Investigation on the Effectiveness of Azotobacter Inoculation During the Recultivation of Mining Spoils

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Considerable areas are unsuitable for agricultural production due to open cut mining activities. The total surface of the landscape has been changed, and a large number of stratifications rearranged. On the newly formed surface of the soil, the creation of soil life starts practically from zero. The largest open cut lignite mine in Hungary is situated at the foot of the Mátra Hills, near Visonta. The soil surface formed by mining activities here consists of various, non-toxic tertiary and quaternary alluvial stones. After technical and biological recultivation, the dumps are suitable for agricultural utilization.

In the area surrounding the mine, research on recultivation has been carried out for about two decades. The investigations included the application of manure and fertilizers, different types of crop rotations and continuous economic analyses /TÓTH, 1983/.

A combined technology was elaborated by recultivation specialists from the Visonta Mining Company to ensure that the Visonta dump areas could be agriculturally utilized without overburdening within a short time. Soil biological experiments were carried out by SZEGI et al. /1983/, VÖRÖS and ANTAL /1988/, VÖRÖS et al. /1987/, GULYÁS /1983/ and BUTI et al. /1987, 1988/.

Materials and methods

The effectiveness of inoculants produced from the nitrogen-fixing bacterium Azotobacter chroococcum on yields, cellulose-decomposing activity and the quantity of free-living nitrogen-fixing organisms has been investigated in an open cut mine recultivated for the last 13 years.

The dump soils and the original soil /chernozem brown forest soil/ were inoculated with an Azotobacter chroococcum concentration of 12.10^{10} bacteria per 1 m^2 surface. For 4 different types of soils from the dumps /yellow sand, yellow clay, grey clay and andesite tuff/ and for the original soil the following experimental treatments were developed: 1. Control; 2. PK fertilizers; 3. PK fertilizer + inoculum; 4. NPK fertilizer; 5. NPK + inoculum.

The dump samples originated from the Open Cut Lignite Mine in Visonta and have been recultivated for a period of 13 years, in concrete rings of

Table 1

The quantity of free-living nitrogen-fixing microorganisms in recultivated dumps after inoculation with Azotobacter /cell number x 10^3/g dry soil/

Types of dump	Treatments				
	Control	PK fertilizer	PK + inoculation	NPK fertilizer	NPK + inoculation
Original soil	778	849	637	596	608
Yellow sand	226	46	345	333	135
Yellow clay	258	336	620	380	896
Grey clay	600	769	1043	902	700
Andesite tuff	312	220	269	368	1109

$LSD_{5\%}$ = 210

Table 2

Yields of Brassica napus /rape/ in recultivated dumps /Air-dried mass of plants, g/m^2/

Types of dumps	Treatments				
	Control	PK fertilizer	PK + inoculation	NPK fertilizer	NPK + inoculation
Original soil	224	264	620	742	864
Yellow sand	72	261	569	650	904
Yellow clay	224	782	1006	1016	1168
Grey clay	132	853	1016	1116	1016
Andesite tuff	51	152	122	640	518

$LSD_{5\%}$ = 126

Table 3

Cellulose-decomposing activity in recultivated dumps /quantity of cellulose decomposition, %/

Types of dumps	Treatments				
	Control	PK-fertilizer	PK+inoculation	NPK fertilizer	NPK+inoculation
Original soil	75.4	61.4	55.6	80.8	81.4
Yellow sand	28.4	58.5	68.2	94.5	76.8
Yellow clay	57.4	42.1	40.7	58.5	51.9
Grey clay	54.3	38.7	43.3	86.2	92.0
Andesite tuff	64.5	54.0	81.1	89.5	90.7

$LSD_{5\%}$ = 15

0.5 m^2 diameter under field conditions. During the recultivation period different crops were alternated, and NPK fertilizer was applied to all variants /except the control plots/ each autumn up to the autumn of 1986.

In the present experiment, set up in the spring of 1988, PK fertilizer equivalent to 120 kg/ha P_2O_5 and K_2O is added to variants 2 to 5, and ammonium fertilizers equivalent to 240 kg N to combinations 4 and 5. Only variants 3 and 5 were treated with Azotobacter inoculum.

The test plant, Brassica napus /rape/, was cut in July 1988 and the total overground parts of the plant were measured.

The quantity of free-living, nitrogen-fixing bacteria was characterized on nitrogen-free Fjodorov medium after harvesting the rape. The cellulose-decomposing activity was measured by means of Unger cellulose tests over a period of five months.

Results and discussion

As can be seen from the data in Table 1, the quantity of free-living, N-fixing organizations was increased by the inoculum in three types of dump soil /yellow sand, yellow clay, grey clay/ when treated with PK fertilizer only, but only in two dump soils /yellow clay, andesite tuff/ when adding NPK. The inoculation of the original soil was without a significant effect.

In the case of phosphorus and potassium treatment the Azotobacter inoculant had a positive effect on yields of Brassica napus /rape/ on the same three dump soils /Table 2/, but after NPK treatment the inoculation only influenced the yield on sandy soil, compared to variants treated with NPK alone.

From the data in Table 3 it can be demonstrated that the cellulose-decomposing activity of the dumps was not influenced by the inoculum, the degree of activity being characterized by fertilization, especially by nitrogen treatment.

It can generally be considered that the free-living, N-fixing organisms multiplied spontaneously in the dumps and were present in considerable quantities after a 13 year recultivation. In spite of this, the Azotobacter inoculation had a very good effect on the quantity and yield-producing ability of the N-fixing bacteria on certain dumps.

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