The effect of organic fertilization on the crop yields and soil properties

Effet de la fertilisation organique sur le rendement des cultures et sur les propriétés du sol

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Abstract

In the long-term field experiment at Prague-Ruzyne (since 1955), the effect of different organic fertilizers (farmyard manure, pig slurry, cattle slurry, poultry slurry, straw, compost) on the plant yields, nutrient uptake and nutrient status in soil has been investigated. In comparison to the variant with farmyard manure, a pig slurry application had the similar positive effect (direct for root crops and subsequent for cereals) on the nitrogen balance, nutrient efficiency and crop yields. Nitrate leaching and crop response to applied nitrogen has been studied in another field experiment on three different sites with annual application of various doses of pig slurry. The efficiency of N from slurry was practically identical to the efficiency of nitrogen from equivalent doses of industrial N-fertilizer, especially on clay loam and loam soils, but it was 2-3 times loer on sandy-loam soil.

The effect of different organic fertilizers on the yield of perrenial ryegrass (Lolium perenne L.), nutrient status of the soil and nutrient uptake, has been investigated in green-house pot experiment. Manure (farmyard manure, pig slurry with and without straw, biofertilizer « Bamil », sewage sludge) was applicated in the same amount of nitrogen (2 g N per one pot, with 5 kg of topsoil). The highest yield of ryegrass and simultaneously the highest nitrogen uptake was observed in the variant with pig slurry, followed by pig slurry plus straw, biofertilizer « Bamil », sewage sludge and farmyard manure.

<u>*Keywords*</u> *: manure, slurry, biofertilizer, yields.*

Résumé

Dans l'essai au champ de longue durée mis en place en 1955 ŕ Prague-Ruzyne, l'effet de différents fertilisants organiques (fumier, lisier de porc, lisier bovin, lisier volailles, paille, compost) sur le rendement des cultures, l'utilisation des éléments et le statut du sol a été étudié.
Un apport de lisier de porc présente le męme effet positif notament vis ŕ vis de l'utilisation de l'azote par les cultures, comparativement ŕ l'application de fertilisants

de synthčse, notamment sur sol argilo-limoneux et limoneux. L'effet azote sur sol sablo-limoneux était 2-3 fois inférieur ŕ celui obtenu avec des engrais chimiques.

L'effet de différents fertilisants organiques sur le rendement de ray-grass permanent, (*Lolium perenne L.*), le statut nutritif du sol et l'utilisation des éléments, a également été étudié lors d'essais en laboratoire (culture sous serre de pots d'incubation).

Les rendements optimum en ray-grass et consécutivement l'absorption d'azote par la plante ont été les plus élevés avec le lisier de porc, suivi par lisier de porc + paille et par le biofertilisant « Bamil », puis par boues de station d'épuration et par le fumier.

Mots-clés : déjections, lisiers, biofertilisants, rendements.

1. Introduction

The average nutrients input from organic fertilizers has been nearly equal to the nutrients input from industrial fertilizers in Czech agriculture in years 1991 - 1996. It reached approximately 75 kg N + P_2O_5 + K_2O per 1 ha of agricultural land (or approx. 100 kg N + P_2O_5 + K_2O per 1 ha of arable land, as the main target of fertilization and manure application). The other sources of organic matter and nutrients in addition to the animal manure are as follows: treated public sewage sludges, urban composts from public garbage collection, industrial wastes, such as products from the food processing industry and other organic products used as fertilisers. The new type of organic fertilizer is represented by microbial biofertilizer, produced in bioreactors on the basis of animal excrements and/or other agricultural wastes.

2. Districtwise analysis of productivity, farmyard manure application and industrial fertilizer consumption in Czech agriculture

The analysis of current situation in plant nutrition, fertilization level and soil fertility status has been done on the basis of the official statistical data on the district level in the year 1995. There are 77 districts in the Czech Republic (4.28 mil. ha of total agricultural land, 3.14 mil. ha of arable land). According to the soil fertility and climatic conditions the area can be divided into three main groups of districts. The average yields of all harvested field crops were recalculated on the basis of their energy value to the « grain units » (1 GU is equivalent to 0,1 t of cereal grain). The « agroecological production potential » represents the level of yield, which can be reached under conditions of optimal agricultural practice.

group of districts	number of districts	arable land area (in	production potential	yields in 1995	production potential

		thousand ha)	of soils (GU/ha)	(GU/ha)	utilization (%)
I	24	1136	65,7	52,6	80
II	23	920	51,4	44,7	87
III	30	1087	43,3	38,5	89
total	**77**	**3143**	**54,0**	**45,4**	**84**

GU = grain units = 0,1 t of cereal grain).

