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# LIQUID MANURE EFFECT ON PHYSICAL AND PHYSICO-CHEMICAL PROPERTIES OF SANDY SOILS

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Agricultural utilization of liquis manure (slurry) as an organic fertilizer causes often changes in the soil medium affectic the formation of physical and physico-chemical properties of soil. These changes are different, depending on the mechanical composition and morphology of soil profile [1, 2, 6, 9]. In view little number of works dealing with this problem, the aim of our investigations was to determine the effect of differentiated cattle liquid manure rates on some properties of sandy soil.

The investigations were carried out within the problem "Liquid manure effect on properties of soils" in an experiment established at the Experiment Station Swojec by the Section of Soil Tillage of the Department of Soil Tillage and Cultivation of Plants, Agricultural University of Wrocław.

## OBJECT AND METHODS OF THE INVESTIGATIONS

The object of investigations constituted typical river alluvial soils developed from weakly loamy sands with loose sands typical silty formations and light loams in the parental material. Liquid manure was applied in the first year in spring and in subsequent years in autumn after the harvest of crops at the rates: 0, 40, 80, 160 and 240 $m^3$ per hectare. They were mixed with soil by means of shallow ploughing and then medium ploughing was carried out. Sunflower, winter rape and post-harvest mixture were comprised with the crop rotation.

Material for detailed investigations were soil samples taken in the second year of the experiment after threefold application of liquid manure at the rates as above. They were taken in autumn 1978 after the catch crop harvest from two depths with the total thickness of

0–35 cm, where in total 120, 240, 480 and 720 $m^3$ of liquid manure per hectare were introduced into soil. Laboratory determinations were carried out by the methods generally applied in the pedologic investigations

## DISCUSSION OF RESULTS

P h y s i c a l p r o p e r t i e s. Investigations on physical properties of the soils under study proved a distinct dependence of these properties on the fertilization with liquid manure (Table 1). Along with the growth of liquid manure rates specific density in the arable layer decreased from 2.64 to 2.45 $g \cdot cm^{-3}$ and bulk density — from 1.57 to 1.38 $g \cdot cm^{-3}$. In deeper layer of 25–35 cm no changes of specific density were found, whereas bulk density increased from 1.65 up to 1.81 $g \cdot cm^{-3}$. Total porosity was inversely proportional to bulk density. On the control plot in the upper layer to 40.5%, increasing up to 43.7% in the treatment with the highest liquid manure, whereas in the deeper layer it dropped from 37.7% to 32.2% of total porosity. Along with the growth of liquid manure rates the number of so-called air pores of >3000 μm in dia decreased by 5.6% in the upper layer and by 2.3% in the deeper layer. Also the number of pores of 3000–30 μm in dia decreased from 15.0 to 11.0% in the arable layer and from 14.4 to 5.7% in the deeper layer. On the other hand, an increase of the number of pores of 30–3 μm in dia in the upper layer from 5.2% on the control plot up to 9.5% in the treatment with the highest liquid manure rate has been found. In the deeper layer the number of these pores decreased. Similar results were obtained in the investigations of B r o g o w s k i and B o r e k [4].

In consequence of the pore structure differentiations favourable changes in the field water capacity and in the amount of water accessible to plants took place. The fertilization with liquid manure caused an increase of the field water capacity in the upper layer of soil profiles from 11.6% on the control plot up to 23.3% in the treatment with the highest liquid manure rate. Similar results were observed also in the deeper layer, where the field water capacity increased from 10.7% up to 16.2%. While comparing soils from plots fertilized with increasing liquid manure rates with the control treatment, an increase of the amonut of water accessible to plants in the arable layer by 2.8, 3.8, 6.5 and 8.1% and in the deeper layer accordingly by 3.6, 2.3, 6.2 and 6.1% has been found.

P h y s i c o - c h e m i c a l p r o p e r t i e s. While analyzing the effect of differentiated fertilization with liquid manure on lines of changes of the sandy soil reaction, a remarkable increase of pH from very acid to slightly acid one along with increasing liquid manure rates should be stressed (Table 2). The above soil reaction changes are reflected in

Table 1

Physical properties of sandy soil fertilized with differentiated liquid manure rates

