Original scientific paper
10.7251/AGSY1404181B

EFFECTS OF FERTILIZATION AND MULCHING ON YIELD OF EARLY CABBAGE

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Abstract

Two field experiments were organized at the experiment field of Agricultural Extension Service in Sombor in 2012 and 2013. Their purpose was to monitor the effects of different fertilization and mulching methods on the yield of early cabbage.
A two-factorial experiment was established to assess the effects of different fertilization methods (only organic fertilizers, organic and inorganic fertilizers combined, and only mineral fertilizers - factor A) and mulching (with and without black foil - factor B) on the dynamics of NO_3-N in the soil and the impact of the factors on the yield of early cabbage.
The results of the two-years research showed that the fertilization with ripe cattle manure and composted pig manure + mineral fertilizers, with and without foil, had higher amounts of NO_3-N that the other fertilization methods. The amounts of NO_3-N in the soil measured at the stage of complete leaf rosette were positively correlated with the yield of cabbage in all fertilization treatments except the treatment with ripe cattle manure in the experiment without foil. The highest yield of early cabbage in the experiment with foil was achieved in the fertilization variant with composted pig manure + mineral fertilizers. This variant also had the highest amount of NO_3-N in the soil, indicating a dependence of crop yield on the dynamics of nitrates in the soil.

Key words *: fertilization, mulching, cabbage, yield, NO_3-N*

Introduction

Vegetable crops form high yields in the course of a short growing season. This is why they have high requirements for nutrients, especially nitrogen which ensures high yields.
To be able to achieve high and stable yields of quality produce in a short growing season, vegetable crops need both mineral and organic fertilizers. Mineral fertilizers are rapidly acting sources of nutrients for plants. The application of organic fertilizers not only supplies the plants with necessary elements but also plays an important part in the process of enhancing soil fertility by improving its structure and hydro-physical properties, increasing organic matter concentration, and reducing the application of synthetic fertilizers (Grandy et al., 2002). Unlike mineral fertilizers, organic fertilizers have a long-lasting impact on chemical properties of the soil and consequently on the yield of crops grown, which is evident for several years after application (Gutser et al., 2005). Organic fertilizers contain most of the nutrients in the organic form, which become available to plants only after they turn into the mineral form following mineralization. Therefore, it is necessary to assess the mineralization capacity of organic matter from organic fertilizers by monitoring the dynamics of nitrates. Only then shall we be able to select fertilizers of appropriate composition and to time their incorporation into the soil, all aimed at harmonizing the release of nutrients with crop requirements (Bogdanović et al., 1995; Čabilovski, 2009).
The dynamics of soil nitrates is determined by many factors, among which soil temperature and moisture are most important. Soil moisture directly affects the process of mineralization

and therefore the content of mineral nitrogen in the soil. Temperature directly affects the decomposition of organic matter, with microorganisms involved in this process having different temperature ranges. Field production of vegetables unfolds during the period when the soil temperature increases continuously (10-15-25-30°C) and so, as intensive vegetable production is not possible without irrigation, conditions are created for mineralization of the applied organic fertilizers and organic matter in the soil.

The rate of mineralization of organic fertilizers depends on fertilizer type, degree of organic matter decomposition, soil temperature, moisture, and microbial activity (Pansu and Truries, 2003; Bogdanović et al., 2012). Excessive application of organic fertilizers, due to intense mineralization, may lead to a high accumulation of NO_3-N in the soil, its harmful level in plants and environmental pollution (Pang and Letey, 2000).

The objective of this study was to investigate the effect of different fertilization treatments on the soil under foil and without foil planted to early cabbage, the dynamics of NO_3-N in the soil, and the effect of the previous factors on the yield of cabbage.

Material and Methods

Dynamics of NO_3-N in the soil under early cabbage was monitored in a field experiment set in the split plot design with and without mulching foil. The experiment was factorial, with fertilization treatments as factor A and soil mulching, with and without foil, as factor B (Tab. 1).

