

Agroecological efficiency of composts and humic fertilizers

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In recent years for Russian agriculture in connection with sharp deficiency of organic fertilizers there is a necessity of fuller usage of all possible resources of organic substance, including waste of cattle-breeding farms, municipal services, woodworking industry and other wastes which are often considered to be sources of environmental contamination.

Domestic and foreign experience shows, that composting is one of the effective methods of processing waste in fertilizers (Shkarda, 1985; Mineev, Dabretseni, Masur, 1993; Sychev, Merzlaya et al. 2007).

Fertilizing ability of composts

In this connection researches of fertilizing ability of composts from various organic components, including unconventional, in their influence on change of fertility and soil ecological conditions, and also in agricultural crops productivity and quality are actual.

In Russia researches of efficiency of composts from containing organic matter waste in system soil-plant have been lead in Moscow area on the Central experimental station of the All-Russian scientific research institute of agrochemistry named after D.N. Pryanishnikov.

In microfield experiment on sod-podsolic heavy loamy soil the action of composts from sewage deposits and wood waste (coniferous trees sawdust) on perennial cereal grasses (*Dactylis glomerata* L.) crop was studied.

The sewage deposits came from Kurianovskaya aeration station of Moscow and differed in storage periods. Compost 1 was prepared from sewage deposits after 10 years remaining on drying beds, compost 2 - from a deposit received directly from the aeration station filter-press in year of a trial establishment.

The deposits composting was carried out with addition of wood sawdust in quantity of 10 % of the mix dry weight. For composts efficiency comparative studying the great cattle manure on straw bedding had been used.

Organic fertilizers - both compost and manure – were applied in the soil in the first year of experiment in two dozes: 10 and 35 t/ha of dry substance. In the next years of researches we studied their aftereffect. Mineral fertilizers in treatment $N_{180}P_{60}K_{100}$ were applied annually: a full doze of phosphorus and half doze of nitrogen and potassium in spring, second half of nitrogen and potassium doze - after the first hay cutting of perennial grasses.

Initial agrochemical parameters values of soil properties in a layer of 0-20 cm were the following: pH_{KCl} - 4, the amount of organic carbon - 0.8 %, mobile phosphorus and potassium (Kirsanov) accordingly - 118 and 119 mg/kg. Investigated organic fertilizers differed on a chemical compound.

Compost 1, compost 2 and manure contained accordingly 29; 46,3 and 20,2 % of dry substance, in dry substance there where 52; 48 and 70,2 % of organic substance, 2; 2,1 and 2,7 % of general nitrogen, 5,3; 5,2 and 2,4 % P_2O_5 ; 0,24, 0,22 and 2,1 % K_2O ; 425, 1452 and 36 mg/kg Cu; 8, 42 and 2 mg/kg Cd; 50, 167 and 6 mg/kg Pb; 147, 774 and 60 mg/kg Cr; 104, 353 and 16 mg/kg Ni; 981, 696 and 387 mg/kg Mn; 1743, 4589 and 160 mg/kg Zn; 11, 31 and 5 mg/kg As at pH 7,4; 7,2 and 7.

These data show that composts from sewage deposits have high fertilizing ability and contain especially much phosphorus - over 5 %. Manure contains less general phosphorus than deposits, but more potassium and organic substance.

The compost from long storage deposit is more polluted by heavy metals, especially Cd and Zn. The general content of heavy metals in this compost is two times higher than in compost from a fresh deposit.

In described experiment the application of various doses of different composts had influenced ambiguously on agrochemical properties of sod-podsolic soil.

In a year of fertilizers application the maximal pH values - 4,5 and 4,7 have been received accordingly in treatments with use of composts made of filter-press deposit, or new deposit, and manure in the raised doses (35 t/ha). Mineral fertilizers application had not changed reaction of the soil solution; pH value did not differ from the control treatment.

Next year the insignificant increase of pH value in all treatments with organic fertilizers application was observed. In the fifth year of organic fertilizers aftereffect sewage deposit composts and manure in 35 t/ha doses had the greatest influence on the soil acidity, the shift of pH was accordingly 0,9 and 0,8 units. In a treatment with mineral fertilizers pH did not change during all years of researches.

Thus, usage of composts on the basis of sewage deposits (both new, and old, i.e. 10-years storage) as fertilizer did not influence negatively on acidity of the soil: in all treatments with application of organic fertilizers the increase of pH value was observed, it can be explained with high amount of calcium in them, which at a gradual mineralization of organic substance passed in a soil solution.

Amount of the soil organic substance in the year of fertilizers application had risen in comparison with the control on treatments with high doses of both investigated composts, and also on both treatments with manure. In the aftereffect of fertilizers in these treatments the amount of organic substance had also increased, deposit compost from a filter-press had been as good as and traditional manure in this parameter.

In treatments of low composts doses (10 t/ha of dry weight) from the moment of fertilizers application to the fifth year of aftereffect the decrease of organic substance amount in the soil occurred due to its intensive mineralization.

Annual application of mineral fertilizers reduced the amount of organic substance in soil in comparison with the control during first two years of researches. In the fifth year of aftereffect this parameter was at a level of the control.