| Liquid manure rate $m^3$/ha | Sampling depth cm | Density, $g.cm^{-3}$ | | Total porosity % | Percentage of effective pores of μm in dia | | | | | Maximum hygroscopicity Wh % | Water capacity vol.% | | Water content in vol.% | | Increment of water accessible to plants in mm in the layer of 0.35 cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | specific | bulk | | > 3000 | 3000- - 30 | 300- - 30 | 30- -10 | 10- - 3 | | maximum capillary | field | Wd accessible | unaccessible H | |
| 0+NPK | 5-15 | 2.64 | 1.57 | 40.5 | 10.2 | 2.0 | 13.0 | 3.3 | 1.9 | 1.2 | 30.3 | 11.6 | 9.2 | 2.4 | 0 |
| | 25-35 | 2.65 | 1.65 | 37.7 | 9.5 | 1.1 | 13.3 | 2.7 | 1.3 | 1.2 | 28.2 | 10.7 | 8.3 | 2.4 | |
| 40 | 5-15 | 2.63 | 1.55 | 41.1 | 11.6 | 1.1 | 11.2 | 2.2 | 1.3 | 1.0 | 29.5 | 14.0 | 12.0 | 2.0 | 10.6 |
| | 25-35 | 2.65 | 1.66 | 37.4 | 8.7 | 0.3 | 11.7 | 2.4 | 1.4 | 1.1 | 28.7 | 14.1 | 11.9 | 2.2 | |
| 80 | 5-15 | 2.62 | 1.52 | 41.9 | 12.9 | 0.5 | 9.5 | 3.6 | 1.1 | 1.1 | 29.0 | 15.2 | 13.0 | 2.2 | 13.1 |
| | 25-35 | 2.66 | 1.69 | 36.5 | 12.1 | 0.7 | 9.1 | 2.2 | 1.2 | 0.9 | 24.4 | 12.4 | 10.6 | 1.8 | |
| 160 | 5-15 | 2.64 | 1.49 | 43.5 | 11.3 | 0.1 | 10.5 | 2.5 | 3.4 | 1.2 | 32.2 | 18.1 | 15.7 | 2.4 | 22.4 |
| | 25-35 | 2.66 | 1.67 | 37.2 | 7.2 | 0.0 | 10.0 | 2.8 | 2.7 | 0.9 | 30.0 | 16.3 | 14.5 | 1.8 | |
| 240 | 5-15 | 2.45 | 1.38 | 43.7 | 4.6 | 1.5 | 9.5 | 4.5 | 4.0 | 2.5 | 39.1 | 22.3 | 17.3 | 5.0 | 26.3 |
| | 25-35 | 2.67 | 1.81 | 32.2 | 7.2 | 0.5 | 5.2 | 2.6 | 1.2 | 0.9 | 25.0 | 16.2 | 14.4 | 1.8 | |

T a b l e 2

Some physico-chemical properties of sandy soil fertilized with differentiated liquid manure rates

| Liquid manure rate $m^3$/ha | Sampling depth cm | pH | | $H_n$ | Exchangeable cations | | | | Sum of exchangeable cations S | Sorption capacity T | Saturation degree with cations V% | Percentage of exchangeable cations in the sorption capacity | | | | C % | N % | C/N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $H_2O$ | KCl | | Ca | Mg | K | Na | | | | Ca | Mg | K | Na | | | |
| | | | | me per 100 g of soil | | | | | | | | | | | | | | |
| 0+NPK | 5-15 | 4.9 | 4.0 | 3.15 | 0.33 | 0.57 | 0.43 | 0.06 | 1.39 | 4.61 | 30.1 | 7.1 | 12.4 | 9.3 | 1.3 | 0.982 | 0.08 | 12.3 |
| | 25-35 | 4.7 | 3.6 | 3.37 | 0.31 | 0.55 | 0.17 | 0.07 | 1.10 | 4.47 | 24.6 | 6.9 | 12.3 | 3.8 | 1.6 | 0.468 | 0.08 | 5.8 |
| 40 | 5-15 | 5.4 | 3.8 | 2.85 | 0.40 | 0.62 | 0.45 | 0.06 | 1.53 | 4.38 | 34.9 | 9.1 | 14.1 | 10.3 | 1.4 | 0.987 | 0.09 | 11.0 |
| | 25-35 | 5.6 | 4.4 | 2.92 | 0.43 | 0.60 | 0.16 | 0.06 | 1.25 | 4.17 | 29.9 | 10.3 | 14.4 | 3.8 | 1.4 | 0.433 | 0.06 | 7.2 |
| 80 | 5-15 | 5.8 | 4.4 | 2.88 | 0.34 | 0.75 | 0.76 | 0.07 | 1.92 | 4.80 | 40.0 | 7.1 | 15.6 | 15.8 | 1.5 | 0.895 | 0.08 | 11.2 |
| | 25-35 | 4.6 | 3.3 | 3.22 | 0.17 | 0.62 | 0.23 | 0.05 | 1.07 | 4.29 | 24.9 | 4.0 | 14.4 | 5.3 | 1.2 | 0.638 | 0.06 | 10.6 |
| 160 | 5-15 | 6.7 | 5.3 | 2.02 | 1.34 | 1.11 | 0.99 | 0.13 | 3.57 | 5.59 | 63.8 | 24.0 | 19.8 | 17.7 | 2.3 | 1.084 | 0.10 | 10.8 |
| | 25-35 | 5.1 | 3.9 | 3.00 | 0.64 | 1.08 | 0.42 | 0.12 | 2.26 | 5.26 | 43.0 | 12.2 | 20.5 | 8.0 | 2.3 | 0.870 | 0.07 | 12.4 |
| 240 | 5-15 | 6.9 | 6.1 | 1.65 | 2.14 | 0.60 | 0.89 | 0.12 | 3.75 | 5.40 | 69.4 | 39.6 | 11.1 | 16.5 | 2.2 | 1.011 | 0.10 | 10.1 |
| | 25-35 | 6.3 | 4.8 | 2.40 | 1.33 | 0.43 | 0.57 | 0.14 | 2.47 | 4.87 | 50.7 | 27.3 | 8.3 | 11.7 | 2.9 | 0.477 | 0.07 | 6.8 |

