The prevention of potato volunteers in organic farming systems by using pigs

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Summary

In organic agriculture potato volunteers, presenting an important primary inoculum source for late Blight (*Phytophthora infestans)*, are controlled by mechanical methods. These may be partly replaced by 'foraging' livestock animals, such as cattle, sheep, horses, ponies or pigs. Most animals eat only the remaining potatoes on the field surface; however, pigs also dig up potatoes. This paper reports on two experiments with pigs (sows or finishing pigs), which appear to be very effective in digging up potatoes that are left in the field after the potato harvest within a reasonable time period. However, the workload for the farmer, problems with animal health and meat quality and possible damage to the soil structure seriously limit the applicability of pigs for the control of potato volunteers. Aspects of animal health, animal nutrition and environmental aspects (nutrient excretion) are discussed.

Introduction

In areas with mild winters potato volunteers, either emerging within potato fields or in neighbouring non-potato crops, may present an important primary inoculum source for late blight (*Phytophthora infestans)*. After potato harvest 20,000 – 300,000 tubers hectare^{-1} may be left on the field (Kempen *et al*., 2005; Helsdingen *et al*., 1985), i.e. 500 – 75,000 kg ha^{-1} (based on an average tuber weight of 25 gr).

In conventional agriculture volunteers may also contribute to too high nematode populations because the effect of the crop rotation decreases when large volunteer populations are present. Because of the wider rotations in organic agriculture, 1:6 or wider, this problem is less serious in organic systems than it is in conventional farming.

In most winters not all left over tubers are killed off by frost or damp. Mechanical weed control and hand weeding between potato crops in organic systems is insufficient to reduce potato volunteers to a level where they do not pose a risk as a blight inoculum source, so other strategies have to be investigated. Mechanical methods for volunteer removal may be (partly) replaced by livestock animals such as cattle, sheep, horses, ponies. Put into the field after the potato harvest, the animals eat potatoes that are left on the field during harvest. Because most livestock animals eat only potatoes from the field surface, additional work may be necessary in order to bring buried potatoes to the surface. Helsdingen *et al.* (1985) report on several experiments in 1983, in which the amount or weight of volunteer tubers was reduced by 6 - 67 %, depending on the circumstances.

Pigs may also be used. Pigs are known to dig up potato tubers, even when they are relatively small, and thus could be a useful alternative or an additional volunteer control strategy. The use of pigs may have additional benefits (e.g. additional fertility inputs), but may also result in greater soil disturbance or increased nutrient losses.

Questions to be answered are:

- How effective are pigs (sows or finishing pigs) in reducing the amount of tubers remaining on the field after the potato harvest?
- Are there serious effects on animal health and / or nutrition when pigs are kept outside on a harvested potato field for a certain period and are able to consume raw potatoes ad libitum?
- Are there serious effects on soil structure or on N-leaching when pigs are kept outside on a harvested potato field for a certain period?

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This study reports on two experiments in which the effects of different levels of pig-days ha^{-1} were investigated with respect to the number of potato tubers remaining on the field after a potato crop. Also effects on soil structure were assessed. In both experiments pigs (sows or finishing pigs) were put on a potato field after the potato harvest. The study focuses on potato volunteers emerging from tubers that are left on the field after the harvest of a potato crop. Volunteers emerging from TPS (True Potato Seed) are not considered.

Materials and Methods

First experiment, 2001 - 2002. In 2001 a randomised block trial with sows was carried out with three treatments (no pigs, 50 pigs ha^{-1}, 200 pigs ha^{-1}) in four replications. All plots were 10 meter wide and 20 meter long. After the harvest of the potatoes the field was grubbed once before the sows were put into the field. The experiment was carried out between 18 and 22 October 2001. The sows were outside by day, at night they stayed in the stable. At the moment of the experiment, the sows were in the first trimester of their pregnancies.
Sows were considered to be preferable to finishing pigs, because they are bigger and stronger for rooting, and are also more hungry because of the way they are typically fed. They will eat more potatoes, and it is not necessary to balance their diet with high protein-supplements in order to keep them in good condition, as would be necessary with finishing pigs. Sows are also easier to keep on an open field within a fence, because they are used to being outside, while the finishing pigs are not.
For the experiment 20 sows, i.e. the whole sow-herd on the experimental farm, were available.

Second experiment, 2003 – 2004. In 2003, a group of 20 finishing pigs was kept on a surface of initially 2250 m^2, of which in the course of 7 days every day on 2 sides 75 m^2 was closed. A shed was placed on the central part of the field, in which the animals could shelter at night or at times of bad weather. A feeding place, in which additional feed was supplemented, was situated near the shed. In the central part of the field (1200 m^2) the pigs stayed one week after the last time the fence was moved inwards. This resulted in an experimental field with on two sides a range from 89 - 1167 pig-days ha^{-1} (see figure 1). The experiment was carried out between 11 and 28 November 2003. The shift to finishing pigs was made because the sows suffered from health problems in the winter after the first experiment (see Results section).

