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Newsletter from Danish Research Centre for Organic Farming • June 2005 • No. 2

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Catch crops have little effect on P and K availability of depleted soils

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It is a well-known fact that catch crops have a significant effect on availability and loss of soil inorganic nitrogen (Thorup-Kristensen et al., 2003) and recently marked effects on soil inorganic sulphur dynamics have also been shown (Eriksen and Thorup-Kristensen 2002; Eriksen et al., 2004).

However, we know much less about the effect of catch crops on phosphorous (P) and potassium (K) mobilisation and availability for the next crop. After several years of organic cash crop production, e.g. vegetables and cereals, yield levels may gradually be limited by soil P and K availability, depending on the initial status at conversion to organic production principles. This is particularly the case during the establishment phase of certain vegetable cultures with a limited rooting system (e.g. lettuce, leeks, onions).

Therefore, it has often been hypothesized that certain catch crops are capable of increasing the availability of P and K when the soil status becomes low.

In the **VegCatch** subproject **'Catch crops as a tool for increasing P bioavailability in soils'** we have therefore studied the ability of different catch crop species to mobilise and take up P and K from soils of low availability, as well as the ability of the catch crops deliver P and K to the subsequent main crop.

Long-term field trials without P and K fertilisation

Field testing of catch crop ability to mobilise and take up P and K, generally requires an experimental site with low levels of available soil P or K. However, most Danish arable soils are high in available P and K due to excessive fertilisation with inorganic fertilisers and animal manures for decades.

Fortunately, at the KVL Experimental Research Farm we have a long-term Nutrient Depletion Trial (see photo) - a site which did not receive any P or K containing fertilisers or manures in the period from 1964 to 1995.

Photo: The long-term Nutrient Depletion Trial at the KVL Experimental Research Farm.

In this period the field was managed with continuous cereal production, and the available P and K levels became relatively low (Olsen-P of 11 mg/kg and exchangeable K of 55 mg/kg) over these more than 30 years of depletion. The soil is a sandy loam (15% clay, 18% silt, sand 65%, organic matter 2%, C/N = 9).

In 1996 a new experimental design was applied in part of the field, with two

more varied crop rotations and seven nutrient application treatments. We selected three of these treatments for catch crop testing: 0P and 0K, 0P and 60K, 10P and 60K (numbers referring to kg/ha of P or K). All these treatments were fertilised with the same relatively moderate amount of N (60 kg/ha).

Five catch crop species, Ital. Ryegrass, Lupine, Chicory, Rumex, Kidney Vetch and a control treatment without catch crop were tested in the field experiment. The catch crops were undersown in spring barley and not incorporated until the following winter/spring. A new spring barley crop was then sown. The variety used (Otira) is known to be less efficient in soil P mobilisation (due to relatively short root hairs) and therefore should respond well to any increase in P availability. The field experiment was carried out twice, first in 2001-2002 with a spring cereal as preceding crop and in 2002-2003 with a 2-y grass-clover pasture as preceding crop. Four replicates were applied.

Biomass production and N, P and K uptake of the catch crops in late autumn and the main crop two or three times in the initial growth stages and once at harvest was measured. In addition, the catch crop effect on autumn mineral N content was measured.

Small differences in catch crop ability to take up P and K

The catch crops did not grow very well on this relatively infertile soil and did not reach a very high biomass production (1-2 tons dry matter/ha in late autumn) in either of the experimental years.

The nutrient uptake was only about 20-30 kg N, 2-4 kg P and 15-30 kg K/ha, regardless of fertilization treatment, which in many cases was less than twice the amount in weeds and stubble of the control treatment **(Figure 1)**. The N-fixing catch crops performed only marginally better, more so in the second experimental year (2002) where catch crops were generally better established.

This relatively low biomass production was possibly due to the infertility of the soil and its limited capability for N mineralization. This is evident from the relatively low levels of soil nitrate found without catch crops (control treatment) in the autumn; soil mineral N to 100 cm was only about 30 kg N-min/ha in November 2001 and about 20 kg N-min/ha in 2002.

