Technique of pneumatic pest control – analyses and a new device

Pest control in organic production of berries, potatoes and vegetables usually employs spreading technique of registered phytopharmaceutical agents. This technique may be supported or even replaced by pneumatic pest control. Pneumatic pest control means suction of pest using a vacuum device similar to a home vacuum cleaner. Up to now there is no evaluation of pneumatic pest control available from an agricultural engineering point of view. This paper concerns the following questions: Which techniques of pneumatic pest control are available and how may these techniques be improved in terms of technical and physical parameters? Based on the answers a new device design is presented.

Customers demand

The target customers for the new device are organic farmers who grow fruits and vegetables in rows, either outside or in greenhouses. Some companies have made pneumatic pest control devices in the past, and customers have praised their effectiveness. The overall size and dynamics of the target market in Europe have been considered by looking both at organic farming and the market for organic food. 5.1 million hectares are used for organic farming in Europe, and total organic food sales are approximately 12 billion euro. After years of rapid growth this has recently started to stagnate.

The device has applications in two main fields: organic farming, and herb and herb seed production. In organic farming the device can be used for low-growing crops grown in rows (strawberry, cabbage, salads etc.). In seed farming the device can be used to help collecting the seeds when ripe.

Available techniques

Based on literature review, process analysis, and evaluation in respect of agricultural engineering parameters (airflow rate, air speed, working hours, energy input, process costs) I found following results:

1. Success of pneumatic pest control varies in a wide range, and the technique does not always grant satisfying results.
2. Collection of eggs and larvae is more difficult than collection of adult insects. Usually weekly treatment is necessary.
3. Frequent treatments may cause soil compaction.
4. Pneumatic pest control may distribute fungal infection.
5. Beneficial organisms may suffer from pneumatic techniques.
6. Investment costs of pneumatic implements are high (ca. 5000-12000 euro/row).
7. Simultaneously blowing and sucking hoods work better than common suction hoods.
8. Neither the interrelationship, nor the control of physical parameters are hardly subjects of research.

An analysis of physical parameters and their interrelationships reveals that airflow rate, working width, and travel speed can be comprised within the term air requirement, as shown in table 1.

The air requirement correlates with the success of the treatment and is an objective evaluation criterion for the implement and its pneumatic efficiency. The

	air requirements	working width$^+$	effective working time	maximum airflow velocity	airflow rate	travel speed	Price, euro, and number of rows		
Author unit	m³/ha	m	h/ha	m/s	m³/h	km/h	3*	2*	1*
Hellqvist, 1992/1995	15833 – 20353	1	6,67	21–27	2375–3053	1,5			x
Vincent & Lachance, 1993	6800	3	0,48	14,7	14280	7	x		
Picket et al, 1994	1950–3900	1	1,25–2,5	4,7	1560	4–8			4000,-
Picket et al, 1994	1688–2250	2	0,63–0,83	8,2	2700	4–8		5.000,-	
Picket et al, 1994	2125–4250	3	0,42–0,83	18,5	5100	4–8	60.000,-**		
Vincent & Chagnon, 2000	12780	1	2,5	30	5112	4			x
Tuovinen, 2000	10602–5903	1	1,67–2,5	25	6361	4–6			17.000,-

$^+$ Assumed row distance 1 m, * number of rows, ** inclusive modified tractor

Table 1.

