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Articles in this issue

Tillage in the growing season is ineffective as a tool of increased soil N mineralization

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Introduction

Soil tillage serves a number of purposes such as control of weeds, incorporation of crop residues and manures, and maintenance or improvement of soil mechanical properties, including seedbed preparations. As a side-effect, soil tillage may affect turnover of organic matter (OM) by changing the particle size and spatial distribution of crop and manure residues in soil and by increasing the intimacy of residue/soil contacts. By breaking soil structural elements, tillage may contribute further to N mineralization by exposing physically protected organic matter to microbial turnover. Therefore, adjusting the time, intensity and frequency of soil tillage operations may enable optimization of synchrony, defined as the matching through time of N availability and crop N demand. This idea was experimentally investigated in the present study.

Tillage and organic amendment strategies

The potential of adjusting soil N mineralization by soil tillage in the growth season was investigated in two years (2002-2003) on two different fields with winter wheat on a coarse sandy loam. The wheat was sown at 25 cm row spacing on plots where four different organic matter strategies regarding pig slurry application, straw incorporation and catch crop growing **(Table 1)** had been applied for the previous 13 years. Soil tillage was carried out between the rows in May in the two years with a row cultivator, a power take-off (PTO) driven row rotovator or a brushweeder. Reference plots were left undisturbed during the whole growing season. Soil for analysis of effects on N dynamics were samples in the treated soil volume between the rows.

Root damage increases soil N

The three soil tillage techniques caused a higher inorganic N level in soil **(Figure 1)**. When averaged over the four organic matter levels, the maximum differences between disturbed and undisturbed soil were 9.1 µg N per g soil. Assuming that half of the soil volume was affected by the tillage, the extra inorganic N corresponded to about 10 kg N per ha present in the upper 15 cm soil.

Despite the clear differences in soil inorganic N content found in the soil sampled continuously in the field, a 15-N pool dilution experiment carried out in the same year showed no consistent effect of tillage on the gross nitrogen mineralization and immobilization processes in soil. The higher inorganic N content in disturbed soil in the field was therefore assumed to result from reduced crop N uptake rather than an increased N

mineralization. The inorganic N in tilled soil was accordingly derived mainly from regular soil N mineralization and only accumulated because crop N uptake from the treated soil volume was reduced as a result of root damage.

Differences between years

In 2002 the higher inorganic N levels after the three soil tillage techniques lasted for the whole sampling period (28 days) whereas effects of soil tillage were of much shorter duration in 2003 **(Figure 1)**. Precipitation was rather low in 2002 and the soil was therefore generally drier than in 2003. The shorter effect of soil tillage in the wetter soil in 2003 was probably caused by more favourable conditions for regrowth of roots into the disturbed soil thereby reducing the inorganic N content. The drier soil in 2002 may have impeded a similar fast root regrowth and the dry conditions would prevent downward water movement that could also have resulted in crop uptake of the inorganic N from the disturbed soil layer.

Dry matter yield

Dry matter yield and N uptake in the wheat biomass harvested in the first four weeks after tillage were not affected by the soil tillage **(Figure 2)**. Thus, the extra soil N present in the weeks after tillage had no influence on wheat growth during the same period. The lack of negative response to the soil tillage indicates that the wheat grown in the disturbed plots could compensate for the inorganic N not taken up by roots in the disturbed soil. Also, as no negative effects were seen, the tillage machinery did not seriously injure the plants during the soil tillage operation.

Grain yield and N uptake

After the row cultivation in May, grain yield of the mature winter wheat harvested in 2002 was lower than after the row rotovation and the brushweeder **(Table 2)**. However, none of the three soil tillage techniques differed significantly from the undisturbed soil. In 2003, grain yield was highest after the brushweeder whereas the two other soil tillage techniques did not differ from undisturbed soil.

The highest grain N uptake in 2002 was obtained after the row rotovator and the brushweeder whereas soil tillage did not influence grain N uptake in 2003 **(Table 2)**. There was apparently no effect of soil tillage on wheat grain quality, as the N concentration of the wheat grains in both years was unaffected by the soil tillage.

Conclusion

On a field with annual ploughing, soil tillage carried out in the growing season does not seem to effectively stimulate soil N mineralization for neither the recently applied organic matter nor old organic matter. Therefore, soil tillage operations on such fields carried out with the purpose of increasing N mineralization cannot be recommended.

About DARCOFenews | **Archives** | **DARCOF** | **Front**