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Soil compaction and oxygen in soil

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1 Introduction

Nowadays drip irrigation has gained more important in agriculture and has been used very intensively on the fields. Although this is a more sustained way to irrigate the plants, it limits oxygen availability for plant roots by creating a nearly saturated condition. Furthermore, high soil compaction also affects the amount of oxygen content in soil which changes gas exchange. In general, gas exchange is also affecting growth and activity of roots and soil organisms, and leading to an alteration of chemical processes (Ampoorter et al., 2010). For instance, N fertilization has significant effect on microbial CO_2 respiration and communities functioning. This was also proved by laboratory incubation experiments (Kowalenka et al., 1978).

In Summary soil compaction involves the compression of pores, which leads to decreased porosity, increase in dry bulk density and reduce hydraulic conductivity.
The questions of this short experiment were “Soil with organic manure has more oxygen depletion rate than soil without manure” and “Soil managed with organic fertilizer contains lower bulk density”.

2 Materials and Methods

Six samples were collected on 26th of June 2017 from the long-term fertilization experiment-site IOSDV in Tartu. Two samples were collected from the same field without organic fertilizers and without manure, two from the same field but with manure. And the last two samples were collected from the field with an alternative organic fertilizer.

The samples were collected in metal cylinders from five centimetres under the surface and these were put in plastic cups. The second part was in the laboratory. First, the samples were weighted and after that all samples were flooded with double distilled water (ddH2O) until the complete soil was saturated. All samples got an oxygen sensor through the plastic lid. For the measurement, the “FIBOX LCD” was used. Periodically, measurements were recorded. When the reading came to zero, the water from the plastic cups were removed manually.

Then the samples were kept on filter paper and the plastic lids were left half open to test the speed of re-aeration. Successively the readings were recorded. After all the measurements have been taken, all wet samples were re-weighted. To measure dry bulk density, the soil has to be oven-dry. Therefore, samples were kept in an incubator at 105_C for 24 hours. Finally the dry soils were weighted again.

3 Results

In the following Figure 3.1, the results are shown for the changing of the oxygen levels. The oxygen concentration in all wet soils decreased in the first 17 hours however, the next two days it was stable. On the 1st of July the samples were reaerated at 11 o'clock. The soil without any fertilizer (beginning value 7.1 mg/l) showed a steep increasing (7.6 mg/l). Then it was on the same level for a brief time before it drastically declined until 0 mg/l. The Inorganic nitrogen fertilized sample (beginning value 8.0 mg/l) was stable as well until 1st of July, 16:30. After that it increased until the end of the experiment (6.2 mg/l). The last sample with organic manure and nitrogen (beginning value 7.7 mg/l) showed no reaeration until the end (0 mg/l).

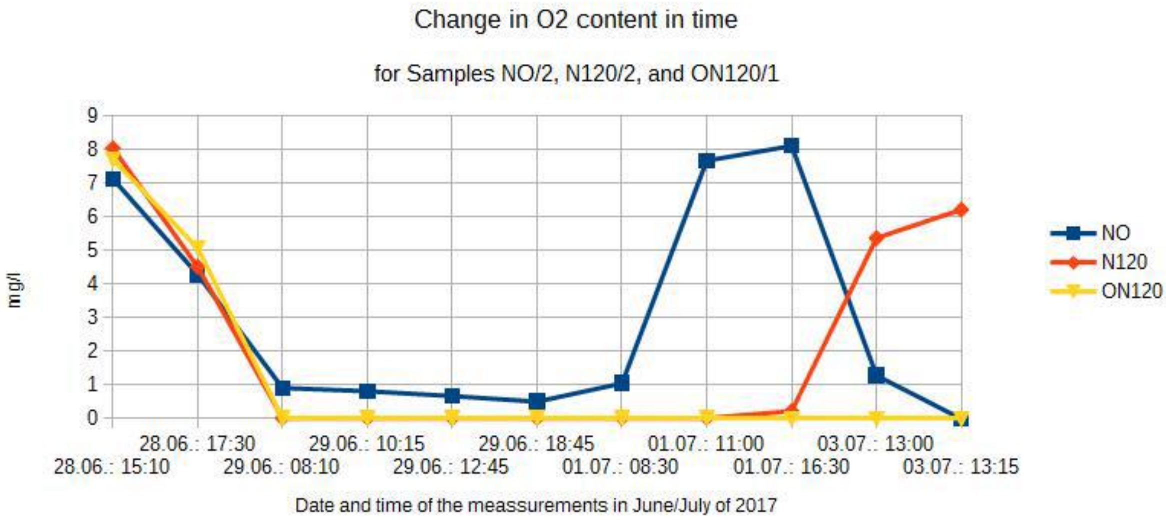

Figure 3.1: Changing of the oxygen rate in time. NO – no fertilizer, N 120 – inorganic nitrogen (120 kg N/ha) fertilizer and ON 120 – alternative manure nitrogen (120 kg N/ha) fertilizer