It is characteristic that in the year of organic fertilizers entering in all treatments the increase of phosphorus amount in soil was observed. At entering deposit composts of different periods of storage in a dose of 10 t/ha the quantity of phosphorus increased in comparison with a control treatment in 1,3-1,5 times in a year of action.

In process of organic substance mineralization the amount of mobile phosphorus had decreased, that was connected with its consumption by plants. The same law was noted in the treatment with a low dose of manure.

Other character of phosphate regime was observed at increasing of organic fertilizers doses. At entering a high dose of deposit compost from the filter-press amount of mobile phosphorus in the soil had rose over 3 times in comparison with the control and remained stable in all years of experiment.

Usage of composts from a long storage deposit in the increased doze had led to gradual increase in the amount of phosphorus in soil from 220 mg/kg in a year of entering up to 260 mg/kg in the fifth year of fertilizers aftereffect. Herewith, amount of phosphorus in soil had lower values than in treatments with compost from the filter-press deposit in the same doze.

Amount of mobile potassium in soil had decreased in all treatments with application of organic fertilizers, though higher values of this parameter have been received at entering farmyard manure in a doze of 35 t/ha.

In the lead experiment high efficiency of investigated composts had been established by analysis of perennial cereal grasses productivity.

For 7 years of experiment average increase of perennial grasses crop dry weight in relation to the treatment without fertilizers had generated, at entering new and old deposit composts in a dry weight doze of 10 t/ha, accordingly 27 and 23,3 %, and in the raised doze of 35 t/ha increased up to 75,4 and 49,1 % (tab. 1).

Table 1 Influence of organic and mineral fertilizers on productivity of perennial cereal grasses

Treatments of experiment	Yield, g/m ² fodder units	Additional yield	
		g/m ² fodder units	%
Without fertilizes	163	-	-
Compost 1, 10 t/ha	207	44	27,0
Compost 1, 35 t/ha	286	123	75,4
Compost 2, 10 t/ha	201	38	23,3
Compost 2, 35 t/ha	243	80	49,1
Manure, 10 t/ha	234	71	43,6
Manure, 35 t/ha	342	179	110,0
NPK	447	284	174,2

An important agroecological aspect of fertilizers usage is their influence on accumulation of heavy metals in soil and plants.

According to experiment, entering of composts from sewage deposits raised the amount of cadmium in soil in comparison with control (without fertilizers) and treatment with manure. More distinctly this dependence was found out at entering drying beds deposit compost in a high doze - 35 t/ha.

Increase of nickel and lead amount in soil was observed only at entering high doze compost from a new deposit. The amount of copper and zinc in soil increased at entering both composts in both dozes. However it is necessary to note, that, despite the composts application, the amount of all investigated heavy metals in soil was low and did not exceed roughly admissible concentration accepted in Russia (ГН 2.1.7.020-94).

Amount of heavy metals in plants depended on a composts doze, however in all treatments it did not exceed standards existing in Russia (tab. 2). It is important to note, that forage value of perennial grasses was enough high, especially in such parameter, as phosphorus. At entering composts from both kinds of sewage deposits with wood waste the appreciable increase of this important element in grassy forages was marked.

Thus, on the basis of conducted experiment it is possible to conclude, that one of effective ways of city sewage deposits recycling is preparation of composts on their basis with subsequent usage as organic fertilizers in forage production.

Table 2 Amount of heavy metals in plants, mg/kg

Treatments	Cd	Pb	Zn	Cu	Ni	Cr
Without fertilizes	0,16	0,5	63,5	2,4	1,9	0,20
Compost 1, 10 t/ha	0,17	0,6	50,3	3,6	2,5	0,29
Compost 1, 35 t/ha	0,24	0,5	78,0	4,2	2,8	0,25
Compost 2, 10 t/ha	0,28	0,8	61,8	2,6	2,8	0,36
Compost 2, 35 t/ha	0,29	0,5	85,5	2,7	3,2	0,22
Manure, 10t/ha	0,15	0,8	58,7	2,9	1,9	0,35
Manure, 35t/ha	0,17	1,2	52,5	3,8	1,2	0,36
NPK	0,09	0,7	43,2	1,7	1,6	0,20
Standards (Russia)	0,3	5,0	50	30	3,0	0,5

Composts, prepared from fermented deposits of city sewage with addition of wood waste (sawdust), were characterized by high fertilizing ability and could be used for the major forage crops, first of all for perennial cereal grasses of intensive usage.

Efficiency of plants growth regulators

In a number of field experiments organized by institute in various regions of Russia efficiency of plants growth regulators in the form of humates was studied. The positive effect of humates application at cultivation of grain crops had been received in Krasnodar Territory.

It had been established, that at processing seeds of a winter wheat by K and Na humates in recommended concentration the production process became more active due to increase of tillering intensity and shares of productive stalks in general haulm stand. In turn it created opportunity to mobilize almost insoluble salts and to transform them in accessible forms for plants. As a result reliable increase of a grain yield (tab. 3 and 4) had been received in treatments with application humates in relation to the control.