Table 1
Production potential and its utilization in 1995.

The response to the industrial fertilizer consumption (kg of N + P_2O_5 + K_2O per 1 hectare of arable land) and to the farmyard manure application (t per 1 hectare of arable land) is shown in figures 1 and 2. The columns represents average yields in subgroups of districts grouped according to fertilization level and/or farmyard manure application expressed as the difference from the mean value of the main group. Because of decreasing of NPK fertilizer consumption, the role of organic fertilization as the plant nutrient source (figure 1) seems to be more important than the role of NPK fertilization (figure 2). The average input of nutrients from both sources is practically identical, but in the case of organic fertilizers the ratio between main elements is more suitable, and into the bargain, by the organic fertilizers farmers supply to the soil other active substances (organic matter, microbes, enzymes etc.).

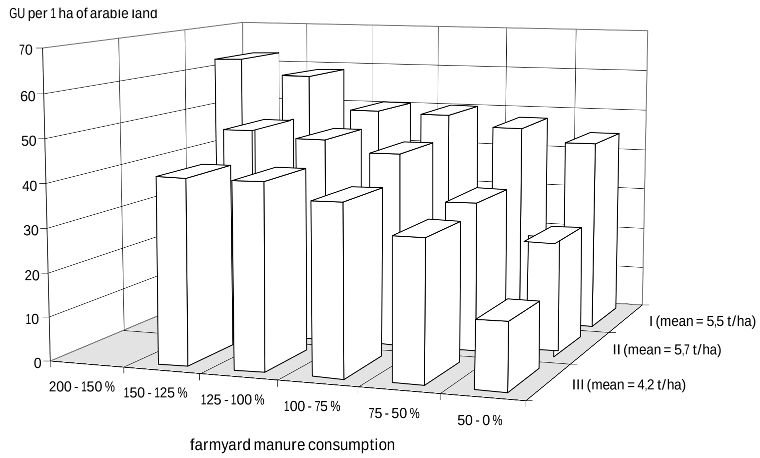

Figure 1
The effect of farmyard manure on crop production

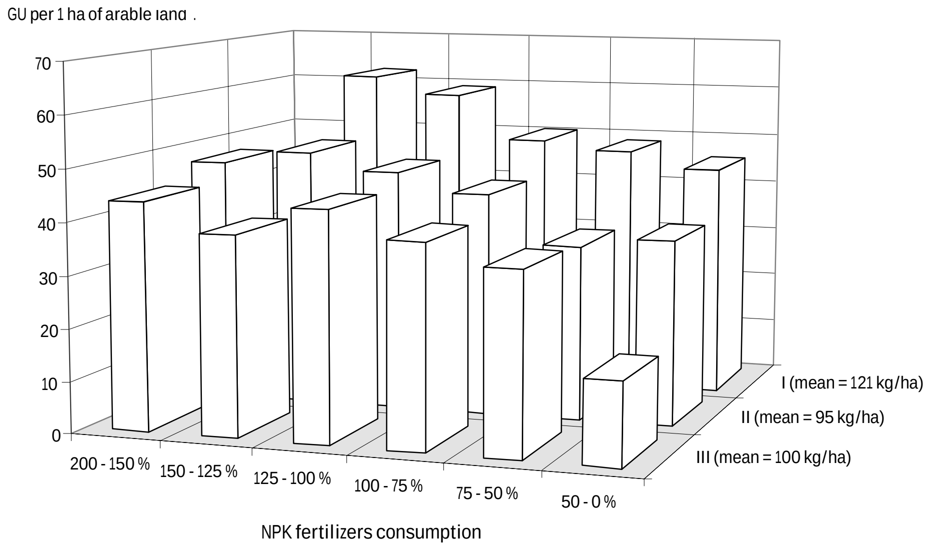

Figure 2
The effects of N P K fertilizers on crop production

3. Animal manure and organic waste nutrients inputs in Czech agriculture

Animal manure and organic waste nutrients inputs in Czech agriculture has been calculated according to the OECD balancing method. The "soil surface nutrient balance" is one of the priority issues in developing an OECD set of agri-environmental indicators, as part of the contribution to the analysis of the interactions between agriculture and the environment and impact of changes in agricultural policy on the environment. The soil surface balance calculates the difference between the total quantity of nutrient inputs entering the soil and the quantity of nutrient outputs leaving the soil annually. The calculation of the soil surface balance is a modified version of the so called "gross balance", which provides information about the complete surplus (deficit) of nutrients into the soil, water and air from an agricultural system.

A soil surface N, P, K balance for the Czech Republic in the years 1985 - 1997 was calculated on the base of official statistical data (fertiliser use, sewage sludge and wastes application, numbers of live animals in terms of different categories according to species, sex, age and purpose, quantity of harvested crops and forage) and converse coefficients (animal excrements production, nutrients content, nitrogen fixation and deposition).

The annual total quantity of nutrients inputs for the soil surface nutrients balance includes in addition to *industrial fertilizers, nutrients contained in seeds and planting* *materials, atmospherical nutrient deposition and biological nitrogen fixation* other sources as follows :

- *net input of manure* = livestock manure production – manure withdrawals (manure withdrawn from agriculture and not applied to agricultural land, destruction of manure and evaporation of ammonia which occurs from stored manure and livestock housing)

- *nutrients from recycled organic matter* (treated public sewage sludge, urban compost from public garbage collection, industrial waste, such as products from the food processing industry and other organic products used as fertilisers)

Recycled organic matter	% in dry matter		
used in agriculture	**N**	**P_2O_5**	**K_2O**
Sewage sludge	4	2,5	0,4
Urban compost	1,5	0,4	0,5
Industrial waste products	1,5	1,4	1,5
Other products	1	0,6	0,3

Table 2.
Average nutrient content of organic wastes.

The results of organic wastes and manure nutrients balances are shown in figures 3 - 6.