Nevertheless, there is a clear difference in the ability of the catch crop species to retain and take up this small amount of nitrate N susceptible to leaching **(Figure 2)**. The two N-fixing catch crops, Lupine and Kidney vetch, had no effect on the nitrate content, whereas Ryegrass and Chicory took up a large proportion of the nitrate, and in particular Chicory depleted the deeper soil layers very effectively in both experimental years.

Catch crops do not increase P and K availability and uptake of the succeeding crop

We did not observe any significant effects of the catch crops on grain yield or grain N, P and K content of the subsequent spring barley in either of the experimental years. Barley P and K deficiency symptoms were observed and it is clear from **Figure 3** that a significant yield increase (36-49 pct) was produced by fertilisation with K (with or without P) compared to no P or K application.

Barley P uptake in the first experimental year was particularly low in all treatments (2-3 kg P/ha in grain, see **Figure 3**), even with the relatively moderate yield level, probably caused by adverse growth conditions this year and the low ability of the barley variety to acquire soil P. In the second experimental year growth conditions were better and the preceding grass-clover pasture probably also contributed to the higher potential yield level.

The barley P uptake pattern following the different catch crops **(Figure 4)** reveals that there was a weak tendency (not significant though) for better P uptake after the catch crops in the early growth stages of 2002, but this disappeared at the later growth stages and was not the case in any growth stage of the second experimental year. Thus, we did not find any indications that the incorporated catch crops mobilised soil P or enhanced barley P uptake early in the growing season.

A paradox about soil fertility

It may seem like a paradox that establishing productive catch crops may be

difficult on relatively infertile and depleted soils, where improved nutrient cycling by such catch crops is most highly demanded. Our experiments confirm that even under relatively infertile growth conditions, Chicory seems to be an unusually efficient catch crop for deep soil nitrate-N, much better than Ryegrass and the N-fixing catch crops. Even then, there were no significant effects of any of the catch crops on yield, or N, P or K uptake of the barley, so this difference in catch crop nitrate depletion did not carry over to the succeeding crop.

We can conclude that if we are not capable of establishing a really productive catch crop on infertile soil, we are not likely to succeed in improving the P and K supply for the main crops on these depleted soils. Whether highly productive catch crops grown on more fertile soils actually play a significant role in the cycling of P and K still remains unresolved though.

References

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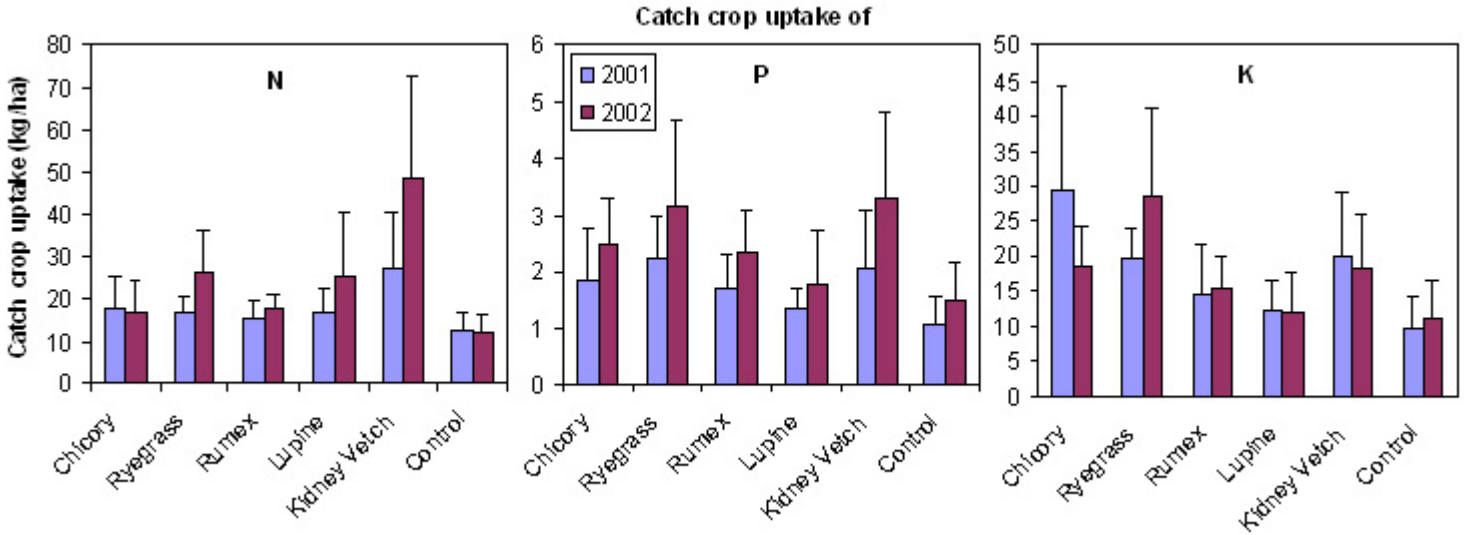