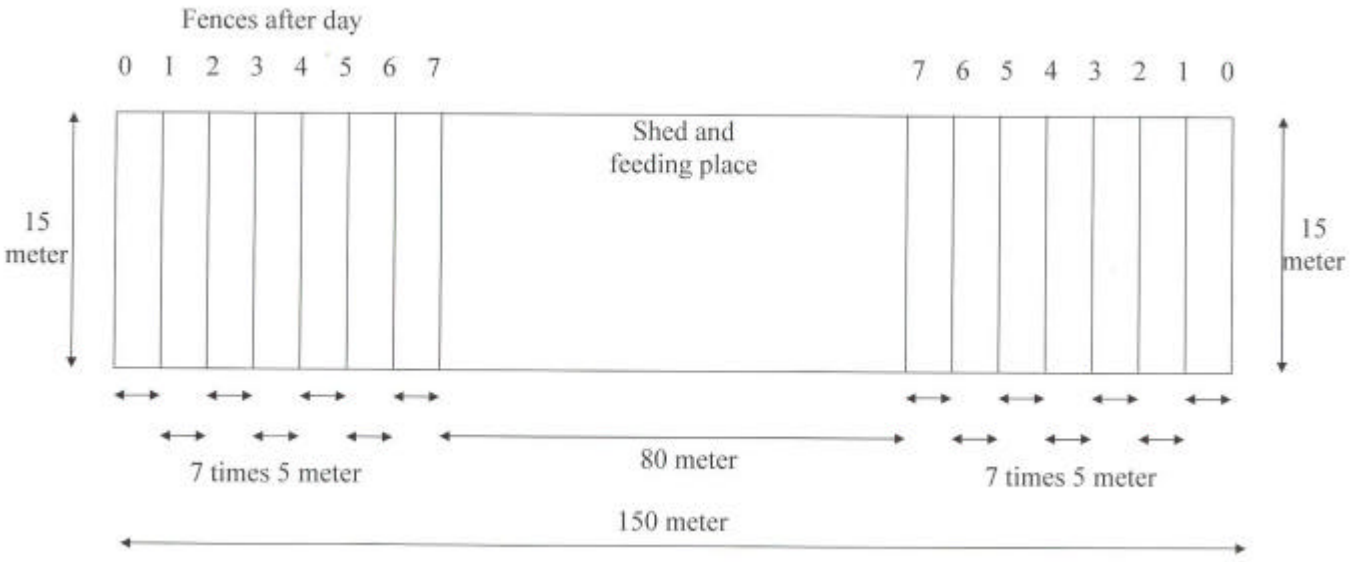

Figure 1. Field layout in 2003

Assessments

Soil structure. In the first experiment, the soil structure in the plots was assessed in December 2001 and April 2002. With a soil drill (9 cm diameter) non-disturbed vertical soil columns of 40 cm were cut out. Soil layers within these columns were assessed visually. Within each layer the volume-percentage of fine aggregates, rounded clods and sharp angled clods was estimated. Per plot the assessment was made on at least three spots. When the assessments for three spots corresponded well to each other, no further assessments were made. When the assessments for the three spots were more different, two more assessments were made in the same plot. In the second experiment the soil structure was assessed by the farmer, by judging the emergence of the following crop, Triticale, sown in the spring of 2004.

Potato comsumption by pigs. In both experiments the amount of potatoes consumed by the pigs was estimated on the basis of reports in the literature about the number of potatoes that remain in the field after harvest. Helsdingen *et al.* (1985) mention numbers between 20,000 and 300,000 tubers per hectare being left in the field. This corresponds to 500 or 7,500 kg potatoes ha^{-1}. This was assumed to be the maximum amount of potatoes available for the pigs.

Remaining potatose after pig grazing. In the first experiment assessment of the number of remaining potatoes after the plots being grazed by pigs in the fall of 2001 was not possible because of a frost period shortly after the end of the experiment. The number of emerging volunteer potatoes in the following summer wheat crop was assessed in May 2002. In the second experiment the number of remaining potatoes after the experimental field being grazed by pigs was assessed in the first week of December 2003 by counting the number of potatoes in the soil on 2 times 1.8 m^2 on every experimental unit, and on 5 times 1.8 m^2 in the rest of the field. All potato tubers on and underneath this surface area, until a depth of 25 cm, were counted and weighed.

Results

First experiment, 2001 - 2002

In 2001, the sows appeared to be very keen in finding potatoes in the field and eating them. In the plots with 200 pigs ha^{-1} all the potatoes were eaten within 3 days. After these 3 days (600 pig-days ha^{-1}) the sows had nothing more to eat, and started to break out, trying to find new and more 'interesting' things to do during the time they were outside. The experiment was then terminated. The sows may have consumed 0,8 – 12,5 kg potatoes $animal^{-1}$ day^{-1}.