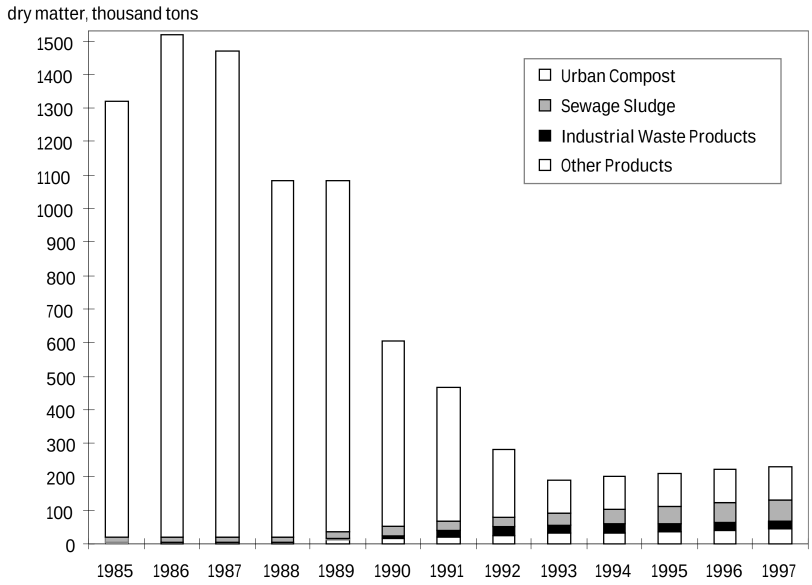

Figure 3
Organic waste recycling in Czech agriculture

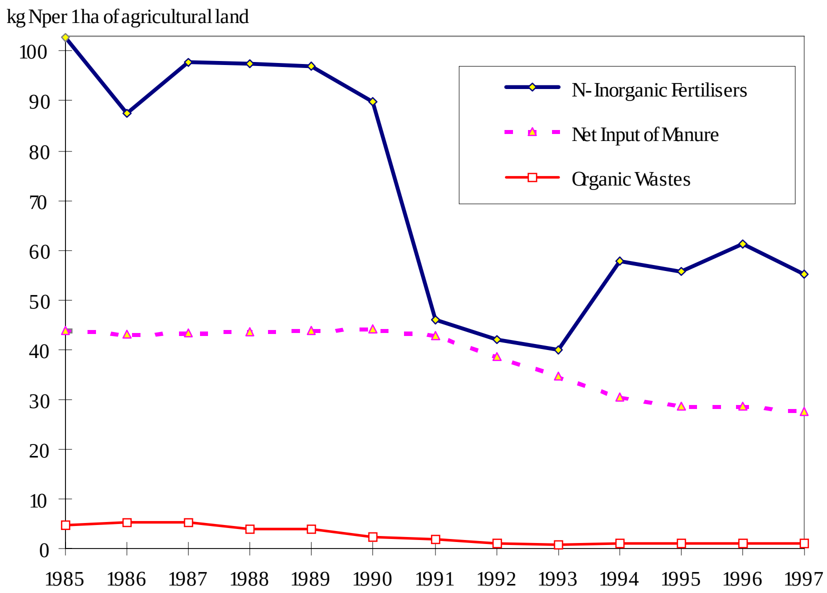

Figure 4
Nitrogen inputs in Czech agriculture

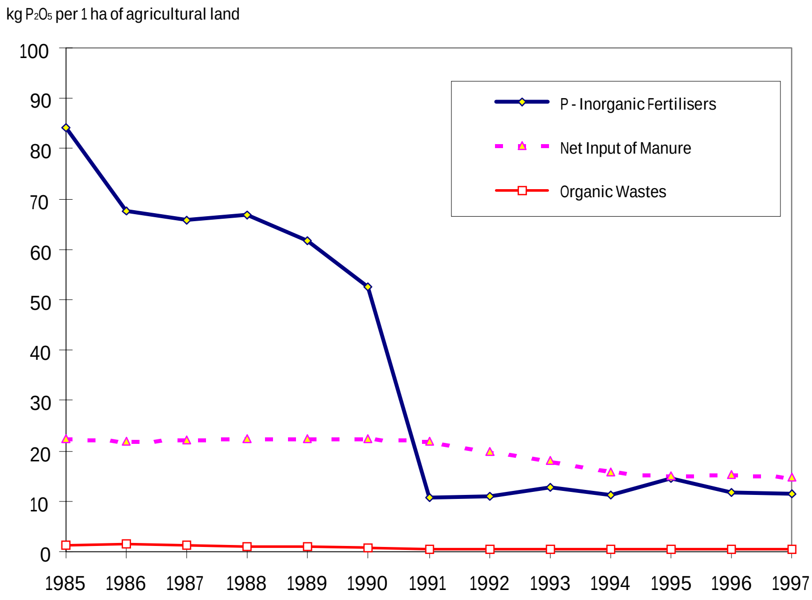

Figure 5
Phosphorus inputs in Czech agriculture

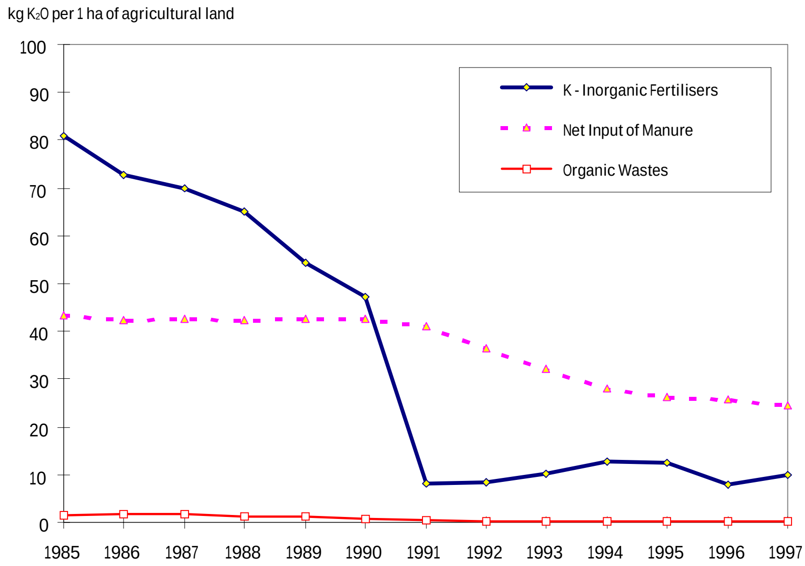

Figure 6
Potassium inputs in Czech agriculture

4. Nitrogen utilization from organic fertilizers in pot experiments

The effect of different organic fertilizers on the yield of perrenial ryegrass (Lolium perenne L.), nutrient uptake by plants and nutrient status of the soil has been investigated in green-house pot experiment. Manure (farmyard manure, pig slurry with and without straw, biofertilizer « Bamil », sewage sludge) was applicated in the same amount of nitrogen (2 g N per one pot, with 5 kg of topsoil). Tested fertilizers were pig slurry (0.55 % N in raw material), farmyard manure (0.39 % N), stabilized solid sludge (0.84% N), biofertilizer « Bamil » (product of Scientific & Technological Centre "NIKA", St.Petersburg, Russia, which is pelletized biofertilizer from products of aerobic treatment of pig farm wastes, 3.9 % N). The control variants were PK and urea (46 % N) + PK.

The highest yield of ryegrass and simultaneously the highest nitrogen uptake from the organic fertilizer was observed in the variant with pig slurry, followed by pig slurry plus straw, sewage sludge, biofertilizer « Bamil » and farmyard manure (figure 7). After application of microbial pelleted biofertilizer « Bamil », successive mineralization and nitrification of organic N was observed, without nitrate accumulation in soil solution and with low nitrate content in the plants (figures 8 and 9).

The effect of the new biofertilizer « Bamil » has been studied although in the course of biological recultivation of various types of man-made violations of soils in the industrial regions of the north-western Czechia. It was marked with the increase of yield in dry weight of grasses, biological activity of soil, reduced removal of nitrates from soil, as well as prolonged effectiveness of fertilizer - gradual mobilization of nutrition elements, primarily nitrogen.

