# THE INFLUENCE OF LONG-TERM MINERAL-MANURE FERTILIZATION STRATEGIES ON THE YIELD OF MEADOW AND SOME CHEMICAL FEATURES OF MINERAL SOILS

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**ABSTRACT**
During the years 1982-1994 on permanent meadow, studies were conducted on soil in layers: 0-10, 10-20 cm in dependence of fertilization. Four fertilizing combinations were applied: "0", NPK (N - 240, K - 100, P - 33 kg/ha) manure (30 t/ha) and alternate fertilization, i.e. one year manure, next year NPK. The soils pH and the content of organic matter and some macroelements were evaluated. It was stated that on the specific black earth after 12 years the most soured were the plots fertilized yearly NPK and a little less the plots with alternate fertilization. The best influence had manure having buffer capacity. The lowest decrease of organic matter was after NPK, a little worse was manure effectiveness and alternate fertilization. The biggest decrease (to 1.06% C) was noticed on plots not fertilized. The manure caused lower changes of capacity of magnesium and calcium than mineral fertilization NPK. The phosphorus and sodium decrease of contents was similar on all objects. During 12 years the highest yields were observed as a result of alternate fertilization and mineral NPK, and only the manure gave yields significantly lower than those, obtained on previous combinations, although simultaneously significantly higher than the yields than plots without fertilization.

**KEYWORDS**
meadow, fertilization, manure, yield, soil

## INTRODUCTION

One of the more important factors having an influence on quantity and feed quality from grasslands is fertilization. But intensive mineral fertilization can only cause many negative effects: the simplification of botanical composition, the excess of same components for example: nonalbuminoid nitrogen or potassium, acidification of soil and impoverishment of the top layers of soil in components collected with the yield: calcium, magnesium, manganese (Czuba and Murzynski, 1993). It is possible to prevent those unfavourable changes by the use of manure, which provides macro- and microelements, having the influence of good yield, and keeping yield on a good level. The aim of this study was to determine the effects of long-term alternate fertilization on yield and the changes of some features of mineral soils.

## METHODS

The studies were conducted during the years 1982-1994 in central Poland on Nizina Mazowiecka on the permanent meadow (specific black earth) in the moderate dry site with 62-140 cm level of ground water in vegetation period. The dominant species of grasses were: *Dactylis glomerata, Phleum pratense, Festuca pratensis, Poa pratensis, Festuca rubra, Agropyron repens*. The experiment was arranged by the method of randomized complete blocks in four replications. Four fertilizing combinations were applied: without fertilization, NPK, manure and alternate fertilization, i.e. in one year manure, in next NPK. The doses of fertilizers were as follows: "fresh" manure - 30 t/ha, N - 240, P - 33, K - 100 kg/ha. With manure applied in late autumn the following doses were introduced annually to the soil: 145 kg/ha N, P - 25, K - 172, Ca - 54, 32 - MgO i 25 kg/ha $Na_2O$. Before the establishment of this experiment: pH of soil, the level of organic matter and some macroelements: P, K, Na and Mg were evaluated. After 12 years once again the chemical analyses were made from layers: 0-10 and 10-20 cm (mean from 4 replication) that is: pH of soil, the content of organic carbon by Tiurin method, phosphorus (wanadic-molybdate method), potassium, calcium, sodium and magnesium (method of atomic absorption).

## RESULTS

**The hay yields**. During 12 years the highest yields were observed as a result of alternate fertilization (mean 9.44 t/ha) and mineral NPK (8.61 t/ha) with no significant difference during 9 years alternate fertilization (Table 1). Similarly in Wesolowski (1995) the highest yields of hay were obtained after manure application together with mineral fertilization NPK. The manure only fertilization (annually) gave yields significantly lower than those, obtained on previous combinations, although simultaneously significantly higher than the yields from plots without fertilization (only 2.80 t/ha). Even in very dry years, for example 1992, applied manure guaranteed the yield of 5.1 t/ha, or comparable with the yield obtained after NPK fertilization (6.14 t/ha).