Figure 2. Soil profile (0-22 cm) in 2001
without grazing (left)
And after grazing by sows (right)

Soil structure. Soil structure assessments in December 2001 showed a clear effect of the pigs on soil structure. In the plots with 200 pigs ha^{-1} the soil layer between 6 and 18 cm was very compact, when compared to the same layer in the plots without pigs (see figure 2). The same effect showed to a smaller extent in the plots with 50 pigs ha^{-1}. In the spring of 2002, however, these differences had disappeared.

In the spring of 2002 only 8 volunteers were found on the total experimental surface1(728 m^2), with no differences between treatments.

Animal health. In the winter 2001 - 2002 many sows had abortion problems. Inquiries with experts (veterinarians) gave no conclusive answer to the question if this had or had not to do

with the consumption of raw potatoes during the experiment. Therefore it was decided to redesign the experiment and to use finishing pigs for the second experiment, in 2003.

Second experiment, 2003 - 2004
In 2003 almost all potatoes on the soil surface were eaten within one day (visual assessment). The pigs ate all potatoes in the top soil within 8 - 16 days: after 8 days (967 pig-days ha^{-1}) the farmer had the impression that all remaining potatoes were consumed. In the central part of the experimental field only one potato was found at the final assessment of potatoes in the top soil (after 1167 pig-days ha^{-1}) (see table 1).
The pigs may have consumed 0,5 – 7,75 kg potatoes $animal^{-1}$ day^{-1}.

Table 1. Numbers of left potatoes after a period of grazing by pigs.
Numbers followed by different letters are significantly different from each other at the 5% probability level (ANOVA-test).

Pig-days hectare	0	89	95	103	111	121	133	148	1167
# potatoes (000 ha^{-1})	101^{bcd}	176^{d}	90^{bc}	78^{abc}	119^{cd}	97^{bc}	35^{ab}	$99b^{cd}$	3^{a}

Meat quality. The quality of the meat of the pigs that participated in the experiment was less than the meat quality for the other pigs on the farm, because the pigs fattened during the period outside, despite of supplementary food that was available. This resulted in a loss of profit of € 60 pig^{-1}.

Soil structure. In the spring of 2004, the farmer experienced serious structural damage in the soil on the whole experimental field: the emergence of the following crop, triticale, was very bad in the central part of the experimental field, but was better in those parts where the pigs had been staying for a shorter time, and it was good on other parts of the field where pigs had not been present. Where the emergence of triticale was bad, the farmer had to grub and harrow several times before the soil was fit for resowing the triticale.

Discussion
Potato numbers. Both sows and finishing pigs appear to be able to remove remaining potatoes in the top soil effectively and within a reasonable time period. In 2001 sows ate all potatoes within 600 pig-days ha^{-1}, and in 2003 finishing pigs ate all potatoes within 1200 pig-days ha^{-1}.

Animal health. All parts of potato plants contain solanine, especially the green parts. Too large amounts of solanine are unhealthy. If a too large proportion of the tubers is green, the grazing time should be limited. Helsdingen *et al*. (1985) report that cattle can consume 8 – 15 kg raw potatoes $animal^{-1}$ day^{-1} without health problems, ponies 5 – 7 kg $animal^{-1}$ day^{-1} and sheep 4 – 5 kg. For pigs no clear reports can be found, but amounts of 1 – 10 kg are mentioned. The calculated potato consumption by the sows in the first experiment (0,8 – 12,5 kg $animal^{-1}$ day^{-1}) corresponds well to these amounts, and should have caused no health problems. Edwards and Livingstone (1990) report on one study in which raw potato was fed ad libitum to sows without causing any problems, but this experiment took place indoors.

Nutrition. A balanced diet is important for a good carcass quality in finishing pigs (Sundrum *et al*, 2000). When the protein supply is too low, the fat content in the carcass will be too high. This is probably what happened in the experiment with finishing pigs in 2003, but exact records on the feeding regime in the period of the experiment are not available.

Environment. Because the pigs are in the field during late summer or early fall, the nutrients excreted in the manure are very vulnerable for leaching. Eriksen & Kristensen (2001) calculate

a N-surplus of 500 kg ha^{-1} with a stocking rate of 32 sows plus piglets during six months. In the experiments reported here, no soil samples were analysed for N-contents. In the tables of the Dutch ministry of agriculture (Tabellenbrochure MINAS 2004) pigs are considered to excrete 10 – 20 kg N $year^{-1}$. This means that in the experiments reported here, the N-excretion was 15-30 kg N ha^{-1} (2001) or 32-64 kg N ha^{-1} (2003). This corresponds well to the numbers of Eriksen & Kristensen (2001). A specific problem is caused by the fact that the distribution pattern of the manure is very uneven, close to the feeding area the N-surplus will be even higher (Eriksen & Kristensen, 2001).

Conclusions

Despite the fact that pigs are very effective in removing potatoes from the top soil, the workload (50 hours - 100 hours) associated with keeping the pigs in the field (placing of fences and shed, animal care), possible health problems when sows are used, carcass quality problems when finishing pigs are used, and possibly damage to the soil structure limit the applicability or benefits of pigs as removers of volunteer potatoes.

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