the formation of some sorption properties of soil. Along with increasing liquid manure rates the amount of hydrolytic hydrogen ions distinctly decreased. It varied in the layer of 5–15 cm from 3.15 me per 100 g of soil in the control treatment to 1.65 me per 100 g of soil after the threefold liquid manure application in the total amount of 240 m$^3$ per hectare. Such dependence has been confirmed in the investigations of Warta, Kukurenda and Maćkowiak [8]. Some authors [3, 5], however, have found an increase of the concentration of hydrogen ions under the liquid manure fertilization effect, what was connected to a considerable extent with soil kind and local conditions.

Among exchangeable cations significant changes were observed in the calcium and potassium content (Table 2). The percentage of exchangeable calcium in the sorption complex increased quite distinctly on the plot with the highest liquid manure rate (39.6%) as compared with its content in soil of the control treatment (7.1%), Similar changes were found also in the content of exchangeable potassium, the percentage of which in the sorption complex of control soil amounted to 9.3% and increased up to 16.5% in soil fertilized with the liquid manure rate of 240 m$^3$ per hectare. In the deeper layer of 25–35 cm the percentage of exchangeable potassium in the sorption complex increased even threefold, what proved the translocation of this cation deeper into the soil profile. A rather intensive potassium accumulation reaching the critical concentration of this cation in the sorption complex of soil fertilized with high liquid manure rates can lead to a decrease of the calcium and magnesium availability to the plants cultivated [2, 7, 9]. Of that the accumulation of Ca ions in the sorption complex of soils fertilized with high liquid manure rates can bear evidence (Table 2).

Changes occurring in the sorption complex composition were reflected in a growth of the sorption capacity of the soils analyzed, caused by the enrichment of soils fertilized with liquid manure in humic compounds. The total carbon content increased with increasing liquid manure rates, exept or the treatment with 80 m$^3$ of liquid manure per hectare, amounting to 0.98% in the NPK treatment and to 1.01% where the liquid manure rate of 240 m$^3$ per hectare was applied. The C/N ratio, instead, showed a narrowing tendency in the fertilized objects, what proved a rapid mineralization of the liquid manure organic matter.

## CONCLUSIONS

1. The threefold sandy soil fertilization with liquid manure led to considerable changes in the structure of pores. In connection with these changes a very favourable growth of water accessible to plants took place, consisting in treatments of fertilization with liquid manure of the following water amounts: 40 m$^3$ per hectare — 10.6 mm, 80 m$^3$ per

hectare — 13.1 mm, 160 $m^3$ per hectare — 22.4 mm, 240 $m^3$ per hectare — even 26.3 mm.

2. Under the liquid manure application effect soil reaction changed from very acid in the control treatment to sligtly acid one at the highest liquid manure rate, what manifested itself in successive decrease of the number of hydrolytic hydrogen ions.

3. The fertilization with liquid manure led to an almost threefold increase of the sum of exchangeable cations, mainly in consequence of a growth of the percentage of Ca and K ions.

4. The soil sorption complex saturation with basic cations increased with the amount of the liquid manure applied and was twice higher in the treatment with its highest rate than on the control plot.

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## WPŁYW GNOJOWICY NA WŁAŚCIWOŚCI FIZYCZNE I FIZYKOCHEMICZNE GLEBY PIASZCZYSTEJ

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### Streszczenie

Zasadniczym celem badań było określenie wpływu zróżnicowanych dawek gnojowicy na niektóre właściwości mady rzecznej piaszczystej. Stosowanie gnojowicy w dawkach: 0, 40, 80, 160 i 240 $m^3$/ha, pod słonecznik, rzepak ozimy i mieszankę poplonową spowodowało korzystne zmiany w strukturze porów. Uzyskano przyrost ilości wody dostępnej dla roślin odpowiednio o: 10,6, 13,1, 22,4 i 26,3 mm. Odczyn analizowanych gleb zmieniał się od bardzo kwaśnego na obiekcie kontrolnym, do lekko kwaśnego przy najwyższej dawce gnojowicy. Stwierdzono też prawie trzykrotne zwiększenie się sumy kationów zasadowych w glebie, głównie wskutek udziału Ca i K, co znalazło swoje odbicie we wzroście wysycenia kompleksu sorpcyjnego kationami zasadowymi.

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