**Changes in the soil**. After 12 years of intensive meadow utilization the highest acidification were observed in the plots fertilized yearly with NPK (Table 2) and a little lower in plots after alternate fertilization. The most favourable was manure fertilization; after 12 years the difference of $pH_{KCl}$ was only 0.24. Similar results were obtained by Dembek and Lyszczarz (1992) and Mikolajczak and Nowak (1992). Applied by them, manure showed the tendency to neutralize soils pH. On all plots the changes of reaction were usually in the top layer. Changes in the layer 10-20 cm were small. The content of carbon decreased in all plots. The biggest reduction of 32.97% in relation to the start content in 1982 was in the soil of plots not fertilized, and the lowest in the soil of plots fertilized with NPK, although the manure applied alternately with NPK and annually had a similar effect as NPK. The carbon decrease was observed usually from layer 10-20 cm, while in layer 0-10 cm the changes did not exceed 0.3% C. Similarly the lack of significant dependence between the content of humus and type of fertilization were stated by Skolimowski, Dembek and Lyszczarz (1988). The change of nitrogen content was the smallest on plots not fertilized, on the remaining plots the changes were similarly independent from the type of fertilization: increase of N content was about 28% and usually in the top layer. According Moraczewski (1996) the manure application has the influence on the increase of humus content in the soil, and hence it is probably rich in macro- and microelements, although obtained results of the study only partially confirmed this supposition. The manure and alternate fertilization caused lower changes in the content of magnesium and calcium than NPK. Under the influence of NPK the Mg content decreased by 76.3% and calcium by 82.6% compared with content at the beginning. This means that manure prevents the excess of some components, usually from the deeper layer. The phosphorus and sodium content decreased on all plots about 60% and 90% of the start content without difference from the type of fertilization and the deepness of the layer (also Mikolzajczak and Nowak, 1992). The content of potassium decreased by about 80% in all plots, which can be caused by the big intake by plants with high yield (NPK and alternate) or the presence of the papillionaceous (combination without fertilization and manure) taking the components from deepest layers of soil, and also probably

by washout to deepest layers of permeable mineral soil.

## CONCLUSIONS

1. Alternate fertilization was optimal with regard to the quantity and repeatability of yield.

2. Long-term mineral fertilization NPK caused higher acidification of soil than fertilization with manure and alternates. The changes of pH were usually in layer 0-10 cm.

3. The organic carbon content in soil decreased in all plots, although in the combination without fertilization the changes were the largest. The highest decrease of the carbon was in layer 10-20 cm.

4. The nitrogen content in soil after 12 years of study increased, but phosphorus, potassium, calcium, sodium and magnesium decreased in all the combinations. The decreases of components from soil were usually highest in the combinations with NPK rather than manure or alternate fertilization.

5. Applied manure (alternate also) prevents to some degree high excess of magnesium and calcium in the soil.

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**Table 1**
Hay yields in DM (in $t.ha^{-1}$) means in 1983-1994

| Years | Fertilizing combinations | | | | |
|---|---|---|---|---|---|
| | without fertilization | NPK | manure | alternate | LSD |
| 1983 | 1.67 | 5.53 | 3.26 | 3.43 | 0.66 |
| 1984 | 1.56 | 7.53 | 3.40 | 8.53 | 0.56 |
| 1985 | 3.60 | 9.73 | 7.54 | 9.33 | 1.27 |
| 1986 | 3.08 | 8.25 | 6.02 | 11.45 | 0.71 |
| 1987 | 3.51 | 8.25 | 7.07 | 8.16 | 1.22 |
| 1988 | 3.52 | 8.54 | 6.10 | 9.80 | 1.02 |
| 1989 | 4.23 | 10.87 | 8.47 | 11.82 | 1.39 |
| 1990 | 2.98 | 9.57 | 5.83 | 10.21 | 1.10 |
| 1991 | 3.13 | 10.63 | 7.74 | 11.31 | 2.10 |
| 1992 | 1.21 | 6.14 | 5.10 | 7.79 | 1.47 |
| 1993 | 2.89 | 8.77 | 7.00 | 9.56 | 0.97 |
| 1994 | 2.24 | 9.52 | 6.07 | 11.59 | 1.34 |
| Mean from years | 2.80 | 8.61 | 6.14 | 9.44 | |