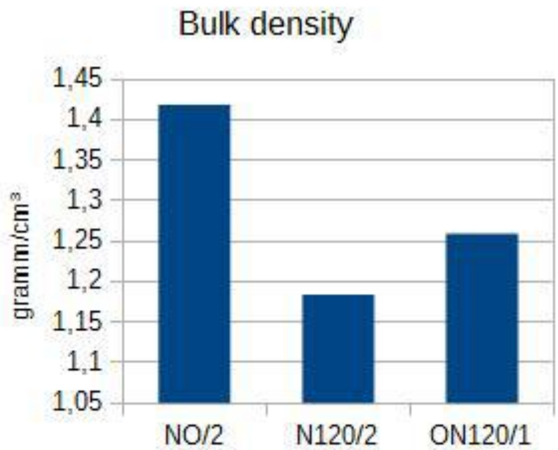

Figure 3.2: Dry bulk density. NO – no fertilizer, N 120 – inorganic nitrogen (120 kg N/ha) fertilizer and ON 120 – alternative manure nitrogen (120 kg N/ha) fertilizer.

Figure 3.2 depicts the dry bulk density (BD). For NO BD the value was 1.4 g/cm^3 for the other two samples the values were smaller. The value for NO 120 was 1.2 g/cm^3 and for ON 120 was 1.25 g/cm^3.

In Figure 3.3 the maximum water holding capacity is shown. The samples NO, NO 120 and ON 120 had 30.3 %, 31.3% and 33.3 %, respectively.

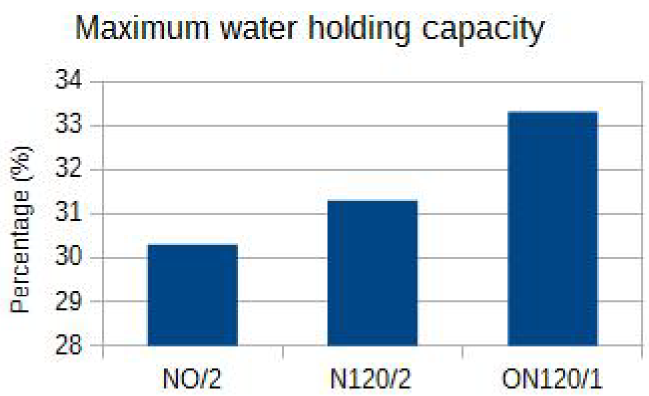

Figure 3.3: Maximum water holding capacity. NO – no fertilizer, N 120 – inorganic nitrogen (120 kg N/ha) fertilizer and ON 120 – alternative manure nitrogen (120 kg N/ha) fertilizer.

The Table 3.1 summarizes variables that are important for soil compaction, which goes respectably in line together. The less the particle density correlated with higher porosity and maximum water holding capacity.

Table 3.1: Different soil compaction variables. NO – no fertilizer, N 120 – inorganic nitrogen (120 kg N/ha) fertilizer and ON 120 – alternative manure nitrogen (120 kg N/ha) fertilizer.

	NO	NO 120	ON 120
particle density in g/cm3	2.04	1.72	1.88
porosity in %	30.7	31.3	33.2
maximum water holding capacity in %	30.3	31.3	33.3

4 Discussion

All three samples showed instant decreasing in oxygen concentration suggested that water created pressure on the air in the soil which lead to escape it from the soil. This can be proved also in the stable phase afterwards where there cannot be any significant different seen.

After reaeration, the air can get inside of the soil and provides more oxygen concentration increased again. Kowalenka et al., (1978) suggested that nitrogen fertilizer has an influential effect on microbial communities. This can be seen in the results where the oxygen concentration increased fast in the sample without fertilizer because the microbial activity was presumably lower. In the sample with just nitrogen fertilizer the microbial activity was better than in the sample without fertilizer. But only in the sample with nitrogen and organic manure did not show any changes in the oxygen concentration due to higher microbial activity. However, there is still a need to optimize the method as there were problems in enclosing air bubbles in front of the sensor. Furthermore, moving the sensors during the measurement could cause its shift into soil parts still anoxic (c.f. Fig. 3.1., sample NO).

The bulk density and the maximum water holding capacity showed a negative relationship. The higher the bulk density, the less the porosity which lead to less water holding capacity. The particle density correlated with the porosity.

5 Conclusion

Irrespectively the soil properties, in flooded soils the water replaces the air in the pores so there is nearly no oxygen left. There wasn't any substantial change in reaeration for organic manure with mineral N fertilized soil. Its most likely due to the microbial activities in the soil Addicted to mineral nitrogen fertilizer with manure, there is a lower bulk density and a higher water holding capacity. , which depends on soil composition.

In the end, the first hypothesis could not be proved in the depletion rate but there was no increase in the oxygen rate in the soil managed with manure while reaeration. Just like the first hypothesis the second was not able to be proved: the bulk density was not lower in soil with the organic fertilizer.

6 References

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