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AGROCHEMISTRY.
SOIL SCIENCE

Effectiveness of Fertilizer Systems on Grey Soils of Opolye

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Abstract—Data on comparable paybacks of various fertilizer systems are presented as harvest increase for grey forest soils of Opolye in three rotations of eight and seven field crop rotations. With the organic–mineral system with full mineral and appropriate mineral fertilizer systems, the payback of 1 kg acting substance is the highest and close. As the level of fertilizer application increases from 10 to 25 cwt per crop rotation, the acting substance is reduced by the close linear relationship from 6.0–6.5 to 3.5 kg of grain unit/kg acting substance. At appropriate cumulative doses of nutrient application with organic ones and their combination with phosphorous-potassium fertilizers against organic–mineral ones with NPK and mineral (NPK) systems, the payback of 1 kg acting substance with addition is decreased by 1.1–2.7 times.

Keywords: Mineral, organic and organic–mineral system, payback fertilizers, unit and crop rotation

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INTRODUCTION

Application of organic fertilizers in Vladimir region decreased to 1.5–2.3 t/ha [1]. At the same time, studies have proven that it is necessary to apply 8–9 t/ha of organic fertilizers on grey forest soils [2] and 10–15 t/ha and more on derno-podzolic soils [3] for environmentally safe agriculture (self-supporting balance of humus). Also, treatment of mineral fertilizers decreased. Ploughed fields are overgrown with weeds and low forest. Mainly better soils are used for agriculture and this fact explains the seeming increase of crop capacity.

In order to maintain fertility of soils, the scientists recommend using other sources of organic substance more: rotation of crops enriched with perennial legume grasses up to 40–50%, overlapping ground straw of cereal crops, different types of sideration, and intermediate postcut and stubble crops.

The aim of our research is to examine comparative payback of mineral, organic, and organic–mineral fertilizers with additional yield on grey forest soils.

MATERIALS AND METHODS

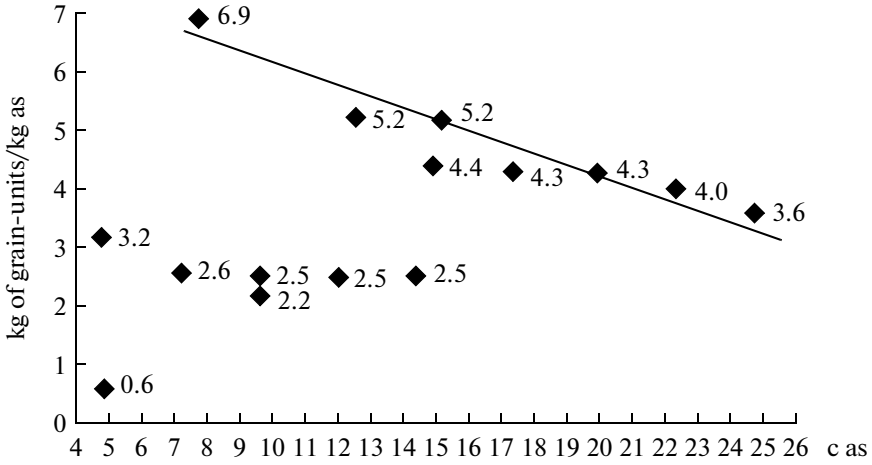
Comparative effectiveness of different fertilizer systems was studied on the basis of the results of a long-term stationary experiment that started on grey forest soils of Opolye in 1991–1993. In the first rotation of eight-field crop rotation the interchange was the following: fallow (vetch–oats mixture)—winter rye—potato—oats with overgrassing (clover and timothy)—grasses of the first years of growing—grasses of the second years—winter rye—spring barley. In the second rotation, winter rye sown after grasses was changed into spring wheat; in the third rotation, hoed crops were excluded, and then wheat was sown after fallow.

Organic fertilizers (doses of litter dung, t/ha: 0, 40, 60, and 80) were treated under winter rye (wheat) after harvesting vetch-oats mixture. We used ammonium nitrate, double or standard superphosphate, and potassium chloride. In autumn, phosphate–potassium fertilizers were treated during main soil cultivation; in spring, nitrogenous fertilizers were treated during presowing cultivation under annual grasses and summer crops, and also for additional fertilizing of winter crops. In the second and third rotations, we studied the consequences of lime treated into fallow in 1991–1993. Table 1 shows the scheme of treatment of organic and mineral fertilizers.

