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Nitrogen fertilizers and soil fertility

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Abstract: Soil fertility is of the most importance in organizing successful plant production and gaining high yield. Protection and preservation of soil fertility are of a high relevance in contemporary agriculture, since inadequate production technology and particularly the application of high doses of fertilizers very often leads to degradation processes and soil damage. The most common mistake is the overdose of nitrogen fertilizers. Therefore, in order to research the changes of basic agro-chemical traits of soil, the increased doses of nitrogen in carrot growing have been researched. The experimental part of the research was performed on sandy loam cambisol, with the following applications of nitrogen: 0, 60, 120 and 180 kgN/ha through KAN fertilizer. After carrot harvesting, the content of humus, phosphorus and potassium decreased, while the content of nitrate nitrogen was directly dependant of growing nitrogen doses. The lowest average content of NO_3-N was determined in control (24.7 mg/kg), and the highest by applying 180 kgN/ha (47.0 mg/kg).

Key words: soil, carrot, NPK fertilizers, fertilizer

Introduction

Carrot belongs to the group of the most important vegetable crops used in human diet, mostly fresh and proceeded. It is rich in vitamins and minerals, especially in carotene content – provitamin A (Pavlović and Jevđović 2002). For

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taproot development, which is being greatly enlarged during the growth, the carrot needs loose, light nutritious soil. Heavy, compact and too moisture soil is not suitable for carrot due to cracking and deformation of the root. Carrot is sensible to alkaline soil, so high yield depends on optimal, neutral to slightly increased acidity. This trait could be a limiting factor for carrot growing in mountainous area with the favourable climate but with acid soil. Nutrients in carrot production have to be in accessible form. During the vegetation period, nutrients adoption is not even. It is lower at the beginning of the vegetation and the most intensive after 60-120 days, depending of agro-ecological conditions. Potassium is of the most importance for the carrot, since it gives the intensive colour to taproot and increases, in this way, carrot's market value (Lazić *et al.*, 1998). However, in order to achieve high yield and quality of carrot, it is necessary to have a good ratio of nitrogen and potassium. If this ratio is unfavourable or if the nitrogen level is high, soil will have too much nitrate. Since carrot belongs to a group of nitrophilic vegetable, special attention should be given to application of nitrogen fertilizers, with special attention to kind, dosage and time of application, so the possibility of nitrate accumulation could be reduced to a minimum. General rule is that for carrot, the level of 60 ppm of nitrate nitrogen in soil is low, while 120 ppm is high (Robic 1984).

Having in mind the significance of the right choice of kinds and doses of the nitrate fertilizer and the level of nitrate nitrogen in soil, the aim of this research was to study the changes in soil caused application of higher doses of nitrogen, with the purpose to decrease the accumulation of unfavourable nitrates in carrot taproot.

Material and methods

The experiments for these researches have been set on a sandy loam cambisol, near Cacak, at 6 m^2. In both years of research (2005 and 2006) carrot has been grown on plowed soil, previously a perennial meadow. The meadow was plowed in autumn, when the samples of soil for the chemical analysis were taken (0-30 cm). In all variances of trail, including the control, in both years of research, 500 kg/ha NPK- fertilizer 7:20:30 has been applied.

Carrot sowing in both years of research has been performed in the middle April at 30x10cm. Materials for this study were two carrot genotypes: variety *Nantes* and hybrid *Almaro* F_1. Agro-technical measures during the vegetation process were standard, and the fertilization has been done by applying KAN, during the intensive growth at the end of June, in the following variants:

I - control Ø
II - 60 kg N/ha
III - 120 kg N/ha
IV - 180 kg N/ha

After harvesting, samples of soil were taken in order to study the changes of the main agro-chemical traits and nitrate nitrogen content. Humus content in the soil was determined by applying Kotzmann's method, pH value potentiometrically, content of easy accessible phosphorus and potassium by applying Egner-Riehm's AL method and the content of nitrate nitogen by Micro Kjeldahl method.

Testing of significant differences among the calculated middle values of the researched factors has been done by applying three way ANOVA. All significances have been determined by LSD-test for the significance threshold 5% and 1%.