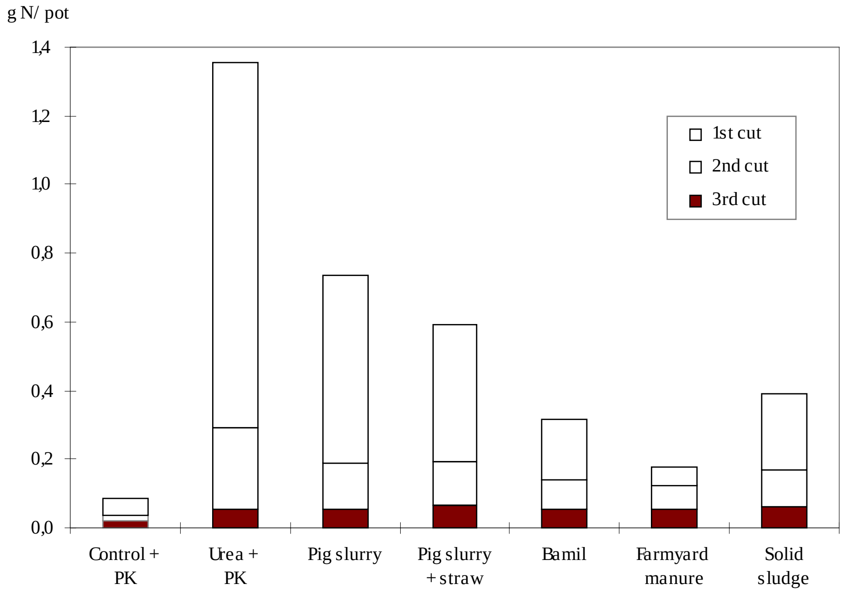

Figure 7
Nitrogen uptake by plants

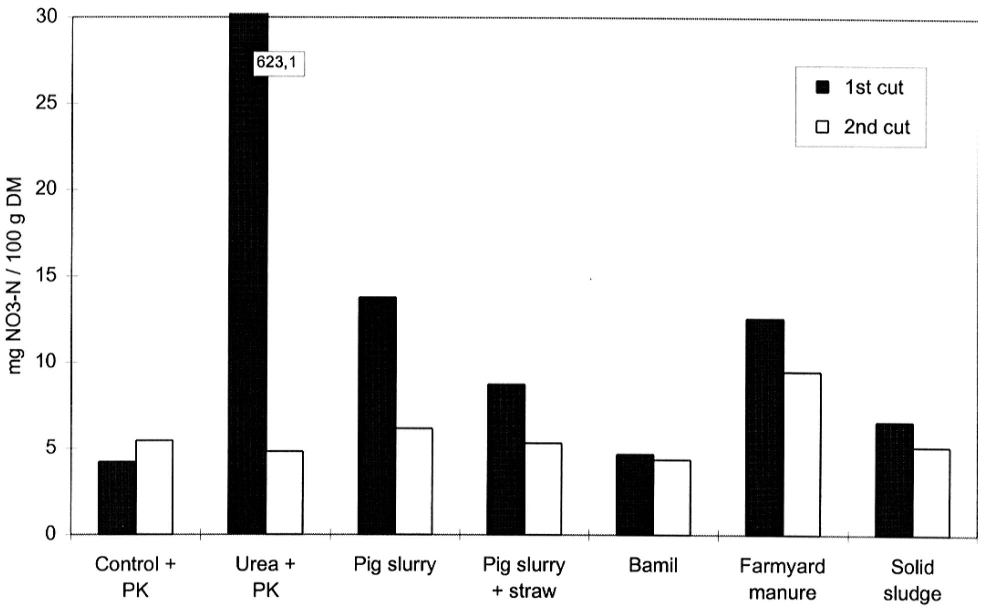

