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BIOLOGICAL N2-FIXATION AND MINERAL N-FERTILIZATION EFFECTS ON SOYBEAN (Glicine max L. Merr.) YIELD UNDER TEMPERATE CLIMATE CONDITIONS

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Summary
In a nitrogen fertilization experiment set up on slightly calcareous Ramann sandy- loam brown forest soil studies were made on the effect of nitrogen (N) x Rhizobium japonicum inoculation (I) x variety (V) interactions on soybean yield in Hungary. The agrochemical parameters of the ploughed layer of soil were as follows: humus 1.3%, CaCO3 2.1%, silty clay 27%, pH (H2O) 7.2, pH (KCl) 7.0. The experiment involved 4N x 3I x 3V = combinations in 4 replications, giving a total of 144 plots. The most important results can be summarized as follows: (a.) 0, (b.) 100, (c.) 150 and (d.) 200 kg ha-1 year-1 of nitrogen application (a.) inoculation effect was maximum at 1 kg t-1 Nitrofix, (b.) yields were linearly and inversely related to the rate of Nitrofix, (c.) presence of any amount of Nitrofix has been a negative effect on yield and (d.) Nitrofix 1 kg t-1 was showed the best results. Both biological N2 fixation (BNF) and nitrate (NO3-) utilization by mineral nitrogen fertilizer (MNF) input were essential for maximum soybean yield.

Introduction
Nitrogen is the most frequently deficient nutrient in crop production therefore, most cropping system require N- inputs (Johnston 2000, Márton 2000, 2001). Many soursces are available for use in supplying N to crops (Kováts et al. 1985). In addition to from N2 fixation by leguminous crops can supply sufficient N for optimum crop production (Wilcox 1987, Kádár & Márton 1999, Márton & Kádár 1998, László & Jose 2001, László et al. 2001). Understanding the behaviour of N in the soil is essential for maximizing agricultural productivity and profitability while reducing the impacts of N fertilization on the environment. Managing the delicate balance in the soil N- supply in order to meet this goals. Nowadays there is an essential need to use nitrogen to achieve both economic yields and to produce enough food. Because the only way for agriculture to keep pace with population (world's population now exceeds 6 billion and continues to increase) and allewiate world hunger is to increase the intensity of production in those ecosystems that lend themselves to sustainable intensification while decreasing the intensity of production in the more fragile ecologies (Reeves 1998). Most plants depend entirely for growth on fixed nitrogen absorbed from the soil, mainly as nitrate but also as ammonium. Therefore to the methods of crop production now dominant in the agricultural systems of many developed countries strongly depend upon a sustained input of N. Economic and environmental considerations surrounding fertilizer use then empasize the need to increase the efficiency of N- utilization by plants. On the other hand the biological nitrogen fixation (BNF) is important under all imput conditions to ensure an optimal supply of nitrogen to the farming system. A well-founded understanding of the mechanistic interactions between BNF and N limitations is presently lacking. Synbiotic nitrogen fixation by legumes makes a valuable contribution to N-inputs, especially in countries like Hungary where effective rhizobia-inoculation techniques have been developed in the context of the new sustainable agricultural system. It is widely known that soya bean -Glycine max (L.) Merr.-, is an important legume. This plant able to fix the atmospheric nitrogen (N2) it needs for growth through the agency of specific bacteria Rhizobium japonicum. Under field conditions fixation usually accounts for only 25-30% of the total nitrogen accumulated by these plants at harvest. Therefore to marginal yield have to optimalise the nitrogen supply of these legume by N-fertilization. Objectives for our experiments were to (1.) comparisons of the plant nutrition performance of different soil nitrogen supply levels by N- fertilization and N- fixation under Mediterranean climate conditions at Hungary, (2.) evaluates the potential for N2 fixation imputs by grain legume

based on the soya bean as a means of improving soil fertility, (3.) considers some aspects of for use mineral N fertilizer (MNF) and N2 fixation (BNF) imputs efficiency in soya production, (4.) to improve crop management and nutrient conservation in the hungarian agro-ecosystem.

Materials and methods

Field experiment was set up on a slightly calcareous Ramann sandy- loam brown forest soil at Hungary in 1986. The ploughed layer contained 1.3% humus, 2.1% CaCO3, 27% silty clay, had a pH (H2O) of 7.2 and pH (KCl) of 7.0 at initial the trial. The soil was medium supplied with easily soluble phosphorus (AL-P2O5 80 ppm) and potassium (AL-K2O 100 ppm) according to soil analysis. The nitrogen fertilization (N) x Rhizobium japonicum inoculation (I) x variety (V) experiment involved 4N x 3I x 3V = treatment combinations in 4 replications, giving a total of 144 plots. Basic fertilization with 100 kg ha-1 P2O5 and 120 kg ha-1 K2O was applied each year at autumn. N was applied at rates of 0, 100, 150 and 200 kg ha-1 year-1 in the form of calcium ammonium nitrate. And Rhizobium japonicum inoculation occured by Nitrofix at rates of 0, 1 and 2 kg t-1. Varieties were as follow: Mc Call (USA), Pz (PL) and Crusader (CDN). The plot size was 2.8 x 4.8 = 13.44 m2 and the plant density of soya was adjusted to 500 000 plants ha-1. The forecrop over 2 years was winter wheat. The ground water level was at a depth of 3m. These presentation is showed the results of 1988. The mean of daily temperature, the daily relatíve humidity and the monthly rainfall were 17oC, 65% and 49 mm, respectively over vegetation period from April to September. The number of pods and seeds ha-1, the mass of the individual plant parts ha-1 and biomass production ha-1 were determined and analysed by MANOVA.