The greatest impact to the change of content of fertilizers in the soil had rainfalls (Table 1). Results show that the aquatic sediment during the intensive germination and growth was low in 2006 (30 mm). Also, during the July in the same vegetation season, the rainfalls were low (44.6 mm) comparing to the same period in the previous year (100 mm of aquatic sediment).

Table 1. Temperatures and rainfalls during 2005 and 2006

Month	Medium monthly temperatures (°C)		Rainfall (mm)	
	2005.	2006.	2005.	2006.
January	1.4	- 4.3	33.5	32.0
February	- 0.8	1.2	70.0	40.0
March	5.7	6.0	43.0	116.0
April	12.0	14.0	80.5	61.0
May	17.2	18.2	72.5	30.0
June	21.0	21.7	83.5	88.3
July	23.7	24.7	100.0	44.6
August	20.3	21.3	65.5	190.0
September	18.2	18.9	91.2	43.0
October	11.8	14.4	23.5	28.5
November	5.2	7.7	82.5	17.3
December	2.9	3.2	41.0	66.0
Average/sum I - XII	11.6	12.3	787.0	757.0
IV - IX	18.7	19.8	493.0	457.0

Results and Discussion

Before the trial and the main fertilization, the chemical analysis of soil at the place of trial has been done. The results were presented in the Table 2.

Tab. 2. Agrochemical characteristics of the soil

Depth (0-30 cm)	pH		Humus	NO_3 (mg/kg)		P_2O_5	K_2O
	H_2O	MKCl	%	2005.	2006.	mg/100 g	
	6.31	5.22	2.91	24.5	29.5	2.90	19.10

Sandy loam cambisol had a slightly acidic soil reaction (pH/H_2O 6.31 and pH/KCl 5.22) and medium humus content. Medium humus content is the result of the fresh plowed natural vegetation and agglomeration of organic matter. This soil was very low on easily accessible phosphorus (2.90 mg/100 g of soil), while the content of easily accessible potassium (19.10 mg/100 g of soil) and nitrate nitrogen (24.5 and 29.5 mg/kg) was medium.

The data in Table 2 shows that the nitrate nitrogen content at the trial field for both years of research was lower than the lowest content for the carrot production recommended by Robic (1984). For this reason and for economically justified carrot production, the application of nitrate fertilizers can be justified. This was proved in the studies dealing with the tendency of growth of all the researched parameters with the usage of the growing nitrogen doses (Bošković-Rakočević *et al*., 2008, 2009).

Data in the Table 3 shows that all the variants increased the level of acidity of soil, comparing to the values before the setting of the trial (pH/H_2O 6.31 and pH/KCl 5.22). The same tendency has been determined for the humus level, which proves that the humus level was decreased mostly due to plowing of fallow land (meadow), as well as the further cultivation of soil. Besides that, low humus content in the loam type of soil can be caused by application of NPK fertilizers. The researches of the impact of the mineral fertilizers on humus content are different. The results of the perennial researches proved that the application of strictly mineral fertilizers does not lead to significant changes in humus content, with the exception of cambisol and loam where the application of mineral fertilizers slightly decreased the level of humus (Džamić and Stevanović 2000).

The content of easily accessible phosphorus after growing carrot stayed low as it was before the trial (Table 3). The phosphorus value varied from 1.7 mg/100g of soil (by applying 120 kg N/ha) to 4.6 mg/100g of soil (in control) growing variety *Nantes*. Variants with hybrid the content of easily accessible phosphorus varied from 1.7 mg/100g of soil (applying 120kg N/ha) to 2.9 mg/100 g of soil (applying 180 kg N/ha).

Table 3. Chemical analysis of the soil after the trial

Genotype	Variance	pH		Humus (%)	P_2O_5	K_2O
		H_2O	KCl		mg/100 g	
Nantes	Ø	6.27	5.13	2.76	4.60	15.80
	60 kg N/ha	5.90	4.81	2.62	1.80	12.10
	120 kg N/ha	5.78	4.72	2.52	1.70	12.50
	180 kg N/ha	5.90	4.76	2.53	2.30	10.90
	Average	5.96	4.86	2.61	2.60	12.80
Almaro F_1	Ø	5.95	4.85	2.46	2.70	11.70
	60 kg N/ha	5.78	4.69	2.38	2.40	10.20
	120 kg N/ha	6.11	4.80	2.36	1.70	10.20
	180 kg N/ha	6.05	4.80	2.65	2.90	14.50
	Average	5.97	4.79	2.46	2.40	11.70