Figure 8
Nitrate content in plants

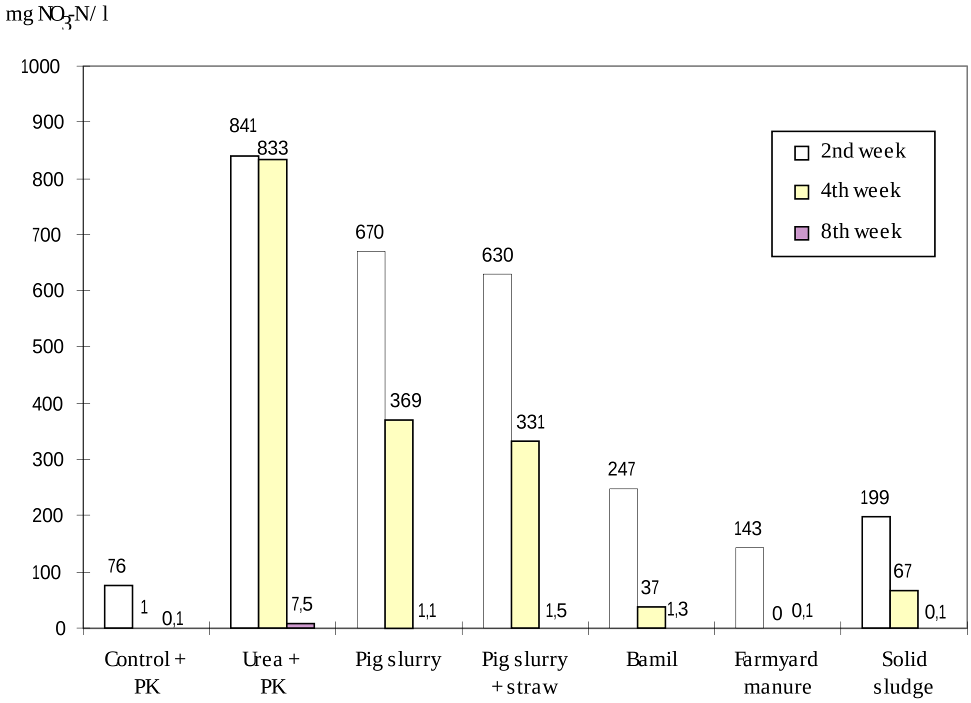

Figure 9
Nitrate content in soil solution