Effect of Fertilizer on Spontaneous Rhizobium Infection in Hungarian Soils

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Leguminous plants have great potential both from the ecological and the economic point of view. They are good sources of protein and, because of their symbiosis with Rhizobium bacteria, they can fix atmospheric N_2 biologically, becoming the available nitrogen source of soils, which will be richer for the crop cultivated after the legumes.

This symbiosis can be improved with inoculation, but the symbiotic N_2-fixing activity is influenced by numerous biotic and abiotic factors (BAKONDI-ZÁMORY et al., 1986; SZEGI et al., 1985).

One of the most important factors is the competitive ability of the microsymbionts, because introduced, selected bacteria have to compete with the indigenous Rhizobium population in the soil (QUISPEL, 1991). So the first step in this process is to learn more about the native Rhizobium flora of the soils. Are there any effective strains for the nodulation of introduced leguminous plants and is this symbiosis influenced by micro- and macroelement fertilization?

Answers to this question have been sought in 8 Hungarian soil types in the case of 5 leguminous plants.

Material and Methods

Soil samples were collected from different sites in Hungary:

1. Őrbottyán - calcareous sandy soil;
2. Keszthely - brown forest soil;
3. Putnok - brown forest soil;
4. Nagyhörcsök - calcareous chernozem soil;
5. Martonvásár - chernozem with forest residues;
6. Békéscsaba - meadow chernozem soil;
7. Karcag - meadow solonetz soil;
8. Mosonmagyaróvár - alluvial meadow soil.

Table 1

Physical and chemical characteristics of soil samples

Sampling site	pH (KCl)	K_A	$CaCO_3$ %	Humus %	NO_3 ppm	$NO_3 + NO_2$ ppm	P_2O_5 ppm	K_2O ppm	Zn ppm	Mg ppm	Y_1	T	L %
1. Őrbottyán	7.5	24	7.2	1.0	18.0	0.5	96	114	4.8	32	0	7.6	5.1
2. Keszthely	7.2	41	3.6	1.7	21.8	10.2	141	265	36.6	115	0	20.7	40.8
3. Putnok	5.5	34	0	1.8	17.0	8.3	25	156	1.7	289	10.1	22.8	46.8
4. Nagyhörcsök	7.3	39	6.6	2.8	9.3	4.9	212	174	1.3	137	0	24.5	34.3
5. Martonvásár	5.6	41	0.1	2.1	17.3	10.3	49	250	2.9	378	0.6	26.6	44.7
6. Békéscsaba	7.3	48	4.3	3.0	54.0	25.9	181	292	2.0	169	0	25.5	49.0
7. Karcag	6.5	39	0.1	1.6	4.8	5.2	193	459	2.9	405	0	27.1	48.1
8.Moson-magyaróvár	7.5	48	17.0	2.4	21.5	17.0	294	127	1.9	75	0	13.6	58.6

K_A: upper limit of plasticity according to Arany; y_1 = hydrolytic acidity.

Table 3

Number of spontaneous nodules on different leguminous plants with (f+) and without (f-) fertilizers

Sampling site	Alfalfa		Pea		Broad bean		Soybean		Crown vetch		Total	
	f-	f+	f-	f+	f-	f+	f-	f+	f-	f+	f-	f+
1. Őrbottyán	400	1462^+	4055	5085	4850	6830^+	840	1480	506	1400^+	10651	16257
2. Keszthely	745	947	1030	567	3635	5187	200	1480^+	1860	2005	7340	10186
3. Putnok	208	349	45	150	4890	4125	30	260	470	432	5643	5181
4. Nagyhörcsök	848	892	3870	4400	5210	5865	1260	310-	2380	3400^+	13463	14567
5. Martonvásár	1299	983	2025	2356	4515	7495^+	3290	3190	3470	3726	14589	17750
6. Békéscsaba	622	1185^+	3565	755-	1080	1340	1235	1680	1470	1892	7972	6852
7. Karcag	1093	776	2385	1735	5405	5580	5	10	2580	2402	11403	10203
8.Mosonmagy.	264	530	233	1319^+	2002	2383	65	760^+	740	986	3304	5978
Total	*5474*	*7124*	*17208*	*16232*	*31237*	*38805*	*6895*	*9290*	*17376*	*15843*		

+,-: significant (+) or (-) differences; For fertilizer treatments: See Table 2; x = 240 kg P_2O_5; 120 kg K_2O

The type of soil at each location and the data of physical and chemical analysis are shown in Table 1.

