Role of Nitrogen Fertilizers in the Transformation of Humus by Microorganisms

N. A. TUYEV, I. I. CHERNYAEVA and O. V. SVIRIDOVA

All-Union Research Institute for Agricultural Microbiology, Leningrad /USSR/

The study of the microbiological processes of humus transformation, which is the basis, of soil fertility and its rational use, is considered to be one of the most important tasks of modern agriculture. The systematic application of nitrogen fertilizers in intensive agricultural systems leads to the change of ecological circumstances in the soils.

The present report covers a piece of research into the specificity of microbiological transformation of humus compounds depending on the source of nitrogen nutrition. Experiments were conducted on pure cultures of Bacterium denitrificans, Agrobacter aerogenes, Pseudomonas mendocina and associations of microorganisms of a well-cultured sod-podzolic soil. Preparations of humic acid /HA/ and fulvic acid isolated 0.1 N NaOH from the studied soil and introduced to the media at 1 g/l, were used in our experiments.

It was demonstrated, that humic compounds are available sources of nitrogen and carbon for the nutrition of saprophyte microflora /Fig. 1/.

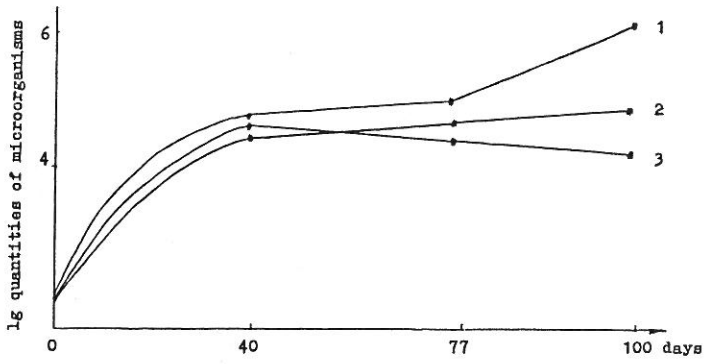

Fig. 1
The dynamics of microorganism quantities in the processes of humic acid degradation by soil associations. 1. proteolytical, 2. amilolytical, 3. microorganisms on nitrite agar

The change in the C, H, N and O contents of humic acid /Table 1/ was a direct proof of the use of humus by the associations of microorganisms. Thus, during the first month of incubation during mineralization the scale of aromatization increased and the relative hydrogen content, due to the splitting off of the aliphatic part, decreased. In this case 20-25% of the HA hydrogen was utilized.

Table 1

Changes in the composition of humic acids during their transformation by associations of soil microorganisms /atomical %/

Variants	C	H	N	O	C/H	C/N	O/H
Control							
HA	37.0	41.9	2.17	18.9	0.9	17.1	0.5
HA + KNO_3	37.0	41.9	2.17	19.0	0.9	17.1	0.5
HA + $/NH_4/_2SO_4$	36.7	42.2	2.16	18.7	0.9	17.0	0.4
Experiment							
HA	43.0	33.5	1.73	21.7	1.3	24.9	0.7
HA + KNO_3	56.2	13.0	1.60	29.2	4.3	35.1	2.3
HA + $/NH_4/_2SO_4$	53.4	17.0	1.61	28.1	3.2	33.2	1.7
$F_{5\%}$	0.5	0.2	0.02	0.2			

Table 2

Decrease of nitrogen in humic acids during their transformation by microorganisms /in per cent/

Trial variants	Bacterium denitrificans	Agrobacter aerogenes	Pseudomonas mendocina	Association of microorganisms
HA	9.2	16.6	16.1	20.3
HA + KNO_3	23.5	29.5	19.8	26.3
HA + $/NH_4/_2SO_4$	19.8	24.9	21.7	25.8

Pure cultures of bacteria also degraded the humic acid rather effectively. Additional introduction of mineral nitrogen to the media scaled these processes down by 5-10% /Table 2/. Associations of microorganisms transformed HA more actively than pure cultures. A considerable effect of two forms of mineral nitrogen on humus destruction was observed.

