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Abstract

A lysimeter N-experiment was carried out over a period of three years (1986-1988) in Hungary on a slightly calcareous Ramann sandy-loam brown forest soil. In a trial without seed inoculation, the effect of N-fertiliser was studied on yield and N-uptake and the mineral (NO3+ NO2) N-content of 0-90 cm soil-layer of soybean. On the given soil with regulated optimal water supply the highest quantity of 200 kg/ha N-dose seemed to give alredy over-fertilization and lowered in its tendency the grain and pod yield. About one third of the dry matter production without roots and foliage at harvest was given by the grain yield, which ranged between 1.8-5.4 t/ha, depending on the treatment applied and on years. The N-content was accumulated chiefly in the grain, its concentration exceeded about 7-10 times the N-content of roots and stalk. The half of the total N-uptake, on an average 102-256 kg/ha, was built in the grain. The highest N-yield = 631 kg/ha was achieved in 1988 by 150 kg/ha N-fertilization per year. In the first years the N-uptake of the plants agreed with the total supply (mineral reserve of soil + given in the form of fertilizer + precipitation N), while in the 3th year a double amount was recorded. The mineral reserve of N in the soil did not decrease at the end of the trial. Presumably, the soil of soybean in monoculture lost gradually its „Rhisobium japonicum sterility", the biological N-fixation increased with the time. In the first years without seed inoculation however, soybean may be in need of N-fertilization.

Key Words: soybean, nitrogen, sustainable agriculture

Introduction

Soya is an important crop and is now grown all over the world (Márton et al. 1998, Márton et al. 1998, Kádár and Márton 1999, Márton and Kádár 1999, Márton and Kádár 1998). This crop originated in the Far East and has been grown in China for more than four thousand years. It has for long been regarded as one of the five sacred grains with rice, wheat, barley and millet on account of its exceptional food value. Nowadays of planted area, it comes fifth after wheat, rice, maize and barley. World soya production is twice as great as that of all other grain legumes. It is a legume able to fix the atmospheric nitrogen it needs for growth through the agency of specific (Rhisobium japonicum) bacteria (Haberlandt 1878, Kurnik et al. 1987, Bódis et al. 1988). Soya is an exelent preparatory crop. It improves soil structure, it leaves considerable residues of nitrogen for the following crop (Walter et al. 1970, Marcus-Wuner 1983, Márton et al. 1990, Németh 1995): it is a first-class entry for winter wheat. It is harvested in good time to allow cultivations for winter wheat and also leaves the ground in good condition for direct drilling. It is a good break crop in cereal rotations, limiting the build-up of fungal diseases. Soya is a reliable crop, tolerant of temporary water excess, more tolerant of cold than sorghum at shooting and flowering and it is more drought resistant than maize. Soya is demanding crop and responds well to physical and chemical soil improvement. The grain of present-day varieties contains on average 40-43 % protein and 21 % oil in dry matter. The various uses for soybeans can be summarised thus: a; whole grain, ground or unground after cooking, for human and animal foods, b; oil in human nutrition, c; special oilseed cakes for human diet (low-fat flour) and on a larger scale, for animal nutrition as a complement to forages and cereals.

In the subject of much soybean research has been to find means of improving yields (Norman 1963, Walter et al. 1970, Caldwell 1973, Hinson and Hartwig 1977, Mengel and Kirkby 1982, Marcus-Wuner 1983, Márton et al. 1990, Németh 1995). Among the means for yield improvement fertilizers (nitrogen) occupy a prime position. The nitrogen is indispensable to the plant, being a yield and an essential constituent of amino acids, proteins and nucleic acids (Fauconnier 1986). Soya uses some 300 kg/ha N, a large proportion of which is contained in grain protein (grain contains about 40% protein or 6% N). Sources of this N are residues in the soil, symbiotic fixation by root nodules and some times N fertilizer. High rates of N fertilizer suppress N2 fixation and most specialists recommend either no fertilizer nitrogen or a modest application of 30-50 kg/ha either at sowing or just before flowering. Some writers have noted a favourable effect of N applied at that time on N2 fixation, root nodule weight and activity (Eaglesham et al. 1983). For this reasons we were analysed in Hungary the effects of nitrogen fertilizer on yield and N-turnover of soybean in lysimeters.

