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EFFECT OF THE FLOOR MAINTEMENT SYSTEMS ON THE CONTENT OF PHOSPHORUS IN THE SOIL AND CHERRY TREES

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Abstract. The study was carried out in an experimental sweet cherry plantation, established in the spring of 1991 at the Institute of Agriculture - Kyustendil, Bulgaria on Chromic Luvisols (*LVch*), heavy loamy soil. It was found that with the application of considerable amounts of phosphorous and potassium (1200 kg/ha P_2O_5 and 1000 kg/ha K_2O) with the pre-planting mineral fertilization was provided a moderate supply of the soil, up to the fourth year after planting. Afterwards soil phosphorous balance was with a negative value. With the green manuring after the rye-peas mixture growing, for the period of investigation 9.8-10.5 kg/m^2 fresh plant matter was incorporated in the soil, containing 0.84-0.88% P_2O_5. Significantly higher quantity plant matter – about 28.5 kg/m^2 was removed by the interrows crops and the phosphorous content was from 0.75 to 0.78% of the dry matter content. As a whole, average for the experimental period less supplied with phosphorous were the leaves of the cultivar Bing at the lower nitrogen (N_{100}) fertilizer norm. This was most strongly manifested in the permanent fallow.

Key words: sweet cherry, fallow, green manure, fertilization, intercrop

INTRODUCTION

The effective soil fertility is determined by the natural environmental conditions and the growing technology. In this respect, floor management systems and environmentally friendly fertilization methods are of significant importance for the successful sweet cherry growing, since they influence soil nutrient, water and temperature regime (Georgiev, 1984, 1992a, 1992b; Jadczuk et al., 1995; Neilson et al., 2005). The effect of their application, however, depends on a number of factors and the genetically determined characteristics of the rootstock or tree (Rozpara et al., 1990; Usenik et al., 2005; Ystaas, 1990).

The aim of this study is to determine the changes of the soil and leaf phosphorous content after good pre-planting site preparation under the conditions of different floor management systems and nitrogen fertilization norms on leached Chromic Luvisols in a typical sweet cherry production region of Bulgaria.

MATERIALS AND METHODS

The investigations were carried out in a sweet cherry orchard, established at the Institute of Agriculture – Kyustendil, Bulgaria in the spring of 1991. The soil is Chromic Luvisols (*LVch*), heavy loamy. On establishing of the field trial, the layer 0-75 cm was moderately supplied with humus and available potassium and poorly with alkaline hydrolysable nitrogen. Mobile phosphorus compounds were 2.1 mg/100 g soil in the layer 0-50 cm. The soil reaction was slightly to moderately acidic.

The field trial included the cultivars Bing and Van, grafted on seedling Mahaleb rootstocks. The distance of planting was 5.7 m between the rows and 4.5 m between trees in the row. The trees were shaped in the freely growing crown whit a height of the trunk about 40-50 cm. Fungicide and insecticide treatments were applied when necessary (Borovinova, 2005; Borovinova and Sredkov, 2003).

The experiment was established in six treatments, each of them in four replications with 5 experimental trees (20 trees in a treatment):

I. Fallow + N_{100} (standard);

II. Fallow + N_{200};

III. Fallow + green manuring + N_{100};

IV. Fallow + green manuring + N_{200};

V. Fallow + intercrops + N_{100};

VI. Fallow + intercrops + N_{200}.

On the background of pre-planting 1200 kg/ha P_2O_5 and 1000 kg/ha K_2O were applied. The fertilization treatments were applied beginning from 1992. The nitrogen (as ammonium nitrate) in norms of N_{100} and N_{200} was applied yearly, twice during the vegetation period – 2/3 in the early spring (the beginning of April) and 1/3 – in the autumn (November).

The floor management systems in the interrows with a width of 4.0-4.2 m were applied starting from 1993. The fallow was maintained yearly by one autumn cultivation (plough or disking), during the vegetation period – by superficial soil cultivations. For green manure and intercrops in treatment III-IV peas-rye mixture was used. The sowing was done in autumn (October), whereas the incorporation (in the treatments with green manure) or the mowing of the green mass – at the beginning of May next year. The intercrops were grown yearly, whereas the green manuring crops – every third year.