Table 1. Fertilization treatments for early cabbage grown in the soil with and without mulching foil

	Experiment A	**Experiment B**
No.	**With plastic foil Fertilization treatment**	**Without plastic foil Fertilization treatment**
1.	Control - no fertilizer	Control - no fertilizer
2.	MCM 20t ha-^{1}	MCM 20t ha-^{1}
3.	CPM 20t ha-^{1}	CPM 20t ha-^{1}
4.	MCM 20t ha-^{1}+MF 11:11:21 (300kg ha-^{1})	MCM 20t ha-^{1}+MF 11:11:21 (300kg ha-^{1})
5.	CPM 20t ha-^{1} +MF 11:11:21 (300kg ha-^{1})	CPM 20t ha-^{1} +MF 11:11:21 (300kg ha-^{1})
6.	MCP 20t ha-^{1} + MF 11:11:21 (500kg ha-^{1})	MCP 20t ha-^{1} + MF 11:11:21 (500kg ha-^{1})
7.	CPM 20t ha-^{1}+ MF 11:11:21 (500kg ha-^{1})	CPM 20t ha-^{1}+ MF 11:11:21 (500kg ha-^{1})
8.	MF 11:11:21 (300kg ha-^{1})	MF 11:11:21 (300kg ha-^{1})
9.	MF 11:11:21 (500kg ha-^{1})	MF 11:11:21 (500kg ha-^{1})

Legend: Mature cattle manure (MCM); Composted pig manure (CPM); Mineral fertilizers (MF)

Tab. 2 shows the initial agrochemical status of the soil in the experiment plots, before cabbage planting. The soil in the experiments was hydromorphic, semigley type (black meadow soils), with alkaline reaction, extremely calcareous, medium to poor in humus for vegetable production, medium provided with total and mineral nitrogen, medium to poor in readily available phosphorus and medium provided with readily available potassium.

The analysis of soil fertility was done by conventional methods. Samples for NO_3-N determination in the soil layers 0-30 and 30-60 cm were taken before the placement of

transplants, at the stage of full formation of the rosette, and at cabbage harvest. Determinations were done by the Nmin. method of Wehrmann and Scharpf (1979).

Table 2. Agrochemical properties of soil before cabbage planting

Year	Depth cm	pH		% $CaCO_3$	% humus	% N	mg $100g^{-1}$		mg NO_3-N kg	
		H_2O	KCl				P_2O_5	K_2O	Before planting	After planting
2012	0-30	7.96	7.45	7,16	3.19	0.16	21.3	16,8	32,5	27.0
	30-60	8.26	7.47	15.59	2.25	0.11	3.3	13.7	64.6	38.0
2013	0-30	8.55	7.62	7.40	1.94	0.10	19.6	19.7	23.1	30.0
	30-60	8.78	7.87	17.98	1.80	0.09	5.1	12.1	23.9	23.0

Chemical composition of the applied organic fertilizers is shown in Tables 3 and 4. Amounts needed for fertilization of early cabbage were calculated on the basis of the nitrogen content in organic fertilizers (Table 1).
The obtained results were analyzed by the analysis of variance for two-factorial experiment.

Table 3. Chemical composition of the organic fertilizers used in the experiment

Organic fertilizer	**% N**		**% P_2O_5**		**% K_2O**	
	2012	**2013**	**2012**	**2013**	**2013**	**2013**
Composted pig manure (CPM)	1.30	3.07	3.58	4.90	1.68	1.32
Mature cattle manure (MCM)	1.20	2.20	1.82	3.17	0.33	0.91