Pot experiments were carried out with these 8 soils in a greenhouse plant growth chamber by Vincent's (1970) method. The test plants were:

- alfalfa (*Medicago sativa* L. Nagyszénás);
- pea (*Pisum sativum* L. Renish Dwarf);
- broad bean (*Vicia faba* L. Lippó);
- soybean (*Glycine max* L. Ewans);
- crown vetch (*Coronilla varia* L. Kompolt)

Based on the physical and chemical analysis of the soil samples and on literary data (BUZÁS & FEKETE, 1979) the soils were enriched with macro- and microelements. In each case nitrogen-free fertilizers were applied (Table 2), after which the pots were moistened to 65% of water capacity.

After two months of growing, the number of nodules/100 plants were counted both in the control and the fertilized treatments.

Mathematical evaluation was made with multilinear regression analysis according to the different soil properties.

Results and Discussion

The indigenous Rhizobium population was estimated by counting the nodules on the roots of various leguminous plants. Data are shown in Table 3.

Favourable Rhizobium - legume symbiosis was found to develop in all cases, but the amount of nodules depended to a great extent on the soils. In the meadow solonetz soil of Karcag, and the brown forest soil (with clay alluviations) of Putnok, for example, only a few nodules could be found on soybean roots. The same was found for peas on the Putnok soil. The best soils for nodulation were the chernozem type ones (calcareous chernozem - in Nagyhörcsök and chernozem with forest residues in Martonvásár).

Table 2

Supplementary fertilization with macro- and microelements in the different soil samples (active agents, kg/ha)

Soil sample	KH_2PO_4	$KHCO_3$	$CaCO_3$	$ZnSO_4$
1. Őrbottyán	300	300	-	-
2. Keszthely	150	150	-	-
3. Putnok	300	300	3200	15
4. Nagyhörcsök	150	300	-	10
5. Martonvásár	450	150	750	-
6. Békéscsaba	150	150	-	10
7. Karcag	300	150	-	10
8. Mosonmagyaróvár	150	600	-	10

Among the leguminous plants tested, soybean gave the worst results for nodulation. As soybean breeding is very problematical in Hungary, studies must be made on which types of soils are good for its production, It is now obvious that for at least 4 soil types, soybean will need to be inoculated with Rhizobia if breeding is to be successful and better yields are to be achieved.

HASSAM et al. (1990) also tested broad bean nodulation in different soils. In a study on clay, calcareous and sandy soils, clay proved to be the best. The answer to nodulation thus seems to depend not only on soil types, but also on climatic conditions. The best conditions and the best inocula must thus be sought for each leguminous plant.

Table 3 shows the effect of fertilizers on nodulation. It can be seen that micro- and macro-nutrients tend to improve the spontaneous Rhizobium infection and may give significantly better results, especially in soils with very low humus contents. In the sandy soil of Őrbottyán, for example, nodulation was greater in alfalfa, broad bean and crown vetch after fertilization. A significantly higher nodule number, however, was only occasionally obtained and in the case of pea on the meadow chernozem of Békéscsaba and of soybean on the calcareous chernozem of Nagyhörcsök there was even a negative effect. The effect of additional fertilization was the most promising in broad bean.

According to the soil properties, a multilinear regression analysis was used to compare the soil data with the nodule numbers of the test plants. It was found that there was a strong positive correlation with the K_2O content of soils and a negative correlation with the plasticity index (K_A). In the case of pea, the humus percentage and N supply of the soils gave positive correlation results, as did the micronutrients (Zn, Mg) in the case of soybean plants. These findings somewhat contradict those of GALRAO (1991), who established that the number of soybean root nodules was not affected by Co, Mg, Zn and Mo. So it can be said with THIES et al. (1991) and SINGLETON and TAVARES (1992) that after determining the size of the indigenous rhizobial population, attention must be turned to the factors influencing it if a successful plant - Rhizobium inoculation process is to be elaborated.

Summary

Studies were carried out on the spontaneous nodulation of five different leguminous plants (alfalfa - *Medicago sativa* L., pea - *Pisum sativum* L., broad bean - *Vicia faba* L., soybean - *Glycine max* L. and crown vetch - *Coronilla varia* L.) grown in 8 Hungarian soils amended with macro- and microelement fertilizers (P, K, Ca, Zn).

According to the data, Rhizobium symbiosis was greatest on broad bean roots, while soybean plants were the least infected. The total number of nodules

was lowest in alluvial meadow soil (Mosonmagyaróvár) and highest in the soil of Martonvásár (chernozem with forest residues).

Micro- and macro-nutrient fertilizers tended to improve spontaneous Rhizobium infection, but this was not significant in every case. Broad beans gave the best response to fertilizer.

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