Samples of soil and leaves were collected yearly in August. The soil samples were collected from two depths in the interrows (0-25 and 25-50 cm), and analyzed for the determination of the available phosphorous content in the soil using the method described by Egner Ream and in leaf samples – photoelectrocolorimetrically, as molybdenum blue with a reductor - hydrazine sulphate (the samples were taken from the middle third of the shoots from all experimental trees in the four geographic directions). The samples of peas-rye mixture in treatment III-VI with green manure and intercrops were collected at the beginning of May – before the fallowing or the mowing of the green mass.

RESULTS AND DISCUSSION

Before the establishment of the experimental plantation the soil was very poorly supplied with P_2O_5 in the layer 0-50 cm, which was the subject of the present investigation. Its concentration was 2.1 mg/100 g soil. The application of considerable amount of phosphorous through the pre-planting fertilization ensured its moderate soil availability in the fourth year after the establishment. Afterwards soil phosphorous balance was negative (Table 1). In 1995, on harvesting the first fruits, its content decreased significantly in all treatments of the experiment. The available quantities were unevenly distributed throughout the soil profile over the years.

Comparing the three treatments of floor management, it was found that there were more mobile phosphates in the treatment with fallow. On the average for the experimental period their quantity in the soil layer 0-50 cm reached 3.6-4.2 mg/100 g.

Table 1

Content of P_2O_5 (mg/100 g soil)

Variants		1994	1995	1996	1997	1998	1999	2000	2001	2003	1994-2003	
											Average	%
		0-25 cm										
Fallow	N_{100}	7.6	5.9	5.5	5.7	4.3	4.3	8.9	4.7	4.0	5.66	100.0
	N_{200}	6.1	4.6	5.4	5.6	4.5	4.4	5.7	4.8	3.2	4.93	87.1
Green manuring	N_{100}	7.2	4.7	4.4	5.2	3.1	5.6	4.5	4.7	2.2	4.63	81.8
	N_{200}	8.1	4.1	5.0	5.3	3.3	7.4	3.7	4.4	5.6	5.22	92.2
Intercrops	N_{100}	6.6	5.7	3.5	4.2	4.1	5.3	3.8	3.3	4.7	4.58	80.9
	N_{200}	7.8	5.4	3.7	4.5	3.4	5.5	5.5	3.4	4.3	4.84	85.5
GD 5%		NS	1.4	1.5	1.2	NS	1.9	2.3	NS	1.5		
GD 1%							2.6	3.2				
GD 0.1%								4.4				
25-50 cm												
Fallow	N_{100}	3.9	2.9	2.9	2.9	2.2	1.6	5.1	1.2	2.0	2.75	100.0
	N_{200}	2.8	1.1	3.3	2.7	2.2	1.5	2.6	2.6	1.2	2.23	81.1
Green manuring	N_{100}	4.4	2.1	2.2	2.9	1.7	4.9	1.8	2.6	1.2	2.65	96.4
	N_{200}	5.1	2.2	2.1	2.8	2.0	5.0	1.4	2.8	2.4	2.87	104.4
Intercrops	N_{100}	3.1	1.6	2.4	2.8	2.5	3.9	2.0	2.3	2.5	2.57	93.5
	N_{200}	3.5	2.2	2.7	3.2	2.5	2.7	2.9	1.9	2.0	2.63	95.6
GD 5%		NS	NS	NS	NS	NS	2.9	2.3	NS	NS		
GD 1%								3.2				

Growing the rye-peas mixture as an interrows crop decreased the mobile phosphorous forms in the layer 0-25 cm, where was situated the major part of its root system. The decrease was more strongly manifested in the treatment with N_{100}, where, its average value for the period of investigation reached up to 81.8% of the standard, or expressed in absolute value - 1.03 mg/100 g. This reduction was statistically confirmed for three of the experimental years.

In the treatment with green manuring in the superficial soil layer such a trend was observed in the years, in which green manuring was not applied and nitrogen fertilization was done with the lower norm, but it is statistically significant only for two years. In depth, however, the soil remained poorly supplied with mobile phosphorous compounds.

Mobile phosphorous content changed due to the effect of the nitrogen fertilization norm. With its increase in the permanent fallow the quantity of the mobile phosphates decreased in the two soil layers. After the application of the higher nitrogen fertilizer norm under the conditions of green manuring was observed a reduction of this suppressive effect. Similar trend was found in the treatment with the interrows crop growing.