Results and conclusions

The soybean has been characterized as being rather nonresponsive to the application of fertilizer N and Rhizobium japonicum inoculation. This characteristics provides the basis for a considerable amount of conflicting research reported in the literature. Here we present results demonstrating that soybean growing under different N and Rhizobium japonicum inoculation conditions maintain a high positive N and positive or negative N2 fixation effects (Table 1). The main conclusions are summarised below: 1. Without N- fertilization input the favourable BNF effects of Rhizobium japonicum on the yield formation and quantity of soya depended decisively on the Nitrofix inoculation rates: 0, 1 and 2 kg t-1. The maximum grain and biomass yield reached 1.4 and 3.7 t ha-1. On this slightly calcareous Ramann sandy- loam brown forest soil the inoculation effects were maximum at 1 kg t-1 Nitrofix on grain (17%) and biomass (12%) production compared to control (without inoculation) treatments. Here the number of root nodules were increased 2 times (8 plant-1) regarding to control plots (3 plant-1). These datas are showed that if soya properly inoculated by Nitrofix (1 kg t-1) was capable of fixing substantial amounts of the required N from the atmosphere. And the biological nitrogen fixation was very important under this zero N- fertilization input conditions to ensure the satisfactory supply of nitrogen to farming. Grain mass was altered from 1.2 to 1.4 t ha-1 and biomass from 3.3 to 3.7 t ha-1. 2. Production in the case of low level of farming of 100 kg ha-1 year-1 our results were demonstrated that the crop was capable of utilizing both soil and fertilizer N. The use of N fertilizer significantly increased seed and biomass yield. Nitrogen fertilization effectivity on the grain and biomass accumulation was decreased by both of Nitrofix 1 and 2 kg t-1 inoculation to 28 and 44% and to 27 and 32%. The yields were linearly and inversely related to the rate of Nitrofix application. Grain mass was altered from 1.4 to 2.5 t ha-1 and biomass from 4.0 to 5.9 t ha-1. 3. At medium level of farming with N- fertilization of 150 kg ha-1 year-1 measured stagnant trends in yield compositions from the use of fertilizer N. With the help of variance analysis it was found that the presence of any amount of Nitrofix inoculum has been a negative effect on seed and biomass quantity. Grain production was altered from 1.6 to 1.9 t ha-1 and biomass from 4.3 to 4.9 t ha-1. 4. On high level of farming with N- fertilization of 200 kg ha-1 year-1 N fertilization significantly increased yield compositions and seed mass on the low amount of residual NO3- -N in the ploughed zone. We concluded that this crop respose to fertilizer N related to the amount of NO3- -N in the rooth zone. Rhizobium japonicum inoculation by the Nitrofix 1 kg t-1 was showed the best results. Pod and grain number, rooth, stalk, pod, grain and biomass were achieved 9365 (1000), 15378 (1000), 0.6, 1.4, 1.5, 2.4 and 5.9 t ha-1. The outstanding yields could be attributed to a greater input of N fertilizer and to the Nitrofix 1 kg t-1. Here we present results demonstrating that can be describe this process by synergic effect between N- fertilizer of 200 kg ha-1 year-1 and Nitrofix 1 kg t-1. Grain yield was altered from 1.4 to 2.8 t ha-1 and biomass from 4.0 to 5.9 t ha-1. There is ample evidence to suggest that to ensure the optimal yield production in the different -poor, low, medium, high- developed level of farming systems we have to apply the fertilizer N and biological nitrogen fixation treatments together. These datas confirm the yield potential and production possibilities of soya under Mediterranean agro-ecological and field conditions. These datas after adaptation can be used as guidelines by the extension service and are offered to apply on other climate and biogeoregions conditions to sustainable soya production.

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References

Johnston, A.E., 2000. Some aspects of nitrogen use efficiency in arable agriculture. In.: Nitrogen efficiency in practical agriculture-fundamental processes and how to control them. Conference at the Royal Swedish Academy of Agriculture and Forestry. April 12th. 1999. (Ed's Jan Persson). 9-23. Kungl Skogs-och Lantbruksakademiens Tidskrift. Stockholm.

Kádár, I. & Márton, L., 1999. Mineral Nutrient Cycle of Soya. Agrochemistry and Soil Science. 48:67-82.

Kováts, A., Márton, L. & Szabó, L., 1985. Analysis of the relation between humus and pH on the ground of results of soil investigations on farm-scale plots. Plant Production. 34:507-512.

László, M., Silva, J.B.C. & José, A.B., 2001. Ecological friendly dragée technics on different crops and vegetables seeds. Acta Agronomica Óváriensis. 43:9-13.

László, M., & Jose, E.M., 2001. Effects of Crotalaria juncea L. and Crotalaria spectabilis ROTH on soil fertility and siol conservation in Hungary. Acta Agronomica Óváriensis. 43:1-8.

Márton, L., 2000. Effect of NPK fertilization on potao (Solanum tuberosum L.) yield. Ph.D dissertation. University of Veszprém, Keszthely, 136. p.

Márton, L., 2001. Climate change and N, P, K, Mg fertilization effect analysis at Tisza-river basin in a long term field experiment. Szent István University, Gödöllő, 21. p.

Márton, L. & Kádár, I., 1998. Effect of nitrogen supplies on the yield components of soya. Plant production. 47:677-687.

Reeves, T.G., 1998. Sustainable Intensification of Agriculture. International Maize and Wheat Improvement Center. Mexico city. Mexico.

Wilcox, J.R., 1987. Soybeans: Improvement, Production, and Uses. Madison, Wisconsin, USA.