Figure 1. Catch crop uptake of N, P and K measured in autumn (November) of the two experimental years where the catch crops were undersown in barley. Control treatment (no catch crop) values are for weeds and stubble. Means across fertilisation treatments (no significant differences).

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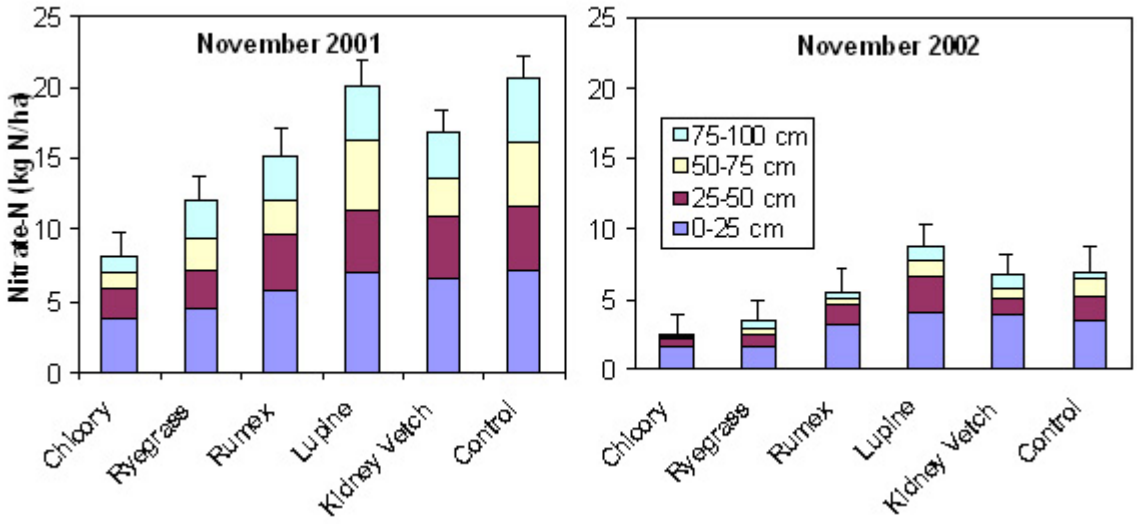

Figure 2. Catch crop effects on soil profile nitrate-N content, measured in autumn (November) of the two experimental years where the catch crops were undersown in barley. Means across fertilisation treatments (no significant differences).