For the whole period of the experiment green manuring was applied 4 times – 1994, 1997, 2000 and 2003 (Table 2).

In the first two years the quantity of the incorporated in the soil green matter was considerably higher. In the first year it is around 3.32-3.50 kg/m^2, and in the second – 3.39-4.23 kg/m^2. For the 10-year period in the soil were incorporated 9.835-10.490 kg/m^2 fresh green matter, and the impact of the applied mineral fertilization was comparatively poor (about 6.7%) - 0.655 kg/m^2. More additional green matter was obtained after the fertilization with N_{200} in comparison with N_{100} (3.17%). The same was true for the quantity of the air dry plant matter.

With the yearly rye-peas mixture growing as an interrow crop, during the period 1994-2003 from the plantation were taken out 28.469-28.624 kg/m^2 fresh plant matter or average of 2.847-2.862 kg/m^2 per year. As seen, here the influence of the nitrogen fertilization was also insignificant.

Table 2

Characteristics of the rye-peas mixture

Variants		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	1994-2003	
												Total	%
Fresh green matter, kg/ m^2													
Green manuring	N_{100}	3.50			3.39			1.39			1.56	9.84	100.00
	N_{200}	3.32			4.23			1,39			1.55	10.49	106.66
Intercrops	N_{100}	3.53	3.40	3.12	3.88	2.36	2.63	1.15	3.44	3.94	1.17	28.62	100.00
	N_{200}	2.82	3.32	3.14	3.78	2.74	2.97	0.89	3.16	3.98	1.67	28.47	99.46
Dry matter content, kg/ m^2													
Green manuring	N_{100}	0.69			0.61			0.26			0.38	1.94	100.00
	N_{200}	0.59			0.82			0.22			0.43	2.06	106.30
Intercrops	N_{100}	0.68	0.73	0.58	0.80	0.56	0.63	0.17	0.61	0.65	0.29	5.70	100.00
	N_{200}	0.60	0.71	0.53	0.73	0.67	0.66	0.13	0.55	0.65	0.46	5.68	99.62

In the treatment with green manuring, with the rye-peas mixture growing in the soil was added plant matter containing 0.84-0.88% P_2O_5, (Table 3). Through the interrows crop each year from the plantation was removed green matter containing from 0.75 to 0.78% P_2O_5 of the dry matter content.

Table 3

Content of P_2O_5 (% to the absolute dry mater)

Variants		1994	1995	1996	1997	1998	1999	2001	2002	2003	1994-2003	
											Ave-rage	%
Green manuring	N_{100}	1.01			0.92					0.60	0.84	100.0
	N_{200}	1.09			0.91					0.64	0.88	104.7
Intercrops	N_{100}	0.96	0.83	0.96	0.75	0.62	0.48	0.83	0.53	0.53	0.75	100.0
	N_{200}	0.85	0.82	1.02	0.93	0.70	0.56	0.77	0.54	0.60	0.78	104.0

Until 1997 leaf phosphorous content was within the optimal range of concentrations (Table 4). In 1998 a trend was observed for its decrease in all variants for the cultivar Bing, and for the higher nitrogen fertilizer norm with the cultivar Van. This was probably due to the more intensive tree growth, and to a lesser extent - to “dilution” as a result of the fruit production (Tasseva, 2005, 2006).

In general, average for the period of investigation, the leaves of the cultivar Bing were less supplied with phosphorous at the lower nitrogen fertilizer norm. This was most strongly manifested in the permanent fallow – the reduction of phosphorous content started in 1996 and continued until 2003 inclusive.

The mentioned “dilution” of the nutrient is explained by some authors as a result from the known antagonistic interrelation between nitrogen and phosphorous.

Other investigators specify the influence of nitrogen fertilization, nutritional area, and the biologic features of rootstocks and cultivars (Neilson et al., 2005; Ystaas, 1990).

