Focus Group Fertiliser efficiency in horticulture

Mini-paper - Costs and benefits of technologies for increasing N efficiency in vegetable production

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Introduction

Surplus fertilisation of vegetables, particularly with nitrogen (N) and subsequent losses through leaching and pollution of ground and surface water is a problem in many European countries, putting at risk compliance with the Nitrates Directive and the Water Framework Directive.

Many vegetable crops require high levels of soil mineral N until the time of harvest to achieve optimum qualities. Additionally, large amounts of crop residues remain on vegetable fields, with corresponding N-contents that can be rapidly mineralised and contribute to N-leaching. N-deficiency can lead to quality defects that reduce marketable yield drastically, while surplus N-supply rarely affects crop quality and revenues. In general, fertilisers are only a minor cost item in vegetable production as compared to other major costs like labor for planting and harvest. Therefore, surplus N fertilisation is often used as a risk mitigation strategy in vegetable production.

In recent years, a lot of practices and techniques[1] for reducing surplus fertilisation and increasing N-efficiency have become available. Some are widely used in some areas, others are not used yet. A number of fail factors for uptake of the techniques were identified by the EIP focus group members. Beyond issues of feasibility, the perceived high costs of implementing the techniques are seen as important constraint to adoption.

Therefore, this paper concentrates on the costs and benefits[2] of techniques that are already available in order to address the fail factor "high costs of implementation". Detailed information on the costs and benefits enable farmers to choose the most suitable fertilisation technique for their specific situation. The objective is to provide an economic framework for the analysis of fertilisation practices. A pragmatic first step of illustrating costs and benefits is described and methods for a more comprehensive quantification are discussed.

[1] For simplification of terms, "techniques" will be used to refer to methods or practices related to fertilisation.
[2] The term „cost efficiency" is sometimes used in this context. However, in economics, cost efficiency refers to the cheapest solution for a precisely defined target and situation. For a comparison of different techniques with different effects, an analysis of costs and benefits is more appropriate.

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Identification of costs and benefits of a new fertilization technique

A first overview of costs and benefits that might be related to the implementation of a new fertilisation technique is given in Table 1. This checklist provides a quick impression of what kind of costs and benefits are expected and can guide further cost analysis.

Costs

The costs of fertilisation include more than just the purchase of the fertiliser. The costs of equipment and labor for application need to be considered, too. Input costs can change if quantity and quality/type of the fertiliser change. Also, materials for soil or crop determinations of N are part of the input costs. Labor for application is determined by the frequency of application and the technology used. Usually, skilled labor is in charge of applying fertiliser with special equipment, for adjusting the machines to specific doses and for taking soil or plant samples.

With respect to the costs of machinery and equipment, the depreciation costs in the current and the new fertilisation practice need to be considered. If investment in special equipment is required when new techniques are implemented, the costs are spread over the utilisation period. New equipment also could lead to savings for repairs of the old machines; hence this item is accounted for in the table as well. Irrigation costs are included in the checklist, because a new technique may require the coordination of fertilisation and irrigation management, or even a change in the irrigation system e.g. if fertigation through drip irrigation is considered. Management costs refer to the time and effort spent by the farm owner/manager or a skilled worker, who decide on the types and amounts of fertilisers that are purchased and applied to the different crops and plots on the farm. According to discussions with advisors and farmers, the management costs are the most important constraint for adopting new fertilisation techniques. In some regions vegetable farms are highly diversified with many crops and sets of crops on different plots, often with two or more crops on the same plot during one year. Plot and crop specific fertilisation planning with soil samples and considering the cropping history is seen as adding more complexity to an already complex task. Thus, even if input costs could be saved and costs in machinery remain similar, management costs may be the main bottleneck in such production systems. For highly specialised farms with larger plots and smaller numbers of different crops and sets, management costs might be less of a problem. Specific advisory services and information systems could support farmers or farm managers during the introduction of new practices. The respective costs will occur mainly in the first years of implementation and decrease as farmers learn more about the new techniques. Also management costs could decrease over time with increasing farmer experience.

