Relationship Between the Biological Activity of the Soil, the Increment Dynamics of Crop Biomass and the N Content of the Soil

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It is known from the literature that manure has a distinct effect on soil fertility, whereas its effect on plants is less clear. According to HURICH and SKLODOWSKI /1961-1962/ and GASSER /1962/, for several weeks after application, mineral nitrogen fertilization in spring ensures a higher level of nitrates in the soil than annual fertilization with farmyard manure. During the remainder of the growing season, more nitrates were found in soils fertilized with farmyard manure. Investigations by GAWRONSKA /1971/ on the yielding level of crops have proved that the soil NO_3-N content at the start of plant growth in spring is responsible for the magnitude of the yields.

The aim of the present work was to estimate the biological activity of the soil by measuring the NO_3-N content before and after incubation and the amount of CO_2 emitted and to check the relationship between the amount of NO_3-N released and the biological yield increment of potatoes.

Materials and methods

The investigations were carried out within the framework of a permanent fertilizing experiment established in 1955 on a black earth type soil with a texture of loamy sand turning into light loam. In the random block experiment with four replications the following fertilizer treatments were applied: 1. NPK; 2. farmyard manure; 3. 1/2 NPK + 1/2 farmyard manure; 4. control /non-fertilized/. /Fertilization in treatments 1-3 was applied every year/.

Potatoes were cultivated in a three-field crop rotation. The biological yield, its total N content and the soil NO_3-N content were determined four times in 1987: on June 24 - 6 weeks /42 days/ after emergence, on July 14 - at the beginning of flowering, on August 5 - at the end of flowering; and on September 15, shortly before harvest.

For this purpose, the dry matter of the above-ground parts and tubers taken from 10 potato bushes per plot was determined, and soil samples were taken for the laboratory analyses.

Soil NO_3-N content was determined colorimetrically in water extracts prepared from fresh soil and from soil after a 14-day incubation. The nitrifying capacity was estimated on the basis of the difference between these two values and the biological activity on the basis of the amount of CO_2 emitted during incubation.

Results and discussion

The results presented in Table 1 show that significant differences occurred at all dates in the NO_3-N content in the ploughed layer of the soil

Table 1

Dynamics of NO_3 content and CO_2 content in soil and nitrification potential during the growing season of potatoes /1987/

Soil horizon, depth /cm/	Treatments	Date of determination			
		23 June	14 July	6 Aug.	15 Sept.
		NO_3 content in soil, mg/100 g soil			
A. /0-25 cm/	NPK	7.33	3.34	1.96	4.47
	Manure	6.27	4.21	2.93	4.21
	1/2 Manure + 1/2 NPK	6.96	3.48	2.35	3.89
	Non-fertilized	3.46	2.43	1.48	2.25
	$LSD_{0.05}$	1.02	0.87	1.09	1.79
B. /25-50 cm/	NPK	4.34	3.24	1.18	2.40
	Manure	4.04	3.52	1.20	2.73
	1/2 Manure + 1/2 NPK	5.37	2.07	1.09	2.89
	Non-fertilized	2.51	2.02	0.95	1.92
	$LSD_{0.05}$	1.41	ni	ni	ni
	NO_3 content in soil after a 14-day incubation, mg/100 g soil				
A. /0-25 cm/	NPK	14.02	11.27	9.43	14.31
	Manure	16.73	13.15	15.06	16.11
	1/2 Manure + 1/2 NPK	14.31	13.92	12.87	14.82
	Non-fertilized	8.11	8.15	6.92	7.55
	$LSD_{0.05}$	5.56	ni	6.23	6.03
B. /25-50 cm/	NPK	5.81	4.79	2.41	7.30
	Manure	6.31	7.87	2.47	7.54
	1/2 Manure + 1/2 NPK	7.49	3.85	3.13	7.85
	Non-fertilized	3.59	4.20	2.62	5.39
	$LSD_{0.05}$	1.11	2.02	ni	ni
	CO_2 content in soil, mg/100 g soil				
A. /0-25 cm/	NPK	20.53	26.00	22.00	27.54
	Manure	26.40	30.50	30.10	32.01
	1/2 Manure + 1/2 NPK	20.40	28.30	28.10	31.64
	Non-fertilized	18.10	22.60	20.50	26.99
	$LSD_{0.05}$	ni	ni	ni	ni
B. /25-50 cm/	NPK	17.90	18.50	16.30	24.10
	Manure	22.08	23.40	18.40	26.24
	1/2 Manure + 1/2 NPK	26.40	17.70	18.60	31.17
	Non-fertilized	17.55	15.70	18.70	22.06
	$LSD_{0.05}$	ni	ni	ni	ni

Table 1 cont.