Materials and Methods

A lysimeter N-experiment was carried out over a period of three years (1986-1988) in Hungary on a slightly calcareous Ramann sandy-loam brown forest soil. In a trial without seed inoculation, the effect of N-fertiliser was studied on yield and N-uptake and the mineral (NO3+ NO2) N-content of 0-90 cm soil-layer of soybean. The characteristics of the soil before trial were the followings: pH(H2O) 7.2, pH(KCl) 7.0, humus 1.3%, CaCO3 2.1%, silty clay 27%, easily soluble phosphorus and potassium content (AL-P2O5 80 ppm, AL-K2O 100 ppm) referred to as a medium supplied soil. The lysimeter had a soil volume of 4m3 and a growing surface of 4 m2. The basic fertiliZation with 100 kg/ha P2O5 and 120 kg/ha K2O was applied each year. N-treatments was applied at rates of 0, 40, 80, 120 kg/ha in 1986 and 0, 100, 150 and 200 kg/ha in 1987 and 1988 in the form of NH4NO3. There were thus 4 treatments x 3 replications = 12 lysimeters in all. The plant density of soya, sown without inoculation, was adjusted to 500 000 plants/ha. The water supply was optimalized to 70% field water capacity. The samples of the soil were analysed for the macro and microelements. The mineral (NO3+ NO2) N-content of the soil were determined by the BREMNER-KEENEY method (1966). The mass of the individual plant parts (roots, stem, leaves, pod, seeds / 6-6 plants) were analyzed separetly for the major macroelements in order to trace the nutrient uptake of the plants. The datas of experiments were estimated by MANOVA.

Results and Discussion

The most important results of the trial can be summarized as follows. On the given soil with regulated optimal water supply the highest quantity of 200 kg/ha N-dose seemed to give alredy over-fertilization and lowered in its tendency the grain and pod yield (table 1). About one third of the dry matter production without roots and foliage at harvest was given by the grain yield, which ranged between 1.8-5.4 t/ha, depending on the treatment applied and on years. The N-content was accumulated chiefly in the grain, its concentration exceeded about 7-10 times the N-content of roots and stalk (table 2). The half of the total N-uptake, on an average 102-256 kg/ha, was built in the grain. The highest N-yield = 631 kg/ha was achieved in 1988 by 150 kg/ha N-fertilization per year (table 3). In the first years the N-uptake of the plants agreed with the total supply (mineral reserve of soil + given in the form of fertilizer + precipitation N), while in the 3th year a double amount was recorded (table 4). The mineral reserve of N in the soil did not decrease at the end of the trial. Presumably, the soil of soybean in monoculture lost gradually its „Rhisobium japonicum sterility”, the biological N-fixation increased with the time. In the first years without seed inoculation however, soybean may be in need of N-fertilization.

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Table 1. Effect of N-fertilization on the yield of soybean. Lysimeter trial, Keszthely, 1986-88. Air-dried weight, kg/ha at harvest.

N kg/ha	Main root	Stalk	Foliage	Pod	Grain	Total
At the and of August 1986.						
0	672	1870	2448	750	1814	7554
40	790	2406	3952	1238	2108	10494
80	828	3044	5045	1325	2666	12908
120	837	3876	4703	2077	3006	14499
LSD5%	360	1320	994	960	740	4320
Average	782	2799	4037	1348	2398	11364
At the begining of September 1987.						
0	510	2285	2665	1431	2679	9570
100	690	2740	2765	2106	3756	12056
150	990	3640	3695	3328	5443	17096
200	995	3965	3360	2552	4130	15002
LSD5%	450	1920	345	740	1920	5440
Average	796	3158	3121	2354	4002	13431
At the begining of September 1988.						
0	718	6368	4160	603	3100	14949
100	750	6340	4260	792	3575	15718
150	1060	8560	7995	1700	4355	23670
200	508	9105	5725	925	4185	20448