An increased degradation of humic acid and the use of its nitrogen part was consequently observed depending on the physiological peculiarities of the microorganisms and their relation to the reduced and oxidized forms of nitrogen.

The data obtained through the study of soil microorganisms' metabolism in the presence of various sources of nitrogen and carbon nutrition evidence a polyfunctional activity of bacteria and the possibilities of change in their biochemical activity. Thus, the substitution of ammonium nitrogen for nitrate one or additional introduction of NO_3-N to the media led to a decrease of respiration intensiveness and a blocade of hydrogen emission by

gaz-cultures. Their metabolism was also changing and microorganisms switched over to nitrate reduction. On the media with humous substances which were introduced as the only source of carbon nutrition, an intensified reduction of nitrates to nitrites with a simultaneous development of soil microorganisms was observed. It may be an indication of the presence of "nitrate-nitrite" respiration in them.

The effect of various doses and forms of nitrogen fertilizers on the processes of humification was studied in vegetational experiments with the introduction of barley vegetative mass, labelled as ^{14}C. It was demonstrated

Table 3

Effect of various forms of nitrogen fertilizers on the indices of humification of vegetative mass in sod-podzolic soil

Variants	Index of humification	
	barley	lupine
PK	4.7	7.2
$NaNO_3$-N + PK	11.0	12.7
NH_4NO_3-N + PK	13.9	12.1
$/NH_4/_2SO_4$-N + PK	12.8	13.2
$/NH_2/_2CO$-N + PK	15.6	14.3
KFU-N	16.2	15.3
$F_{5\%}$	0.4	0.3

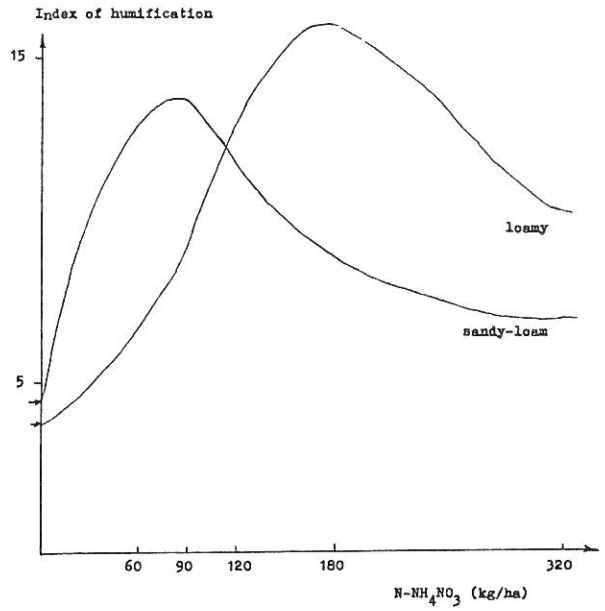

Fig. 2

Effect of various doses of N fertilizers on the indexes of humification

that not only the different doses, but also the different forms of N fertilizers are reflected by the indexes of humification /Table 3/. Easily-soluble forms of nitrogen fertilizers, nitrate ones in particular, are less effective in promoting humification than fertilizers with prolonged effect. Higher doses, while increasing the mineralization of humic substances, still decrease the index of humification.

For example, 45 and 90 kg/ha doses of nitrogen fertilizers were the most favourable for the microbiological humification of vegetative residues in a less-buffered sandy-loam, sod-podzolic soil. In soils with complicated mechanical contents the highest indexes of humification were recorded at the 120 and 180 kg/ha variants /Fig. 2/.

Comparison of the applications of the vegetative masses of barley and lupine showed that the larger indices of humification were observed in the case of barley, which is known to have more aromatic compounds.

Hence, nitrogen fertilizers play a significant role in the regulation of microbiological processes of humus transformation. Under the effect of the nitrogen content of the fertilizers a considerable change of not only the taxonomic structure of microbiological complexes, but also of their biochemical activity, occurs. Having adjusted to new conditions, many microorganisms switch over to another type of metabolism, thus changing considerably the quality of its metabolites, that influence the specifity of transformation of both fresh organic substances and humus.