Learning in context – improved nutrient management in arable cropping systems through participatory research

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Abstract

Participatory research (PR) provides opportunities to build knowledge relevant to site-specific farms conditions. This study used a PR approach to develop nutrient management strategies in stockless organic farming. A thorough problem identification process was carried out and the problem prioritised was how to combine preceding crop effects with fertilisation strategy in crop rotations. On-farm fertiliser (biogas digestion residues, chicken manure and meat-bone meal) experiments were conducted in spring wheat and winter rapeseed. Significant yield responses were achieved in spring wheat, up to 1200 kg ha^{-1}, and they were higher than in rapeseed. The implications of the results for nutrient management at crop rotation level are discussed.

Introduction

Learning in context is a process of gathering information and developing knowledge relevant to specific situations, such as site-specific conditions on farms (Eshuis & Stuiver, 2005). Participatory research (PR) is a tool to address relevant problems and facilitate technology transfer (Poudel *et al*., 2000). Sustainable practices need to be implemented on farms by farmers and can be improved by involving farmers in the research process.

The background to the present project was the lack of knowledge on sustainable nutrient management strategies in stockless organic farming, since low nutrient use efficiencies (NUE) have been reported (Olesen *et al.,* 2007). Studies on optimal combinations of crop rotations and fertilisation strategies that include preceding crop effects and manuring are scarce. Participatory research was considered to be a suitable approach to address the complexity of nutrient management at the cropping system level. A PR project was started in 2006 and will end in 2008. Some of the results are reported in this paper.

Materials and methods

A group of six farmers with similar organic production systems in southern Sweden were selected to form a PR group together with an advisor and a researcher. In PR, identification and prioritisation of a common problem is central (Fujisaka, 1989). In this project, although we had specific funding for nutrient management studies we initiated

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a broad process of problem identification and used communication facility tools such as drawing problem-trees and solution-trees of high complexity to highlight biological and socio-economic issues. Each of the six farms was thoroughly described by the farmer, and problems and future possibilities of the individual farms were discussed and documented.

The cropping systems on the farms consisted mainly of spring cereals, one-year clover-grass green manure (GM) leys, winter rapeseed and green peas. The nutrient management strategies differed among the farms, from a strategy of no inputs of nutrients from outside the farm except N_2 fixation to inputs of nutrients replacing outputs and further on to 'inputs to get high yields'. Different kinds of manure and organic fertilisers based on food industry waste products were used.

Field experiments were conducted on the farms in 2006 and 2007. The experiments were managed in cooperation between the farmers and the local Agricultural Society. Here we briefly describe two fertilisation experiments in 2007 on two sites: spring wheat (*Triticum aestivum* L.) trial on a loam and winter rapeseed (*Brassica napus* L.) trial on a medium clay soil. The experimental plots were arranged in a randomised block design with three replicates. The following fertiliser treatments were included: Biogas digestion residues (0,8% total-N), chicken manure (2,1% total-N), and meat-bone-meal (9,5% total-N). In the spring wheat trial two intended rates, 50 and 100 kg total N ha^{-1}, of the organic fertilisers were applied in spring. In the winter rapeseed trial the organic fertilisers were spread in early spring 2007 in the standing crop with the intended N rate of 120 kg total-N ha^{-1}. Winter rapeseed was sown with 48 cm row distance in early September 2006.

Results

The relative importance of external inputs of organic fertilisers compared with N_2-fixing crops in the rotation was identified in the PR process to be a key issue for the farmers. The PR group was aware of the difficulty of devising long-term nutrient strategies during a project of three years, but concluded that short-term on-farm fertilisation experiments would be most valuable.

Significant fertiliser effects on yield and N uptake in grain were achieved in a spring wheat trial (Table 1). The intended fertiliser rates were not achieved for chicken manure due to discrepancy between preliminary and final fertiliser analyses. On average the lower fertiliser rate gave the highest NUE. The yield increase in rapeseed due to fertilisation was not significant due to large variation between plots, but was on average 600 kg ha^{-1}. The economic evaluation showed higher economic benefits from fertilisation in spring wheat compared with winter rapeseed. However, the wheat and rapeseed experiments were conducted on two different sites, making direct comparisons difficult.