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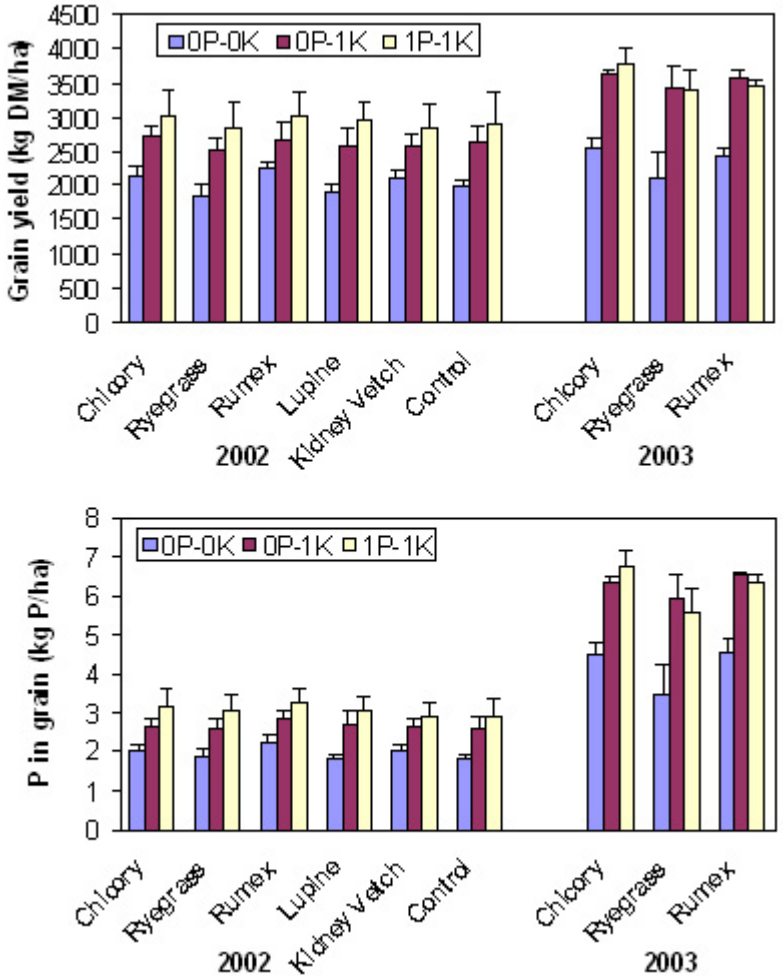

Figure 3. Grain yield (dry matter) and grain P content of the spring barley grown after incorporation of the different catch crop treatments in 2001 and 2002, respectively (in the second experiment, measurements were only made after Chicory, Ryegrass and no catch crop), and in the 3 fertilisation treatments (1P = 10 kg P/ha and 1K = 60 kg K/ha applied).

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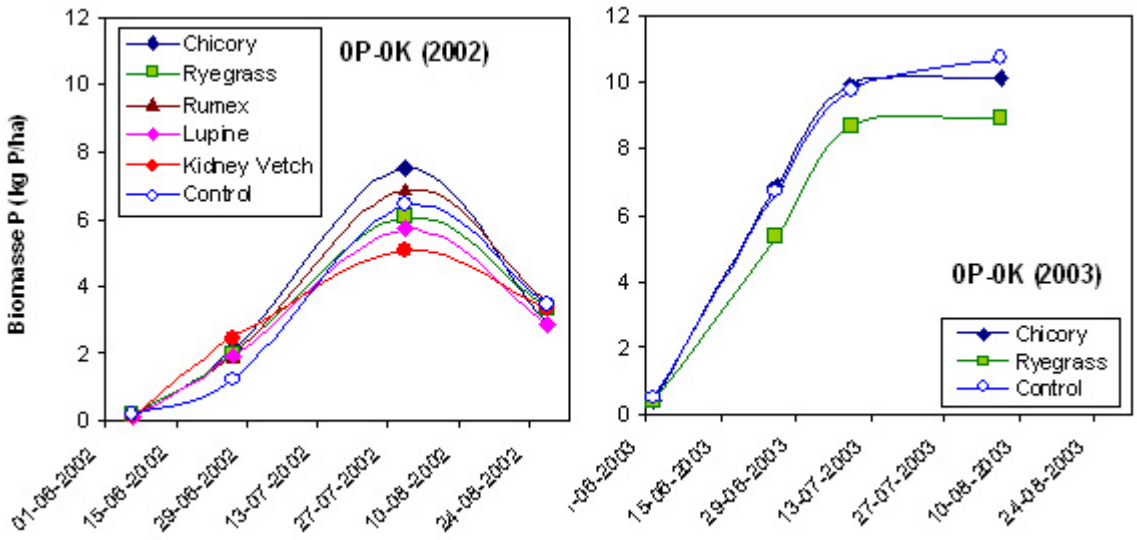

Figure 4. P uptake pattern over the growing season of the spring barley grown after incorporation of the different catch crop treatments in 2001 and 2002, respectively (in the second experiment, measurements were only made after Chicory, Ryegrass and no catch crop) in the fertilisation treatment without P or K application (0P-0K).