The level of easily accessible potassium in all variants of the trial was medium. For variety *Nantes*, easily accessible potassium varied from 10.9 mg/100 g of soil (by applying 180 kg N/ha) to 15.8 mg/100g of soil (control). Hybrid *Almaro* F_1 had the highest level of easily accessible potassium in variant with 180kg N/ha (14.5 mg/100 g of soil), and the lowest with 60 kg N/ha and 120 kg N/ha (10.2 mg/100 g of soil). The results show that in all variants the level of available potassium decreased. This was expected since the carrot needs large amounts of potassium of high yield.

The level of nitrate in the soil depends, mostly, upon the usage of nitrogen fertilizers and plant nitrate adoption. Growing carrot in the light soil with low content of organic matter can decrease the nitrate level in the taproot (Geyer 1978). The changes of content of nitrate nitrogen after the trial are shown in the Table 4.

Results of analysis of nitrate nitrogen content in the soil proved that the increase of the doses of nitrate fertilizers in all variants of the trial in both years of research caused the increase of its content in the soil. In the variants of trail with variety *Nantes*, the average increase of nitrogen nitrate content depended on applied nitrate quantities from 22.6 to 79.7%, while for hybrid *Almaro* F_1 the increase was from 22.3 to 90.3%, comparing to control

Table 4. The level of nitrate nitrogen in the soil (mg/kg)

Variance	Variety/hybrid							
	Nantes				Almaro F_1			
	2005.	2006.	Average	Index	2005.	2006.	Average	Index
Control Ø	25.3	26.8	26.1	100	26.0	23.4	24.7	100
60 kg N/ha	29.8	34.2	32.0	122.6	32.2	28.1	30.2	122.3
120 kg N/ha	42.6	46.9	44.8	171.6	41.5	43.5	42.5	172.1
180 kg N/ha	48.1	45.6	46.9	179.7	46.3	47.6	47.0	190.3
Average	36.5	38.4	37.5		36.5	35.7	36.1	

Both hybrids and varieties had the uniformed increase of nitrate nitrogen in the soil when higher doses of nitrogen were applied. The differences in nitrate nitrogen content in the researched years were not significant, as well as among the researched genotypes.

Conclusions

The results of this study proved:

The researched soil, before the trial set up, was slightly acid. Regarding the content of plant fertilizers, soil had the medium content of humus, low content of easily accessible phosphorus, while the level of easily accessible potassium and nitrate nitrogen was medium.

After the experiment, most of the researched variances had the low level of humus, easily accessible phosphorus and potassium, while the level of nitrate nitrogen was increased in all variants, but stayed at the level of medium supply.

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UTICAJ ĐUBRENJA AZOTOM NA OČUVANJE PLODNOSTI ZEMLJIŠTA

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Rezime

Plodnost zemljišta predstavlja jedan od najvažnijih faktora za uspešnu biljnu proizvodnju i postizanje visokih prinosa. Zaštita i očuvanje plodnosti zemljišta predstavlja najvažniji zadatak i aktuelan problem poljoprivredne struke, jer neadekvatnom tehnologijom proizvodnje, a posebno primenom visokih doza đubriva veoma često dolazi do degradacionih procesa i oštećenja zemljišta. Najčešće greške se javljaju prekomernim korišćenjem azotnih đubriva, pa je u cilju ispitivanja promena osnovnih agrohemijskih osobina zemljišta ispitivan uticaj rastućih doza azota pri gajenju mrkve. Eksperimentalni deo istraživanja izveden je na zemljištu tipa smonica u ogajnjačavanju, sa primenom doza azota: 0, 60, 120 i 180 kgN/ha kroz prihranjiavnje sa KAN-om. Nakon vađenja mrkve, sadržaj humusa, pristupačnog fosfora i kalijuma se smanjio, dok je sadržaj nitratnog azota pokazao direktnu zavisnost od rastućih doza azota. Najmanji prosečni sadržaj NO_3-N je utvrđen na kontrolnoj varijanti (24.7 mg/kg), a najveći primenom 180 kgN/ha (47.0 mg/kg), što je u okviru dozvoljenih vrednosti.

Ključne reči: zemljište, mrkva, NPK hraniva, đubrivo