While estimating effectiveness of mineral, organic and organic–mineral fertilizer systems, we have to consider the fact that the more the doses of fertilizers increase, the less the payback of active substance (wt). Thus, only mineral fertilizer is characterized with the highest payback on grey forest soils of Opolye.

RESULTS AND DISCUSSIONS

According to Table 1, during the first rotation of eight-field crop rotation, payback of 1 kg as of fertilizer was the highest when applying a single dose of NPK (correlation of elements of nutrition 1 : 1 : 1). If dose increased by two times, it decreased from 5.4 to 4.2 grain-units per kg as. Payback of less dose of phosphate–potassium fertilizer in comparison with full mineral (Tables 1, 2) decreased from 5.4 to 2.4 grain-



Interrelation of fertilizer payback (kg of grain-units/kg as) for the third rotation of seven-field crop rotation and quantity of treated fertilizers during rotation (c wt); points beyond linear dependency belong to the second group of variants.

units/kg as. Such regularities of fertilizer payback were noticed during the second and third rotations of crops.

For comparative estimation of effectiveness of fertilizer systems, we analyzed the data on their payback regarding quantity of treated fertilizers (Table 2); these data were divided into two groups. The first group included variants with full mineral fertilizers in combinations with organic ones, the second group included those with phosphate–potassium and organic fertilizers separately and in combinations (variants 3, 6–8, 9, 12, 15).

Table 1. Fertilizer payback (kg of grain-units/kg as) on crop rotations

Variant	First rotation of eight-field of crop rotation	Second rotation of eight-field of crop rotation	Third rotation of seven-field of crop rotation
1. Control	–	–	–
2. Lime (Background – B)	–	–	–
3. B + PK	2.4	3.6	0.6
4. B + NPK	5.4	6.7	6.9
5. B + 2 NPK	4.2	4.3	5.2
6. B + dung, 40 t/ha (H40)	3.8	6.6	3.2
7. B + H60	4.9	5.4	2.6
8. B + H80	3.2	4.0	2.2
9. B + H40 + PK	2.0	3.6	2.5
10. B + H40 + NPK	4.9	5.2	5.2
11. B + H40 + 2NPK	4.0	3.6	4.3
12. B + H60 + PK	2.2	3.2	2.5
13. B + H60 + NPK	4.3	5.0	4.4
14. B + H60 + 2 NPK	3.4	3.3	4.0
15. B + H80 + PK	2.2	3.4	2.5
16. B + H80 + NPK	4.2	4.4	4.3
17. B + H80 + 2 NPK	3.2	3.3	3.6

In the first and second rotations, we show data concerning payback on average on three fields; in the third is that on the first field.

Table 2. Quantity (c as) of treated fertilizers on crop rotations

Variant	Quantity of fertilizers during rotation		
	first	second	third
1	–	–	–
2	–	–	–
3	7.0	6.6	4.8
4	10.4	10.4	7.8
5	20.4	20.0	15.2
6	5.2	4.9	4.8
7	7.8	7.3	7.2
8	10.4	9.8	9.6
9	12.2	11.5	9.6
10	15.6	15.3	12.6
11	25.6	24.8	20.0
12	14.8	13.9	12.0
13	18.2	17.7	15.0
14	28.2	27.3	22.4
15	17.4	16.4	14.4
16	20.8	20.2	17.4
17	30.8	29.7	24.8

Table 3. Equations of interrelation of payback of 1 kg of as of fertilizers with additional harvest (y is kg grain-units/kg as) with quantity of their application (x is c as) during crop rotation (the first group of variants)

Crop rotation	Interrelation equation	n	$t_{existing}$	r	r^2
1	$y = 6.42 - 0.104x$	8	12.00	0.980	0.960
2	$y = 8.09 - 0.175x$	8	9.85	0.970	0.942
3	$y = 7.67 - 0.174x$	8	5.83	0.922	0.850

Interrelation of payback of as unit in variants with full mineral fertilizers and their combinations with organic ones (y is kg of grain-units/kg as) with quantity of active substance of fertilizers during crop rotation (x is c as) can be described using equations of linear regression (Table 3, figure). When fertilizer dose increased, payback decreased. In the second group of variant and at the same quantity of treated fertilizers, it was very low (figure). We conducted estimation of fertilizer payback for the second group of variants by interrelations obtained for variants of the first groups (Table 3). Calculated fertilizer payback value (PV_c) appeared to be much higher than its actual value (PV_{act}) (Table 4). For example, during the first rotation, effectiveness of phosphate–potassium fertilizers was by 2.38 times lower than payback calculated for the same dose of full mineral fertilizer (Table 4).

