peas.

CONCLUSIONS

According to the obtained results, it can be concluded that cover crops plowing had considerable influence on the content of soil mineral nitrogen. Winter cover crops, oilseed rape and forage peas are suitable for exploitation in viticulture since their vegetation partly overlaps with vine vegetation and they do not represent a problem for vine plants from the aspect of N uptake from the soil. Also, growing of winter cover crops reduces the losses of N, and vine plants are provided with additional amount of N from the mineralization process of cover crop green mass in the time when vineyard requirements for nitrogen are high.

Oilseed rape, used as a cover crop, is suitable for storing reserves of soil mineral nitrogen in winter and spring, when there is minimal need for nitrogen in the vineyard. Thus, nitrogen losses can be prevented. Apart from uptaking nitrogen from the soil, forage peas also fixate considerable amount of nitrogen from the air and additionally enriches soil with nitrogen.

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