If the new techniques include changes in land use, e.g. crop rotations or alternative crops/varieties, catch crops etc., opportunity costs have to be considered, i.e. the foregone revenue of substituting the vegetable crop for another crop.

Benefits

The new fertilisation techniques are expected to have benefits for both, the environment and the farm economics. A reduction in fertiliser costs due to reduced amounts is probably the most immediate economic benefit. Further benefits may include reduced labor for application. Also, effects on plant health are possible, e.g. if a more targeted N-supply reduces susceptibility to fungal diseases. If soil

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quality improves with the increased use of organic fertilisers, the effects could be measurable in terms of yield increase or a reduction in yield variation.

Table 1: Checklist to estimate costs of a new fertilisation technique

Item	Change with respect to current practice*
Input costs	
Quantity of fertiliser	
Price of fertiliser	
Frequency of application	
Fees for soil/crop samples	
Material for soil/crop samples	
...	
Labor costs	
Skilled labor for fertiliser application	
Unskilled labor for fertiliser application	
(Skilled) labor for soil nutrient determination	
(Skilled) labor for crop nutrient determination	
Management costs	
Management labor for fertiliser planning	
Fees for advisory service for fertilisation	
Training of manager and skilled labor	
...	
Machinery and equipment costs	
Fuel and repair costs of own machinery	
Fees for hiring machinery	
Depreciation of own machinery	
Irrigation costs	
Software for fertilisation management (annual user fees or depreciation of purchase price over utilization period)	
...	
Output	
Yield /ha /year	
Share of marketable yield	
Quality	
Output price	
Variation in yield	
Variation in quality	
Foregone vegetable yield in crop rotations	
...	

*for example: increase/decrease/no change/not applicable: +/- / o/n.a.

Risk

Finally, risk has to be considered. Open field vegetable production is always associated with risk of yield or quality loss due to climate conditions or pests and diseases. Risk perceptions are one of the reasons for surplus N supply to the crop. New fertilisation techniques may have different effects on the production risk: They could reduce the risk due to closer monitoring of crop nutrient demand, or due to improved soil quality. On the other hand, risk could increase when reducing nutrient doses. These changes in risk need to be assessed carefully.

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Increasing N-efficiency in a systems approach: Evaluation of costs and benefits of new fertilisation strategies

Most of the fertilisation techniques described in the Nutrihort inventory (D'Haene et al., 2013) are more effective if they are used as elements of an integrated nitrogen or nutrient management. A more fundamental change of the fertilisation strategy with effects on crop rotation, labor organization and probably new technologies for irrigation requires a more comprehensive economic analysis of the production systems. Costs and benefits of the measures may be interrelated and not adequately addressed in a single checklist.

Economic modelling using price and quantity data can be a useful method to assess costs and benefits of such significant changes in the vegetable production system. One possible approach for comparing the new and the current production system in an ex-ante assessment is the typical farm approach (Brüggemann, 2011; Ebmeyer, 2008; Krug, 2013). Typical farms are commonly used for comparing the cost structures in different production systems (Isermeyer, 2012; Strohm et al., 2014). A typical farm is a virtual farm model, which represents the prevailing type of production system of a crop. This farm model includes physical and economic data and is established for a specific production region, and a farm size class (Hemme, 2000). The typical farms are derived in focus group discussions with farmers, advisors and scientists (Deblitz and Zimmer, 2005). Therefore, typical farms are modelled farms but based on data and experience of real existing farms. Farmer involvement is an important part of the method in order to ensure the relevance for farmer practice. Using these typical farm models as reference or status quo, new fertilisation strategies can be evaluated against this reference. Based on expert assessment of researchers, farm advisors and farmers, the new fertilisation strategies that are appropriate for the typical farm (i.e. for a specific region, crop and farm type) will be defined and the implications for adoption into farm practice be described. In group discussions with farmers and advisors, the physical and economic changes resulting from adopting the new fertilisation strategy are defined for the typical farm model. This allows calculating production costs and revenues for both – the current production system and the one with new fertilisation strategies and to compare cost structure and benefits.

This method has been applied for ex-ante assessment of different fundamental changes in production systems, e.g. new technologies for cauliflower production (Lindemann, 2013) and will be used in a recent German initiative for reducing N-losses in vegetable production (Garming and Dirksmeyer unpublished).