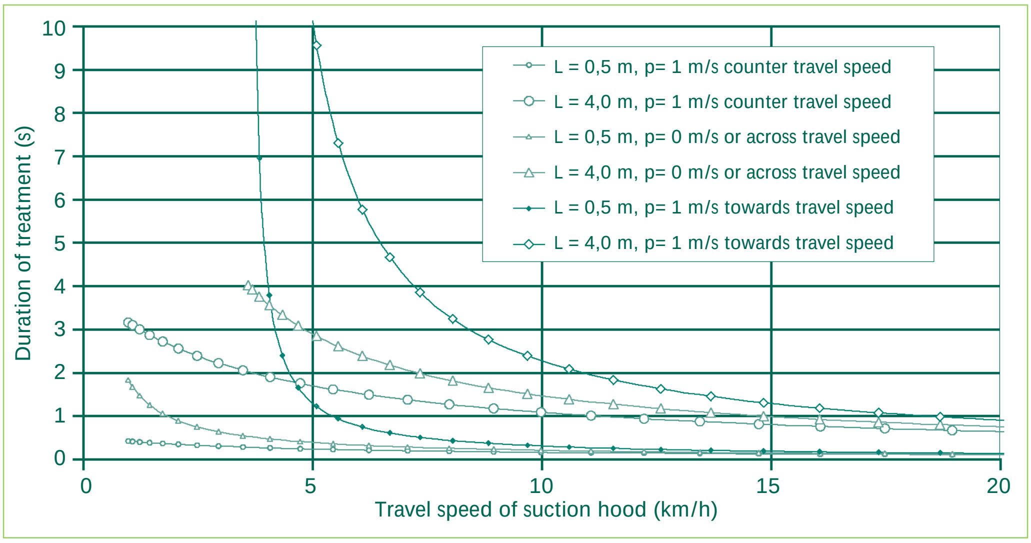
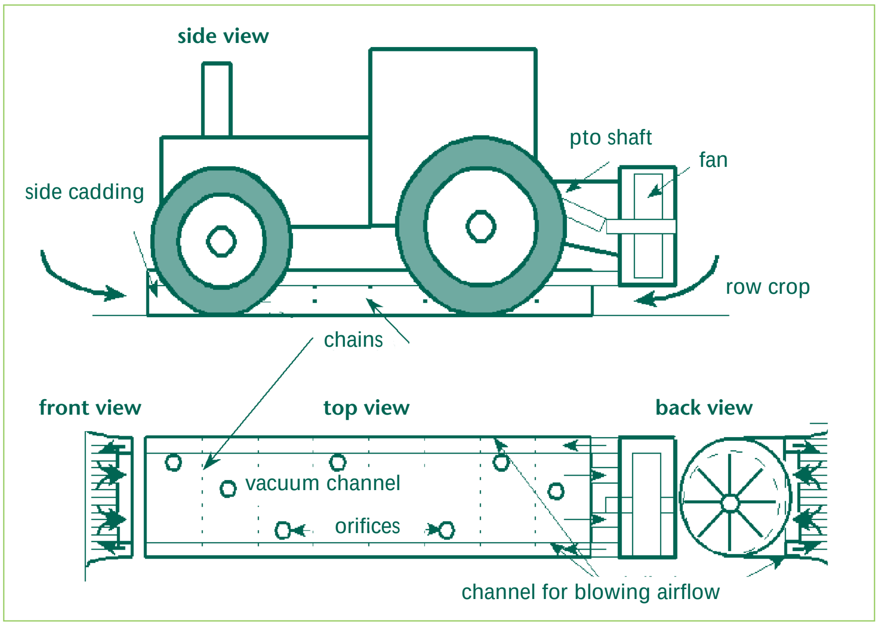


Figure 1. Duration of treatment depends on travel speed (v), length of suction hood (L), and flying speed and direction of pest (p).



latter may be improved by the following measures:

1. High travel speed prevents pests from escaping the suction hood.
2. Pests sitting upon the plant should start to fly before suction. This may be achieved pneumatically by blowing nozzles and/or mechanically by chains, brushes or similar devices.
3. A suction hood stretched in direction of travel may prolong the duration of pneumatic treatment to ensure successful control, see figure 1.

To minimize the tractor power required the suction airflow velocity under the suction hood should be as low as possible. However, the suction airflow velocity must always be greater than the flying speed of the pest. Low airflow velocity may also contribute to go easy on useful insects. Figure 1 shows the relationship between travel speed, length of suction hood and duration of treatment.

