Hungarian Experiments With the Utilization of Rhizobial Inoculant in Practice

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The significance of biological nitrogen fixation is on the increase now that agricultural production is more aware of the need for environmental protection and energy saving. Its great advantage over mineral nitrogen fertilizers is that it is not so expensive and is less harmful to the natural environment. According to the latest estimations, the annual and perennial legumes grown on arable land are capable of fixing 25-50 million tons of nitrogen per year, calculating with 50-100 kg of nitrogen per hectare. The leguminous components of meadows, pastures, and savannahs produce 45 million tons of biologically fixed nitrogen, while the symbiont nitrogen-fixing microorganisms of the non-legumes are responsible for 9 million tons. The nitrogen fixed by free-living, nitrogen-fixing bacteria is estimated to be between 10-20 million tons. Altogether, this amounts to 94-124 million tons of nitrogen. At the same time, the world capacity for industrial fertilizer production is about 50 million tons at present.

The production technology of rhizobial inoculum has developed a great deal during the last one-two decades. A good inoculum must meet the following requirements:

a/ It has to contain bacteria of high effectiveness, which are competitive against the less efficient strains occurring spontaneously in soils;
b/ the packing and storing of the inoculant must be such that the bacteria will remain viable until the roots of legumes have been infected;
c/ suitable nodulation must be achieved under various environmental conditions;
d/ the inoculant must be resistant to the toxic effects of different extraneous matters - pesticides, heavy metals, etc.;
e/ among the technological criteria, the speed of multiplication in an artificial nutrient medium and a long expiry date without an essential decrease in the cell number are of utmost importance.

Systematic strain selection is fundamental to inoculant production, because the efficiency of the strains applied in production may decrease during artificial storage.

The Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences in cooperation with the FLR PROTEINVEST Agricultural Developing Enterprise, manufacture a peat-based inoculant which has already been utilized for the rhizobial inoculation of peas, beans, horse-beans and soybeans on several tens of thousands of hectares. The main targets of research and development in the production of this inoculant, marketed under the trade name BAKTOLEG, are as follows:

a/ the elaboration of a rhizobial multiplication technology under semi-scaled conditions, with special emphasis on the achievement of huge biomasses and the elimination of infection with alien microbes;

b/ the elaboration of a gamma radiation sterilizing system for the peat carrier, making total sterilization possible. Experimental determination of the necessary additives;

c/ the design and construction of a batcher to interfuse the fermentation-liquid and the sterile peat, ensuring aseptic conditions during this phase of the production technology;

d/ the elaboration of a method for small-plot field trials, suitable not only for checking the yield-increasing effect of the inoculant, but also for investigating the complex interrelation between fertilization, seed-pelleting and inoculation.

Field trials to prove the efficiency of BAKTOLEG inoculants

In 1987, small plot field trials were set up with soybeans, peas, horse-beans and beans as experimental plants in a poorly humous sandy soil /Őrbottyán/ and in a calcareous chernozem soil /Nagyhörcsök/ in order to judge the effectiveness of the inoculant. The efficiency was checked in a split-plot experiment combined with NPK fertilization.

Treatments of the experiment:

a/ non-inoculated,

b/ inoculated,

1/ control,

2/ PK: P = 100 kg P_2O_5/ha, K = 100 kg K_2O/ha

3/ BOJ: N = 60 kg N/ha, P = 100 kg P_2O_5/ha, K = 100 kg K_2O/ha

Plot size: 40 m^2, number of replications: 4.

In field trials, the effect of seed treatment with fungicide on the rhizobial seed inoculation of soybeans was also examined, but this experiment will not be touched on here due to lack of time.

In Tables 1 and 2 the surplus yield arising from the inoculation is expressed as the difference in seed yield between inoculated and non-inoculated variants given the same fertilization treatment.

The highest surplus yields due to inoculation with BAKTOLEG were obtained for soybeans. After fertilizing with PK, the seed yield was increased by over 100% in the sandy soil of Őrbottyán.

In the case of soybeans grown on a chernozem soil, also fertilized with PK, the surplus from inoculation was lower, somewhere in the region of 20%.

For peas, the surplus was 16-18%, in the case of PK fertilization, while for horse-beans the surplus yield of the inoculated variant in PK-fertilized plots was 15-23%. In the case of beans the inoculation surplus was approximately 15%.

It can be seen from the results that an adequate phosphorus and potassium supply to the soil is of vital importance for the effective inoculation of legumes. The best inoculation effects were gained in plots fertilized with PK. The application of N-fertilizer equivalent to 60 kg N active agents reduced the inoculation surplus; in fact, in certain cases, the yield of inoculated plants treated with NPK was lower than that of inoculated variants treated with PK only. This was observed for soybeans in

Table 1
The effect of inoculation with BAKTOLEG on the air-dried seed yield of soybeans, peas and horse-beans /1987/

Treatment	Őrbottyán			Nagyhörcsök		
	Inoculated	Non-inoculated	Surplus from inoculation	Inoculated	Non-inoculated	Surplus from inoculation
	seed yield kg/ha		kg/ha	seed yield	kg/ha	kg/ha
			A. Soybeans			
Control	1388	790	598	2089	1956	133
PK	1655	797	858	2479	2083	396
NPK	1540	1075	473	2564	2360	204
$LSD_{5\%}$			404			325
			B. Peas			
Control	1399	1294	105	1424	1282	142
PK	1520	1304	216	1620	1373	247
NPK	1496	1354	142	1609	1515	94
$LSD_{5\%}$			134			166
			C. Horse-beans			
Control	855	814	41	1234	1132	102
PK	964	836	128	1444	1183	261
NPK	942	888	54	1556	1458	98
$LSD_{5\%}$			114			197

Table 2
The effect of inoculation with BAKTOLEG on the air-dried seed yield of beans /Nagyhörcsök, 1987/

Treatment	Inoculated	Non-inoculated	Surplus from inoculation
	seed yield, kg/ha		kg/ha
Control	1782	1623	159
PK	1957	1727	230
NPK	2004	1858	146
$LSD_{5\%}$			220

sandy soil, for peas in sandy and chernozem soils and for horse-beans in calcareous sandy soil. This decrease remained within the limits of significance in all cases.

In 1987, a pilot plant trial was also set up on soybeans, with and without BAKTOLEG, on a soil poorly supplied with N in Nagyhörcsök. Plot size: 1700 m^2, number of replications: 4. In the non-fertilized experiment the seed yield of soybeans was increased by 55% after BAKTOLEG inoculation, compared to the non-inoculated variants. Over the average of four replications the seed yield of soybeans was 1135 kg/ha in the non-inoculated plots and 1654 kg/ha in the inoculated ones.

Summing up, it can be stated that the rhizobial inoculation of the seeds of leguminous plants forms an important part of up-to-date plant cultivation technologies. The general introduction of inoculation could lead to a significant increase in the yields of legumes and to major reduction in the production costs.