On-farm profits and environmental /off-farm effects

During the discussions in the EIP focus group, the aspect of environmental benefits was emphasized as equally important as on-farm profitability of the new fertilisation techniques. In this section, the ideas of the focus group are presented as different approaches to address environmental benefits versus on-farm costs.

For society in general, environmental effects are the main motivation for demanding a reduction of nitrate leaching to water sources and an increase in fertiliser use efficiency. However, producers making decisions on fertiliser use perceive on-farm profitability of innovative fertilisation strategies or systems as main incentive for adoption. Although an increase in fertiliser efficiency usually is linked to either reduced use of fertiliser or an increase in marketable yield, these benefits may not always compensate for the investment in machinery, labor or N-determination of soil or plant. In this case, an assessment of the environmental and off-farm benefits of the innovative strategies provides basic information for decision making.

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Different approaches are possible:

1. An analysis, why the new technologies are not profitable for the farmer:
   - Will the technology become cheaper, if more farmers use it?
   - Are the technologies used appropriately or is more training/support needed to improve efficiency?
   - Are long-term or indirect economic benefits on-farm e.g. reduced water use, already considered?

   Initial supporting policies could be implemented to reach a critical number of adopters allowing for cost reductions in technology supply. Training and advisory schemes could address the lack of technology use efficiency.

2. Are the new fertilisation strategies manageable at farm level?
   Community or regional approaches could be required to improve fertiliser efficiency such as a local network for the determination of N mineralisation during the cropping season or a regional benchmarking of fertiliser use efficiency. For some regions and farm types, it could be profitable to outsource soil sampling and fertiliser need determination to a service provider e.g. advisory business or a specialised service of farmer cooperatives.

3. Are there stakeholders who are willing to pay to obtain the environmental benefits?
   Public or private suppliers for drinking water may have a vital interest and also willingness to pay to prevent nitrate leaching into their water sources. In some regions, even with full compliance with current legal requirements of fertiliser use, water sources are at risk of contamination with nitrate. Water suppliers could establish special schemes to encourage adoption of advanced and innovative N-management strategies and offer compensation for on-farm costs.
   Also, consumers might have a willingness to pay for environmentally friendly produced vegetables. Good agricultural practices required for integrated or sustainable production certification schemes should include the adoption of the innovative fertilisation strategies and communicate this benefit to the consumers. However, whether improved fertiliser use could be effectively used as a marketing strategy and to what extent price premiums could be achieved to compensate for farm level costs is unclear.

4. Policy measures

   Finally, the experts in the focus group proposed to quantify the environmental benefits of the new technologies in order to assess which legal or policy options could be considered: more restrictive fertiliser legislation or subsidy schemes for technology adoption.

Recommendations

The assessment of costs and benefits of new fertilisation techniques is needed as basic information for farmers and farm advisors. A detailed list of different cost items affected by the new technologies enables the farmer to weigh costs according to his specific situation and preferences. Therefore, a first assessment of costs and benefits using a simple checklist should be carried out for all proposed new techniques and included in the inventory.

Increasing nutrient efficiency and reducing N-losses is not a specific goal for vegetable producers. Considering the importance of management costs as constraint for innovative fertilisation techniques,

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emphasis should be made in the development of methods and tools for simplification or automation of fertilisation planning and application. Innovative fertilisation advisory services or even specialised business models for outsourcing this complex task from the farm management could be evaluated.

Comprehensive economic assessment based on a production system analysis should be included in projects where a system approach is used to develop and disseminate new fertilisation strategies. Projects should be extended beyond individual production regions in order to promote an exchange of experiences with different technologies and facilitate the evaluation of the applicability of techniques in other regions and production conditions. Linking stakeholders and experts beyond the production regions also will facilitate the implementation of measures to increase the profitability of the new techniques, such as approaches for training and farmer support or reducing costs in technology supply to the farmers.

For policy making and further research, the assessment of environmental benefits of the different technologies is an important aspect for the evaluation of policy options. Such information could also help to identify regional solutions with different stakeholders e.g. water users, vegetable producers and consumers.

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