The PR group discussed implementation of results for the cropping systems on the farms. Optimal fertiliser strategies in the crop rotation were the main focus for discussions. The conclusions can be summarised as follows: 1) Early spring application of organic fertilisers or a high nutrient-delivering preceding crop is crucial for good crop development and high NUE in winter rapeseed. 2) Low and variable NUE of organic fertilisation in rapeseed entail that a combination of a moderate nutrient-delivering preceding crop and a low early fertiliser application may be an advantageous option. 3) Large yield benefits could be achieved by applying organic fertilisers to spring cereals. 4) Low rates of organic fertiliser supply together with N_2-

fixing crops in the rotation could be an economically and environmentally benign solution. 5) To get high NUE of organic fertilisers farmer's experiences show great importance of immediate fertiliser soil incorporation. 6) Successful weed management is a requirement for high NUE in the cropping system.

Table 1: Yield and protein concentration of spring wheat fertilised with different types of organic fertilisers in one on-farm field trial. NUE = (N in grain of fertilised wheat - N in grain of unfertilised wheat)/total N in applied fertiliser

Fertiliser	Total N in fertiliser kg ha^{-1}	Yield kg ha^{-1} 15%wc	Protein conc. %	N in grain kg ha^{-1}	NUE %
Unfertilised	-	3630a	11.4	62a	-
Biogas residues	52	4240b	11.9	75b	26
	104	4840c	12.5	90c	27
Chicken manure	33	4060ab	12.2	74b	37
	65	4260b	11.9	75b	20
Meat-bone meal	46	4330b	12.0	77bd	34
	92	4630bc	12.5	86cd	26
p-value		*0.006*	*n.s.*	*0.004*	*n.s.*

Discussion

Farmer PR offers possibilities to learn in context and to build knowledge that could lead to improvements of on-farm nutrient management. However there are drawbacks with the PR approach. It is time-consuming, at least in the short-term perspective, and it could be difficult to obtain funding for PR projects with very open aims. The flexibility and simplicity that are important traits of successful PR could lead to poor scientific validity of research results (Poudel *et al.,* 2000).

Agricultural knowledge stems from different sources and PR combines researcher-advisor-farmer inputs with possibilities to develop and implement cropping system solutions. Field experiments carried out by researchers tend to focus on evaluation of single factors excluding a cropping system context. With the PR approach the experimental design of field trials were formed by the group, with the outcome that locally available fertilisers were used and also that farmer's techniques concerning spreading and incorporation of the fertilisers were followed. The choice to conduct fertiliser trials in both spring wheat and rapeseed reflected the farmer's interests of comparing NUE for different crops in the rotation.

The difficulty with application of organic fertilisers to winter rapeseed observed in this project is consistent with other studies, mainly caused by the large nutrient requirements very early in the season (Rathke *et al.,* 2006). At the same time, it is crucial to avoid spreading manure on wet clayey soils, causing compaction injuries. A favourable preceding crop leaving residual N in the soil profile could consequently be an alternative to fertilisation. The farmers in the group grew GM leys, which could be a suitable preceding crop to rapeseed. Farmer's experience showed however difficulties to establish rapeseed after GM due to dried up soil and attacks of slugs. An alternative could be a pulse crop leaving at least moderate nutrient rich residues. The rapeseed

probably needs supplementary fertilisation, depending on inherent soil nutrient-delivery. But then the farmer does not have to completely rely on fertilisation to get an acceptable yield. Furthermore an important lesson learned by the farmers was that it is of the utmost importance to have reliable manure analysis to enable high NUE of organic fertilisers.

Ecological sustainability concerning fertiliser inputs was the focus of many discussions in the PR group. Earlier studies have sometimes shown negative nutrient balances in stockless organic farming caused by low or no inputs of fertilisers to the farm (Wivstad *et al.,* 2005). Olesen *et al.* (2007) stressed the importance of applying organic fertilisers to such cropping systems in order to maintain good crop yields and to ensure that crops are sufficiently competitive against perennial weeds. There was general agreement that the nutrient inputs and outputs need to be balanced for long-term on-farm sustainability. In a wider perspective, however, it is not sustainable to deplete non-renewable resources, e.g. phosphorus, to sustain nutrient needs on the farm. More advanced nutrient cycling in the food chain would decrease the need for using nutrient stocks.

Conclusions

* More sustainable solutions for nutrient management could be implemented by PR compared with researcher-managed studies. Different kinds of knowledge are combined in PR, providing a broader multidisciplinary base for decisions.
* Higher NUE of organic fertilisers could be achieved in spring cereals compared with in winter rapeseed.

* A combination of a moderate nutrient-delivering preceding crop and a supplementary fertilisation could be a solution for high NUE in winter rapeseed.

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