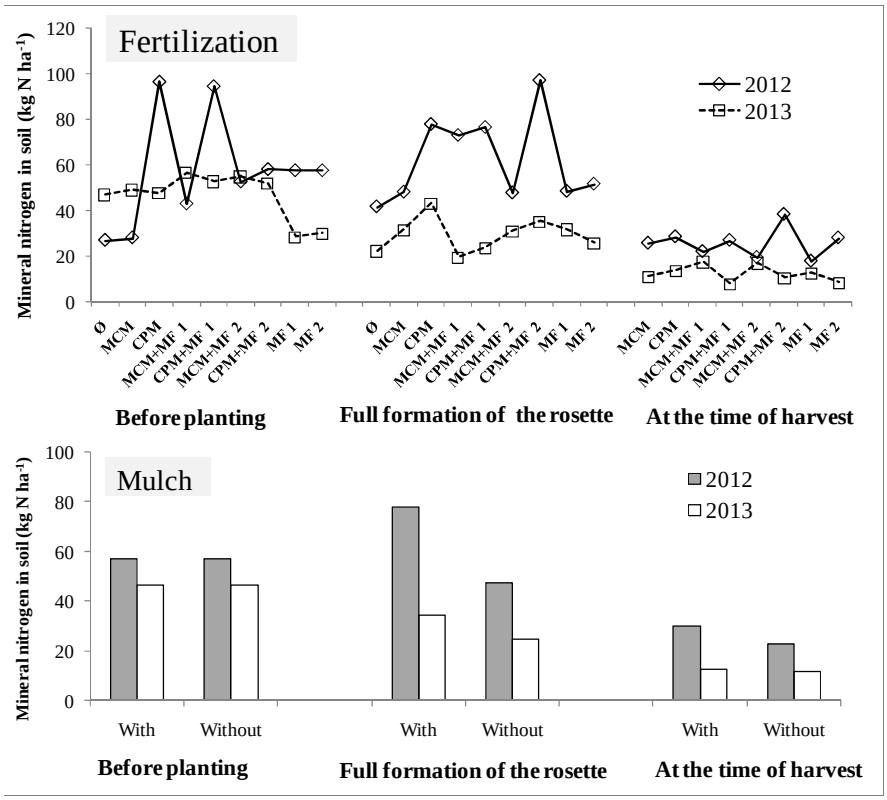
Table 4. Concentration of micronutrients and heavy metals in the organic fertilizers (mg kg^{-1})

Fertilizer	**Mn**	**Fe**	**Zn**	**Cu**	**Cd**	**Ni**	**Pb**
Composted pig manure (CPM)	177	1087	35.8	5.54	1.56	78.86	7.12
Mature cattle manure (MCM)	123	792	170.1	31.69	1.52	88.62	3.63

Results and Discussion

Graph 1 show the dynamics of NO_3-N in the soil in the experiments conducted in 2012 and 2013, respectively. The dynamics was found to vary depending on the applied fertilization treatments. In both years of the experiment, higher amounts of NO_3-N were found, for all sampling dates and all fertilization treatments, in the variants with mulching foil than in the variants without it.
Significantly higher amounts of NO_3-N were found in the soil under foil than in the soil without foil, obviously because the former variant provided better conditions for mineralization of organic fertilizers. In the two years of the experiment, the variant with mulching foil provided higher soil temperatures, by 2-3°C, and higher soil moisture, by 1.5%-2.7%, than the variant without foil. The variations of the previous figures were due to the time of sampling.

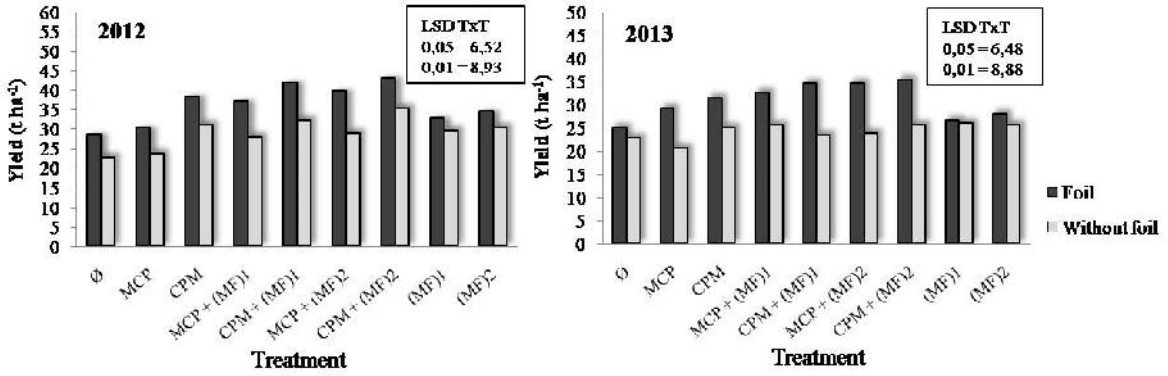
The values of NO_3-N in the soil under cabbage obtained at the different sampling dates indicate that the mineralization of N from organic fertilizers was more intensive in the first part of the growing season, when the cabbage grew vigorously, than in the second part of the season, at the end of cabbage harvest when lowest values were registered.
The values of NO_3-N in the soil under cabbage obtained at the different sampling dates show the balance between the rate of mineralization of the applied organic fertilizers and soil organic matter on one side and the rate of immobilization of mineral nitrogen by the early cabbage crop and soil microorganisms on the other (Bogdanović and Čabilovski, 2007; Bogdanović and Ubavić, 2008; Čabilovski et al., 2010).