**Table 2**
Reaction of soils pH and the concentration of particular fertilizing components in dependence from applied fertilization; layers 0-10 and 10-20 cm

| Component | Years | Soil layer cm | Fertilizing combinations | | | |
|---|---|---|---|---|---|---|
| | | | without fertilization | NPK | alternate | manure |
| $pH_{KCl}$ | 1982 | 0-20 | 4.45 | 4.40 | 4.43 | 4.73 |
| | 1994 | 0-20 | 4.07 | 3.69 | 3.84 | 4.49 |
| | | 0-10 | 3.97 | 3.43 | 3.61 | 4.33 |
| | | 10-20 | 4.16 | 3.94 | 4.06 | 4.64 |
| C,% | 1982 | 0-20 | 1.76 | 1.57 | 1.61 | 1.63 |
| | 1994 | 0-20 | 1.06 | 1.18 | 1.14 | 1.16 |
| | | 0-10 | 1.47 | 1.72 | 1.59 | 1.61 |
| | | 10-20 | 0.65 | 0.64 | 0.68 | 0.72 |
| $N_{total}$, mg/100 g of soil | 1982 | 0-20 | 90.0 | 100.0 | 90.0 | 90.0 |
| | 1994 | 0-20 | 105.3 | 128.3 | 117.8 | 118.8 |
| | | 0-10 | 142.3 | 182.6 | 166.3 | 163.4 |
| | | 10-20 | 68.2 | 73.9 | 69.2 | 74.1 |
| $P_2O_5$, mg/100 g of soil | 1982 | 0-20 | 80.0 | 80.0 | 80.0 | 80.0 |
| | 1994 | 0-20 | 33.2 | 30.1 | 36.7 | 28.1 |
| | | 0-10 | 54.4 | 39.5 | 49.8 | 28.0 |
| | | 10-20 | 12.0 | 20.6 | 23.5 | 28.1 |
| $K_2O$, mg/100 g of soil | 1982 | 0-20 | 220.0 | 260.0 | 240.0 | 260.0 |
| | 1994 | 0-20 | 45.0 | 41.3 | 47.1 | 51.1 |
| | | 0-10 | 46.7 | 41.3 | 52.0 | 53.9 |
| | | 10-20 | 43.2 | 41.3 | 42.2 | 48.2 |
| CaO, mg/100 g of soil | 1982 | 0-20 | 110.0 | 140.0 | 110.0 | 120.0 |
| | 1994 | 0-20 | 31.0 | 24.4 | 29.8 | 31.3 |
| | | 0-10 | 34.0 | 20.7 | 27.0 | 25.5 |
| | | 10-20 | 28.0 | 28.0 | 32.6 | 37.1 |
| $Na_2O$, mg/100 g of soil | 1982 | 0-20 | 70.0 | 70.0 | 70.0 | 70.0 |
| | 1994 | 0-20 | 7.0 | 7.6 | 7.3 | 7.6 |
| | | 0-10 | 6.4 | 7.6 | 7.9 | 7.6 |
| | | 10-20 | 7.5 | 7.6 | 6.7 | 7.5 |
| Mg,f mg/100 g of soil | 1982 | 0-20 | 100.0 | 120.0 | 110.0 | 100.0 |
| | 1994 | 0-20 | 31.9 | 28.4 | 44.7 | 39.5 |
| | | 0-10 | 36.4 | 27.2 | 35.8 | 32.5 |
| | | 10-20 | 27.4 | 29.6 | 53.5 | 46.4 |