Soil horizon, depth /cm/	Treatments	Date of determination			
		23 June	14 July	6 Aug.	15 Sept.
		Nitrification potential, mg/100 g soil			
A. /0-25 cm/	NPK	6.69	7.93	7.47	9.85
	Manure	10.46	8.94	12.13	11.91
	1/2 Manure + 1/2 NPK	7.92	10.46	10.51	10.94
	Non-fertilized	4.65	5.72	5.45	5.37
	$LSD_{0.05}$	3.95	ni	5.29	4.25
B. /25-50 cm/	NPK	1.47	1.55	1.24	5.41
	Manure	2.27	4.35	1.27	4.81
	1/2 Manure + 1/2 NPK	2.13	1.77	2.05	4.96
	Non-fertilized	1.07	2.18	1.67	3.47
	$LSD_{0.05}$	ni	1.07	ni	ni

/0-25 cm/. The greatest difference was observed at the first determination date. The highest amount of nitrates was found in the soil of treatments given mineral and mineral+organic /farmyard manure/ fertilization. The non-fertilized soil was the poorest in this element. Later, however, the highest nitrate content was found in soils treated with farmyard manure.

At the initial stage of potato growth a higher nitrate-N content was registered in treatments given mineral and mineral+organic fertilization than in those given nitrogen fertilization alone and in non-fertilized soil.

The fertilization type and soil sampling date determined the amount of nitrates made available in the soil during the two-week incubation.

The effect of the type of fertilization on the nitrifying capacity of the soil was different at different determination dates. A higher nitrifying capacity was found in treatments fertilized with farmyard manure alone or with farmyard manure combined with mineral fertilizers.

In the A layer /0-25 cm/ the lowest nitrifying capacity was observed in non-fertilized treatments. Soil fertilized with farmyard manure was more capable of mobilizing nitrate nitrogen during incubation. This was confirmed by the results of investigations carried out by other authors /GAWRONSKA, 1966; GETMANEC et al., 1978/.

The biological activity /Table 1/, measured by the amount of CO_2 emitted in the course of a 14-day incubation, was most intensive at all determination dates, both in the ploughed /0-25 cm/ and lower layers /25-50 cm/ in treatments fertilized with farmyard manure. The lowest amount of emitted CO_2 was observed in treatments where the soil was not fertilized for 35 years, but even these differences were not statistically significant.

The results presented in Table 2 show that the biological yield increment is quicker for mineral fertilization. This may indicate that the mobilization of nutrients, especially, of nitrogen, from farmyard manure is too slow.

The estimation performed did not prove any significant relationship between the NO_3-N content in the soil before and after incubation and the increment of fresh matter in the plants. Nevertheless, the grouping of the data suggests the occurrence of such a relationship.

Table 2

Increment dynamics of potato biomass. Average weight of one plant /g/

Treatments	Date of determination							
	23 June		14 July		5 Aug.		15 Sept.	
	ab.p.	t.	ab.p.	t.	ab.p.	t.	ab.p.	t.
NPK	14.8	-	39.2	15.1	62.0	121.1	41.2	193.6
Manure	13.5	-	22.9	6.9	46.3	92.4	22.1	139.4
1/2 Manure + 1/2 NPK	13.8	-	33.2	12.7	49.9	100.2	27.3	146.4
Non-fertilized	10.4	-	16.2	1.3	27.8	49.3	14.7	56.0
$LSD_{0.05}$	3.8		10.7	9.1	13.3	26.2	3.5	54.8
Correlation between NO_3 content in soil and biomass of potatoes	y=11.045+ 1.37x		y=15.9575+ 7.92x	y=1.915+ 4.715x	y=30.59+ 10.6025x	y=57.21+ 22.3475x	y=13.615+ 8.465x	y=70.87+ 41.982x

ab. p. = above-ground parts; t. = tubers

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