Legend: Mature cattle manure (MCM); Composted pig manure (CPM); Mineral fertilizers (MF)

Graph 1. Dynamics of NO_3-N in the soil under cabbage grown with and without foil depending on the fertilization treatments conducted in 2012 and 2013

The dynamics of NO_3-N in the soil under cabbage was in correlation with cabbage yields in both years. In all fertilization treatments, the yields of cabbage were significantly higher in the variant with mulching foil than in the variant without foil (Graphs 2). The higher yields of cabbage in the variant under foil were directly associated with the amounts of NO_3-N in the soil, as a consequence of better conditions for mineralization of organic fertilizers (soil moisture, temperature, and microbial activity) during cabbage growing season.
Highest yields of early cabbage were achieved in the treatments with composted pig manure and the higher and lower doses of mineral fertilizers, followed by mature cattle manure and the higher and lower doses of mineral fertilizer. Lowest yields were obtained with mineral fertilizers, higher with the higher dose, lower with the lower dose (Graphs 2).



Legend: Mature cattle manure (MCM); Composted pig manure (CPM); Mineral fertilizers (MF)

Graph 2. Yield of early cabbage depending on fertilization treatment and mulching in 2012 and 2013

The higher cabbage yields in the treatment with composted pig manure than in the treatments with mature cattle manure and mineral fertilizers can be explained by the high solubility and mobility of biogenous elements, primarily nitrogen, in the first treatment compared with the other two treatments. According to Denić (2010), who studied corn, and Bogdanović et al. (1995), who studied wheat, the effect of NO_3-N from liquid pig manure, in the year of application, was identical to the effect of the applied mineral fertilizers.

Conclusion

Following conclusions were drawn on the basis of monitoring the impact of different fertilization treatments and mulching of the soil under early cabbage on the dynamics of NO_3-N in the soil and yield of cabbage.

- Mineralization of NO_3-N from organic fertilizers was more intensive in the first part of the growing season, when cabbage growth was intense, and significantly lower in the last part of the growing season.
- In 2012, the largest amount of NO_3-N in the soil under cabbage was found in the variant with mulching foil, the treatment with composted pig manure and the higher fertilizer dose, at all sampling dates. In 2013, the largest amount of NO_3-N was found again in the variant with mulching foil and the treatment with mature cattle manure, but only at the stage of fully formed leaf rosette.
- In both years, at all sampling dates and in all fertilization treatments, larger amounts of NO_3-N were found in the variant with than in the variant without mulching foil.
- In both years, the yield of cabbage was significantly higher in the unfertilized variant with mulching foil than in the variant without foil.
- In all fertilization treatments, yields of cabbage were significantly higher in the variant with mulching foil than in the variant without foil.

Regarding the effect of the applied fertilizers on the yield of cabbage grown with and without mulching foil, highest effect was achieved with the combination of composted pig manure and mineral fertilizers, then by mature cattle manure and mineral fertilizers. The lowest effect was achieved when only mineral fertilizers were applied.

Acknowledgement

This paper was written as part of a project TR-031036 funded by the Ministry of Education and Science of the Republic of Serbia

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