The even greater effect was reached at carrying out of double processing with humates - seeds and plants of winter wheat. Potassium humate turned out to be the most effective among studied growth regulators. At processing only seeds of winter wheat with potassium humates the 13 % increase of a grain yield in relation to the control was achieved, at processing only plants - 11,9 %, and at double application of humates, i.e. at processing by it both seeds, and plants, it reached 15,5 %.

Table 3. Formation of crop structure elements at processing plants of winter wheat with humates

Treatments	Productive tillering capacity	Length of a spike, sm	Quantity of grains in a spike, pieces	Weight, g/plant	
				grain	straw
Processing of seeds					
No additions	1,8	6,5	21,5	1,03	1,34
Humate K	2,5	7,5	26,1	1,89	1,73
Humate Na	2,4	7,2	25,7	1,77	1,74
Processing of plants in a tillering stage					
No additions	1,9	6,9	25,3	1,21	1,49
Humate K	2,2	8,1	28,5	1,91	1,80
Humate Na	2,1	7,8	27,6	1,78	1,78

Table 4. Productivity of winter wheat, processing with growth regulators, t/ha

Treatments	seeds	Processing plants	seeds and plants
No additions	3,93	3,77	3,87
Humate K	4,44	4,22	4,47
Humate Na	4,34	4,08	4,28

In conditions of the Far North, in Yakutia near Verkhoyansk potassium humate was applied at cultivation of potato. As organic fertilizer manure of cattle with humidity of 70 %, containing 1 % of general nitrogen (in dry substance), 2,1 % P₂O₅ and 1,1 % K₂O was used. Potassium humate, applied in experiment, have been made from brown coals of local origin. It contained 37-42 % of carbon, 3,5-5 % of hydrogen, 48-57 % of oxygen, 2-6 % of nitrogen.

The soil was taiga cryogenic alluvial loamy. Before establishment of the trial the arable layer of soil (0-20 cm) contained 2,2 % of humus, general nitrogen - 0,21 %, mobile forms of phosphorus and potassium 198 and 265 mg/kg accordingly, pH_{KCl} 6,5. Action of potassium humate was tested in two dozes: 2,5 and 4,2 kg of dry weight per 1 hectare.

Verkhoyansk Region, where researches were carried out, concerns to territories not only with the coldest, but also droughty climate. Annual rainfall here is 154 mm, 90 mm fall in summer period. The duration of period with air temperatures higher +10°C is 78 days (from June, 4th till August, 20th); sum of temperatures is 1045-1200 degrees.

Potato was planted on June, 8-10th. In conditions of Verkhoyansk soil warms-up well enough in the last days of May and reaches physical ripeness in these terms. Vegetative period for years of experiment was 84-87 days.

Researches had shown, that without fertilizers the average crop of potato tubers was 4,56 t/ha with variances in years from 3,9 up to 5,03 t/ha. Due to only mineral fertilizers the crop addition was 0,9 t/ha, so the increase of a crop in this case had appeared doubtful.

The organic system of fertilizer, i.e. entering of only manure in a doze of 30 t/ha, also did not provide essential growth of potato crop. At the same time doubling of manure doze increased productivity significantly, it allowed to receive 64 t/ha of tubers on the average for a year, or 40 % increase above the control.

At entering of potassium humate in both dozes reliable increase of crop had not been received. Significant effect of humate and of mineral and organic fertilizers had not been reached also.

Table 5. Influence of manure, mineral fertilizers and potassium humate on potato productivity

Treatments	Yield, t/ha	Yield increase	
		t/ha	%
No additions	4,56	-	-
NPK	5,46	0,9	1,97
Manure 30 t/ha	5,63	1,07	2,34
Manure 60 t/ha	6,40	1,84	4,03
Humate 2,5 t/ha	4,86	0,30	0,65
Humate 4,2 t/ha	5,10	0,54	1,18
NPK + manure 30 t/ha + humate 2,5 kg/ha	6,98	2,42	5,30
NPK + manure 30t/ha + humate 4,2 kg/ha	7,17	2,61	5,72

In both treatments with application of potassium humate nitrates amount in tubers was at a level of the control, at the same time at entering manure or mineral fertilizers, and also their combinations the tendency of nitrates accumulation in vegetative production was outlined. In all tested fertilizers treatments of the experiment amount of nitrates in tubers did not exceed the Russian hygienic specifications of quality and safety of food raw material and foodstuff, i.e. 250 mg/kg.

Phytopathological supervision spent in field experiment in the end of the vegetative period showed that defeat of potato tubers by common scab was 13-17 %, by *Rhizoctonia* rot - 18-28 % in all treatments, including the control without application of fertilizers.

Application of mineral fertilizers, manure of large horned livestock, and also potassium humate had not rendered essential influence on distribution of potato illnesses.

Conclusion

Thus, generalizing results of researches in the field experiments, it is possible to ascertain, that application both traditional, and unconventional organic fertilizers by optimization of their dozes and combinations to mineral fertilizers, and also regulators of growth in the form of humates, provides increase of productivity of agricultural crops, improves their quality, promotes preservation of soil fertility and preservation of the environment from pollution.

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