A new prototype design

The new device design is a result of discussions with Kainuun Marjakone Oy and a literature review. This is a proposed improvement of an existing technology, a technology that has been successfully tested in various applications. This device differs from a conventional one in that the suction hood is significantly longer. On conventional machines the suction hood is similar to a home vacuum suction nozzle (brush). The hood is wide but narrow and runs perpendicular to travel direction. The advantage of this device is that the vacuum stretches over the entire length of the tractor, permitting longer vacuuming times at greater speed. This is beneficial in two aspects: a) the insects stay inside the hood for longer which increases the likelihood that they will be caught and b) the working time is reduced. The better catch-rate also needs fewer runs over the field which again reduces working time and costs, as well as reducing soil compaction.

With some modifications to the design the device could also be used with gantry-technology. This technology is mainly used in greenhouses in which pest problems are also severe. Devices are mounted on gantry cranes, which move on rails over the entire field. Today gantry-robots are used for planting, watering and harvesting purposes. They can carry weights in excess of 1000 kg, which is more than enough to carry this device.

This particular device has not yet reached a prototype and testing stage. The estimated price of the device will be 3000 – 5000 euro. The material costs per unit are estimated to be 2000 euro.

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Does Cedomon work?

Biological seed dressing solution Cedomon® is commonly used, especially in Sweden. Cedomon is accepted in organic farming in many countries. In Sweden a big amount of conventionally cultivated cereal is also dressed with Cedomon. In Finland benefits of Cedomon has been variable.

Cedomon is a natural preparation. The active ingredient is a common soil bacteria *Pseudomonas chlororaphis*. In addition rape oil is used as carrier component. Cedomon is not risky to humans, animals or the environment and it is biodegradable. These are the great benefits.

The seed dressing products has usually effect only on seedborne or soilborne plant diseases. They cannot prevent diseases, which come through air. The manufacturer of Cedomon claims that the product has effect on barley net blotch (*Drechslera teres*), barley leaf stripe (*Drechslera graminae*) and fusarium. The plant diseases can remarkably decrease yields of barley and wheat, but normally not much the yields of oat and rye. The manufacturer claims that Cedomon can increase the yields of barley 3–5 % under northern European conditions.

Experiments in Finland

In 2003 there was an experiment in Agrifood Research Finland (Vihti), which compared Cedomon, Baytan®, wood smoke treatment and no-treatment. Barley (Saana) and oat (Roope) were chosen to the experiment. The experiment (4 replications) was set up in a conventionally cultivated field using chemical fertilisation. The seed dressing treatments were conducted in a concrete mixer. Wood smoke treatment was done in a specially designed grain dryer.

The seed dressing treatments did not raise the yields of oat compared to untreated. Wood smoke treatment slightly decreased the yield. Probably the oat seed did not have seed- or soilborne diseases in 2003. In 2002 Baytan treatment increased the yield of oat about 1000 kg/ha. In that year Cedomon was absent. For example oat loose smut (*Ustilago avenae*) and leaf spot (*Drechslera avenae*) are diseases of oat, but fortunately they decrease yield of oat quite seldom. Cedomon is claimed to be effective against oat leaf spot, but not against loose smut. Chemical Baytan has broader effect to different diseases.

In 2003 Baytan had a tendency to increase yield of barley compared to untreated (not statistically significant difference). Cedomon did not increase the barley yield. Wood smoke treatment slightly decreased the yield. The treatments had very little effect on quality of barley or oat.

Probably barley seed neither had any diseases in 2003, which could be controlled by Cedomon.

Profitability of biological seed dressing

Agrifood Research Finland (Jokioinen) has done experiments, where Cedomon has controlled barley net blotch nearly as well as chemical products. Cedomon has increased barley yield 200–300 kg/ha, if there has been plenty of net blotch. Cedomon has decreased barley leaf stripe 40 – 80 %, when chemical products have given nearly 100 % effect. The effect of Cedomon against leaf stripe has not usually been enough to increase the yield, but the quality can become better.