LSD5%	480	3240	445	530	495	6120
Average	759	7593	5535	1005	3804	18696

Table 2. Effect of fertilization on N-content of soybean. Lysimeter trial, Keszthely, 1986-88. N% in air-dried weight

N kg/ha	Main root	Stalk	Foliage	Pod	Grain
At the and of August 1986.					
0	0.45	0.53	1.38	0.93	4.24
40	0.39	0.39	1.66	1.02	4.19
80	0.38	0.33	2.13	1.03	4.15
120	0.38	0.34	3.17	1.05	4.37
LSD5%	0.06	0.16	0.55	0.20	0.16
Average	0.40	0.40	2.08	1.01	4.24
At the begining of September 1987.					
0	0.54	0.50	1.85	0.49	6.34
100	0.58	0.58	2.12	0.50	6.22
150	0.54	0.58	2.32	0.54	6.28
200	0.56	0.69	2.64	0.63	6.45
LSD5%	0.10	0.25	0.17	0.20	0.55
Average	0.56	0.59	2.23	0.54	6.32
At the begining of September 1988.					
0	0.82	1.00	2.32	1.50	6.74
100	0.82	1.06	2.59	1.69	6.82
150	0.92	1.10	2.52	1.72	6.82
200	0.72	1.06	2.12	1.60	6.58
LSD5%	0.11	0.20	0.19	0.48	0.16
Average	0.82	1.06	2.39	1.63	6.74

Table 3. Effect of N-fertilization on N-uptake of soybean. Lysimeter trial, Keszthely, 1986-88. N kg/ha

N kg/ha	Main root	Stalk	Foliage	Pod	Grain	Total
At the and of August 1986.						
0	3.0	9.9	33.7	7.0	76.9	131
40	3.1	9.5	65.4	12.6	88.3	179
80	3.2	10.1	107.6	13.7	110.7	245
120	3.2	13.3	149.2	21.8	131.2	319
LSD5%	1.1	3.5	22.4	4.8	32.4	66
Average	3.1	10.7	89.0	13.8	101.8	218
At the begining of September 1987.						
0	2.8	11.5	49.3	7.0	170.0	240
100	4.0	15.8	58.7	10.4	233.7	323
150	5.4	21.2	85.9	17.8	341.6	472
200	5.6	27.2	88.8	16.1	266.4	404
LSD5%	1.6	9.4	8.8	4.4	112.2	104
Average	4.4	18.9	70.7	12.8	252.9	360
At the begining of September 1988.						
0	5.9	63.6	96.7	9.0	208.8	384
100	6.1	67.2	110.3	13.4	244.0	441
150	9.8	93.7	201.1	29.1	297.0	631
200	3.7	96.1	121.1	14.8	275.6	511
LSD5%	4.2	24.7	20.8	8.4	72.4	140
Average	6.4	80.2	132.3	16.6	256.4	492

Table 4. N-turnover of soybean. Lysimeter trial, Keszthely, 1986-88. N kg/ha
Given by N-fertilizer In soil be-fore fert. Input byprecip. Total(supply) Uptake byplant Found in soil at harvest Balance *EDM
In 1986
0 124 10 134 131 +3 206
40 119 10 169 179 -10 174
80 136 10 226 245 -19 154
120 178 10 308 319 -11 143
LSD5% 62 - 72 66 - 16
Average 139 10 209 218 -9 169
In 1987
0 232 19 251 240 +11 203
100 220 19 339 323 +16 201
150 231 19 400 472 -72 252
200 227 19 446 404 +42 248
LSD5% 42 - 59 104 - 64
Average 228 19 359 360 -1 226
In 1988
0 140 11 151 384 -233 136
100 145 11 256 441 -185 127
150 157 11 318 631 -313 178
200 166 11 377 511 -134 210
LSD5% 35 - 41 140 - 69
Average 152 11 276 492 -216 163
Comments: Leaching of N was between 0-8 kg/ha independently of treatments, so it was not taken into consideration at calculations. *Extraction Destillation Method by BREMNER-KEENEY (1966)

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