Potential of Soil Microflora in the Decomposition of Plant Residues: Effect on the Yield of Maize

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The direct ploughing-in of plant residues with a high C/N ratio produces a negative effect on the yield of the following crop /LYNCH, 1983/. This effect can be avoided: a./ if the plant residues are ploughed into the soil some time before the next sowing and b./ if the plant residues are introduced into the soil in combination with mineral nitrogen.

The purpose of the experiment was to investigate whether a 3-month period before sowing was enough to avoid this negative effect on the following crop.

Materials and methods

The soil used was a calcareous chernozem with total C=1.43%, total N= 0.12%, pH_{H_2O}= 6.8 and $CaCO_3$=3%. The soil was treated with urea /400 mg N/kg soil /pot/ enriched to 50.9% atom ^{15}N KH_2PO_4 /400 mg P/kg soil/pot/ was added to all variants. Wheat straw /1 g per 1 kg soil per pot/ and lucerne /1 g per 1 kg soil per pot/ was previously stirred and incorporated into the soil. The lucerne had 33% C, 3.15% total N and 2.46% protein N, while the straw contained 40.2% C and 0.41% total N. The soil was moistened to 65% water holding capacity and incubated at 28 °C for 3 months. The soil was then sown with maize under greenhouse condition.

Before sowing the soil was analysed for the following indexes:

1. Biomass C and N with mineralization coefficient k=0.45 /LYNCH, 1983/.
2. Total and mineral nitrogen /BREMNER, 1965/;
3. Excess % atom ^{15}N /FAUST, 1969/. After the vegetation period the soil, roots and vegetative mass were analysed for total N and excess % atom ^{15}N.

Results and discussion

The data shown in Table 1 indicate that the total amount of applied urea is nitrified during the incubation period. A slightly larger amount of NH_4-N was determined in the variant treated with straw and urea. The im-

Table 1
Mineral nitrogen, biomass carbon and nitrogen before sowing /three-month incubation period/

Variants	Mineral N mg N/kg soil			Biomass N mg N/kg soil		Biomass mg C/kg soil
	NH_4-N	NO_3-N	NH_4-N+NO_3-N	fumigation method	method of differences	
1. Soil + P	13.3	51.1	64.4	31	-	800.8
2. Soil + P + N	21.9	280.8	302.7	89	-	759.0
3. Soil + P + lucerne	16.7	226.5	243.2	32	-	818.0
4. Soil + P + lucerne + N	13.5	246.6	260.1	50	42	781.0
5. Soil + P + straw	10.2	39.2	49.2	29	15	763.0
6. Soil + P + straw + N	55.0	182.0	237.0	72	65	810.0

Table 2
Distribution of nitrogen in the soil and vegetative mass /three-month incubation period/

	Soil				Vegetative mass			
	before sowing		after vegetation		Roots		Top mass	
	excess atom % ^{15}N	N from fertilizer mg	excess atom % ^{15}N	N from fertilizer mg	excess atom % ^{15}N	N from fertilizer mg	excess atom % ^{15}N	N from fertilizer mg
2. Soil + P + N	7.01	$\frac{234}{58.5}$ *	3.24	$\frac{87.1}{21.7}$	26.48	$\frac{82.4}{20.6}$	24.87	$\frac{58.1}{14.7}$
4. Soil + P + lucerne + N	7.41	$\frac{248}{62.0}$ *	3.59	$\frac{93.9}{23.4}$	28.19	$\frac{80.0}{20.0}$	25.97	$\frac{65.2}{16.2}$
6. Soil + P + straw + N	6.56	$\frac{195}{48.0}$ *	3.89	$\frac{100.0}{25.0}$	25.47	$\frac{70.71}{17.6}$	25.04	$\frac{75.0}{15.6}$
$LSD_{0.05}$					2.48	1.49	2.2	15.6

* denumerator is % from applied nitrogen

mobilized nitrogen, calculated by the method of differences, also showed higher values in this variant. The application of urea increases the nitrogen content of the microbial biomass. Lucerne has the best positive effect on biomass C. The slight differences between the immobilized nitrogen values calculated by two methods /fumigation and method of differences/ may indicate that the immobilized nitrogen is incorporated mainly into the biomass of soil microorganisms.

The application of plant residues with different C/N ratios has different effects on the yield. The decreasing in yield /34% for stalks, 15% for leaves, 22% for top mass and 38% for roots/ observed when the straw was ploughed in alone may suggest that the investigated period is not long enough for the soil microflora to decompose the ligno-cellulose complex to the necessary level. The application of urea alone and in combination with lucerne and straw increased the yield of the top mass to 159%, 169% and 197% respectively. The increase in the roots for the same variants was 134%, 278% and 300%, respectively. When applied alone, lucerne also gave a positive effect, mainly for the top mass /26% for stalks, 41% for leaves and only 1% for roots/.

The distribution and balance of applied urea in the soil and the vegetative mass are presented in Table 2 and 3. It can be seen that there were no big differences between the variants treated with urea. This soil would appear to have a high immobilization potential. After vegetation, the labelled nitrogen decreased to 21.7%, 23.4%, 25.0%, which indicates that about 49% to 62% of the immobilized ^{15}N is mineralized during vegetation.

This high rate of immobilization-mineralization potential is probably due to the good agrochemical properties of this soil, and especially to the presence of $CaCO_3$, as pointed out by IKONOMOVA /1978/. It can also be suggested that the immobilized nitrogen is incorporated mainly into the microbial biomass /ALIEV, 1988; CARTER, 1986; DINTCHEV, 1982; IKONOMOVA, 1978; TARVIS, 1973/. The differences between the variant in the ^{15}N values in the vegetative mass are also very small. In the roots, 17.6% to 20.6% of the applied dose was found, which corresponds to the data of POWER and LEGG /1984/ and is considerably higher than the values given by DINTCHEV /1981, 1982/. In the top mass this percentage varies from 14.7 to 18.7% of the applied dose. The ratio between the fertilizer-N in the top mass and that in the roots increased from 0.71 to 1.06 in variants treated with plant residues.

Table 3

Balance of applied nitrogen in the vegetative mass /three-month incubation period/

Variants	% derived from fertilizer		% derived from soil		% recovery	Lost N, %
	Roots	Top mass	Roots	Top mass		
2. Soil+P+N	53.5	48.8	46.5	51.2	53.2	46.8
4. Soil+P+lucerne+N	55.3	51.0	44.7	49.0	54.4	45.6
6. Soil+P+straw+N	50.0	49.2	50.0	50.8	57.9	42.1

The nitrogen balance assessed by the ^{15}N dilution method /CARTER, 1986; CHI-YU-CHIN and YOSHIDA, 1986; LYNCH, 1983; WILBER and YOSHIDA, 1978/ showed that a combined application of straw and urea has the highest degree of recovery and the smallest degree of denitrification. The relatively higher percentage of lost N is probably due to the very high experimental dose of urea applied /CARTER, 1986; DINTCHEV, 1981; JANSON, 1981, KUNDLER, 1970; POWER and LEGG, 1984; WILBER and YOSHIDA, 1978/.

Conclusions

In a calcareous chernozem soil under optimum conditions /pH 7, t° 28 °C, 65% WHC/ a three-month period is not sufficient to overcome the negative effect of straw decomposition on the yield and nitrogen content of maize. This negative effect disappears when the straw is incorporated together with urea. The combined application of straw and urea leads to the highest percentage of recovery and the smallest loss of nitrogen.

Summary

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