Table 4

Content of P_2O_5 in the cherry leaves (% to the absolute dry mater)

Variants		1994	1995	1996	1997	1998	1999	2000	2001	2003	1994-2003	
											Average	%
		Cv. Bing										
Fallow	N_{100}	0.40	0.38	0.34	0.35	0.32	0.36	0.32	0.32	0,37	0.35	100.00
	N_{200}	0.38	0.37	0.33	0.34	0.30	0.34	0.30	0.30	0,34	0.33	94.29
Green manuring	N_{100}	0.37	0.39	0.36	0.38	0.34	0.40	0.40	0.37	0,39	0.38	108.57
	N_{200}	0.35	0.37	0.35	0.34	0.31	0.27	0.31	0.32	0,34	0.33	94.29
Intercrops	N_{100}	0.34	0.37	0.39	0.37	0.32	0.32	0.39	0.32	0,44	0.36	102.86
	N_{200}	0.36	0.35	0.36	0.34	0.31	0.29	0.35	0.32	0,38	0.34	97.14
GD 5%		0.01	0.01	0.03	NS	NS	0.05	0.05	0.03	0.02		
GD 1%		0.02	0.02	0.04			0.07	0.07	0.04	0.03		
GD 0.1%		0.03	0.03	0.05						0.04		
Cv. Van												
Fallow	N_{100}	0.41	0.42	0.35	0.36	0.32	0.38	0.37	0.29	0.41	0.37	100.00
	N_{200}	0.42	0.41	0.33	0.36	0.33	0.36	0.33	0.27	0.40	0.36	97.30
Green manuring	N_{100}	0.39	0.42	0.35	0.38	0.36	0.32	0.40	0.35	0.52	0.39	105.41
	N_{200}	0.38	0.42	0.34	0.33	0.31	0.26	0.36	0.34	0.40	0.35	94.59
Intercrops	N_{100}	0.40	0.38	0.37	0.40	0.35	0.36	0.43	0.34	0.49	0.39	105.41
	N_{200}	0.37	0.38	0.36	0.34	0.31	0.40	0.40	0.34	0.47	0.37	100.00
GD 5%		0.02	0.02	0.01	0.02	0.02	0.04	0.01	0.02	0.05		
GD 1%		0.03	0.03	0.02	0.03	0.03	0.05	0.02	0.03	0.06		
GD 0.1%		0.04	0.04			0.04	0.07	0.03	0.04	0.09		

CONCLUSION

It was found that with the application of considerable amounts of phosphorous and potassium (1200 кg/ha P_2O_5 and 1000 kg/ha K_2O) with the pre-planting mineral fertilization was provided a moderate supply of the Chromic Luvisols (*LVch*), up to the fourth year after planting. Afterwards soil phosphorous balance was with a negative value.

With the green manuring after the rye-peas mixture growing, for the period of investigation in the soil was incorporated 9.8-10.5 kg/m^2 fresh plant matter, containing 0.84-0.88% P_2O_5. Significantly higher quantity plant matter – about 28.5 kg/m^2 was removed by the interrows crops and the phosphorous content was from 0.75 to 0.78% of the dry matter content.

As a whole, average for the experimental period less supplied with phosphorous were the leaves of the cultivar Bing at the lower nitrogen fertilizer norm. This was most strongly manifested in the permanent fallow.

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REZUMAT

EFECTUL SISTEMELOR DE INTREȚINERE A SOLULUI ASUPRA CONȚINUTULUI DE FOSFOR DIN SOL ŞI CIREŞI

Studiul s-a efectuat într-o plantație experimentală de cireş, înființată în primăvara anului 1991 la Institutul de Agricultură Kyustendil, Bulgaria, pe un luvisol cromic (Chromic Luvisols - *LVch*), destul de argilos. S-a descoperit că, odată cu aplicarea unor cantități considerabile de fosfor şi potasiu (1200 kg/ha P_2O_5 şi 1000 kg/ha K_2O) prin fertilizarea minerală pre-plantare, s-a furnizat solului o rezervă moderată, până la al patrulea an de la plantare. După aceea, balanța de fosfor a avut valori negative. După fertilizare cu îngrăşământ verde prin cultivarea unui amestec de secară-mazăre, pe perioada cercetării, 9,8-10,5 kg/m^2 de masă verde vegetală a fost încorporată în sol, conținând 0,84-0,88% P_2O_5. O cantitate de masă vegetală semnificativ mai mare – aproximativ 28,5 kg/m^2 a fost folosită de culturile ascunse; conținutul de fosfor a fost de 0,75 to 0,78% din conținutul de substanță uscată. În concluzie, ca o medie pentru perioada experimentală, frunzele cultivarului Bing au primit o cantitate mică de fosfor, la o normă mică de fertilizare cu azot (N_{100}), în condiții de desțelenire permanentă a solului.