Effectiveness of single organic fertilizers treated in proper doses was lower than combination of mineral fertilizers with dung by 1.14–1.66 times, and combination of phosphate–potassium with organic fertilizers was lower by 2.09–2.60 times. The lower payback of phosphate–potassium and organic fertilizers separately and in combinations in comparison with full mineral and its combination with organic fertilizers was also found out in the second and third rotations of crops (Table 4). The highest effectiveness of mineral and organic–mineral fertilizers in comparison with organic ones was noticed on sod-podzolic soils as well [4].

In general, we specified the following peculiarities of fertilizer payback.

(1) In variants of usage of full mineral fertilizers and their combinations with organic ones in bigger quantities, it decreases according to a linear dependency. If quantities of treated elements are the same, it is still higher than in variants without nitrogenous mineral fertilizers.

(2) If only phosphate–potassium and organic fertilizers and their combinations are used, correlation of PV_c/PV_{act} is more than one. This testifies to lower effectiveness of these fertilizer systems than full mineral and organic–mineral in combination with nitrogenous fertilizers.

(3) If we treat only organic fertilizers increasing their doses, correlation of PV_c/PV_{act} increases as well. This testifies to higher effectiveness of low optimal doses of their treatment.

(4) In variants of treatment of organic fertilizers in combination with phosphate–potassium fertilizers, correlation of PV_c/PV_{act} decreases. This means that payback of organic–mineral fertilizers increases. It is caused by decrease of portion of phosphate–potassium fertilizers, which is characterized by lower payback than nitrogenous ones in general quantity of treated nutrition elements.

Thus, lower payback of as of particular organic fertilizers in comparison with full mineral ones and their combinations with organic fertilizers is connected with movement of nitrate nitrogen accumulated from autumn with melt waters into deeper layers and its less active participation in the process of formation of structural elements (stooling level, number of grains in ear) in spring. It ensures a rich harvest of grown crops. At the same time, nitrogenous fertilizers treated in spring contribute to increase of stooling level of crops and formation of bigger quantity of flowers in ear. And nitrates of organic fertilizers moving inside ensure improvement of nutrition of plants with nitrogen in later phases of their growth and development. This

Table 4. Changes of fertilizer payback (kg grain-units/kg as) on crop rotations (the second group of variants)

Index	Variant						
	3	6	7	8	9	12	15
First rotation of eight-field of crop rotation							
Actual payback of 1 kg as with additional harvest during crop rotation, VP_{act}	2.4	3.8	4.9	3.2	2.0	2.2	2.2
Calculated payback of 1 kg as with additional harvest during crop rotation, VP_c	5.7	5.9	5.6	5.3	5.2	4.9	4.6
VP_c/VP_{act}	2.38	1.55	1.14	1.66	2.60	2.23	2.09
Second rotation of eight-field of crop rotation							
Actual payback of 1 kg as with additional harvest during crop rotation, VP_{act}	3.6	6.6	5.4	4.0	3.6	3.2	3.4
Calculated payback of 1 kg as with additional harvest during crop rotation, VP_c	6.9	7.2	6.8	6.4	6.1	5.7	5.2
VP_c/VP_{act}	1.92	1.10	1.26	1.60	1.69	1.78	1.53
Third rotation of seven-field of crop rotation							
Actual payback of 1 kg as with additional harvest during crop rotation, VP_{act}	0.6	3.2	2.6	2.2	2.5	2.5	2.5
Calculated payback of 1 kg as with additional harvest during crop rotation, VP_c	6.8	6.8	6.4	6.0	6.0	5.6	5.2
VP_c/VP_{act}	11.3	2.12	2.46	2.73	2.40	2.24	2.08

causes increase of content of crude protein in grains correspondingly.

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