Covercrops and scab resistant apple varieties.

Hanne Lindhard Pedersen and Marianne Bertelsen.

Abstract

The use of scab resistant apple varieties is the best way to prevent infections of apple scab *(Venturia inaequalis*). In 1995 the then 10 most promising resistant apple varieties for Denmark where planted at Research Centre Årslev, Denmark in an organic production system. Three different covercrops where established in the alleyways. Weed cleaning in the tree row was done mechanically and the trees were kept unfertilised.
The annual shoot growth, nutrients in leaf sample, mineralised nitrogen in soil, content of water in the upper 50 cm soil, fruit yield and fruit quality were assessed.
The annual covercrop caused the longest shoot growth, the highest content of nitrogen in leaves and soil, the smallest competition with the trees concerning soil water and the highest gross yield of the lowest quality. The resistance to apple scab was broken down in most varieties.

Keywords

Apple, covercrop, nitrogen, soil water, scab resistance, varieties, fruit quality, diseases, pests.

Introduction

In Denmark most organic pesticides are banded. Copper has not been on the market for 6 years. Based on a questionnaire to organic growers a crop loss of at least 86 percent of the apple yield in an organic production compared to a conventional production was estimated (Lindhard et al. 1998). The estimation was based on production of the most common conventional grown varieties. The main reason for this low production is lack of possibilities to control diseases and pests, especially apple scab (*Venturia inaequalis*). The best way to prevent infections of apple scab is to plant resistant varieties.

Materials and methods

In January 1995 the then 10 most promising resistant apple varieties for Denmark where planted in a sandy loam soil, with a clay content of 11-15 % at the Research Centre Årslev, Denmark, in an organic production system. The varieties were: 'Delorina', 'Florina', 'Otava', 'Prima', 'Redfree', 'Retina', 'Rewena', 'Saturn', 'Vanda' and 'X6398'. Three different covercrops where established in the alleyways.

1. A permanent week grass mixture of red fescue (*festuca rubra*) and meadowgrass (*Poa pratensis*). Grass.
2. A permanent clover grass mixture of white clover (*Trifolium repens*) and perennial ryegrass *(Lolium perénne*). Clover grass.
3. An annual covercrop sown every year in July. Italian ryegrass *(Lolium multiflorum*) and Persian clover (*trifolium resupinatum*). Mulched down in April. Mechanical weed cleaning from April to July. Annual.

Weed cleaning in the tree row was done mechanically and the trees were kept unfertilised and unsprayed.
The annual shoot growth, nutrients in leaf sample, mineralised nitrogen in soil, content of water in the upper 50 cm soil, fruit yield and fruit quality were assessed.

Danish Institute of Agricultural Science, Department of Horticulture, Research centre Aarslev, Kirstinebjergvej 10, 5792 Aarslev. Denmark. Phone: 0045 63 90 43 43. Fax: 0045 63 90 43 96. E-mail: Hanne.Lindhard@agrsci.dk

Results and discussion

Nutrition and water.

For the two varieties ‘Prima’ and ‘Vanda’ detailed studies of growth, nutrition and water content in the soil were carried out.

Table 1. Nitrogen and potassium in leaves (percent of dry matter), water content in the soil in the tree row and the alleyway (percent in the upper 50 cm) and shoot growth (cm/ tree) for three covercrops, average of 2 varieties, 1998-2000.

Treatment	Nitrogen	Potassium	Soil water Alleyway	Soil water Tree row	Shoot growth
Grass	2.23 b	1.54 a	25.4 b	22.0 b	1277 c
Clover Grass	2.51 a	1.29 b	21.8 c	22.7 a	1715 b
Annual	2.58 a	1.29 b	27.1 a	22.6 a	2215 a

Values followed by the same letter in columns do not differ significantly at $p<0.05$.

Optimum level Nitrogen: 2.0-2.5. Optimum level potassium: 1.3-1.7.

The levels of nitrogen in the leaves are within the optimum level. The lowest content was in trees grown in the grass mixture and the highest in trees grown in the annual covercrop. The clover in the clover grass covercrop added nitrogen to the trees after decomposition compared to the grass cover crop (Table 1).

The potassium levels in the leaves were within the optimum level, even in the very low end for trees grown in clover grass and the annual covercrop (Table 1). The grass covercrop gave the best supply of potassium to the trees. Grass contains potassium, which is released from the moved material when it becomes moist. Potassium is necessary for the fruit growth.

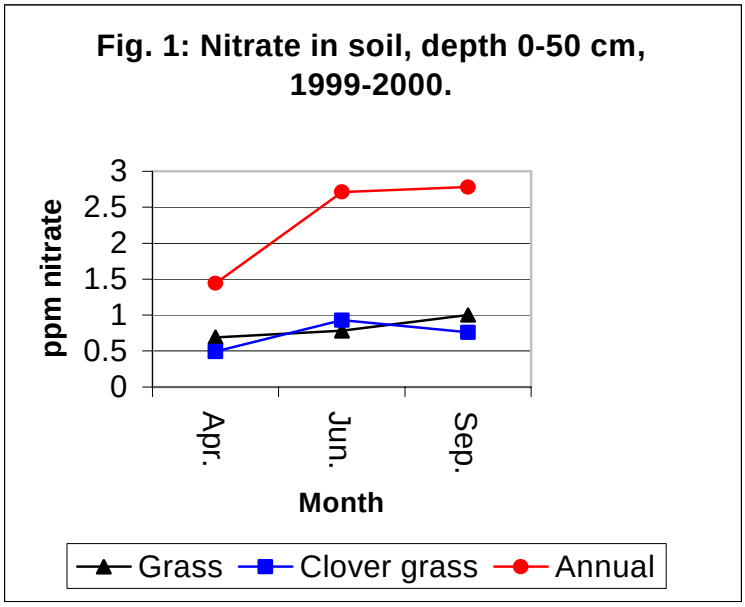
The clover grass had the highest utilisation of the water in the soil (Table 1). Even in dry periods in summer the clover grass was green, whereas the week grass had a water deficit and withered. The highest water content was found in the annual covercrop where the soil was free of vegetation in spring and early summer.

In the mechanical cleaned tree row the differences from the covercrops are weakened. The water supply to the trees close to of the water-using alleyway consisting of clover grass or the almost clean soil in the annual covercrop is at the same level.

The water supply for trees grown in the mechanical cleaned tree row close to the week grass was smaller. This may be due a different root pattern of the covercrops.

The lowest nitrogen level and the lowest water supply in the tree row resulted in the smallest shoot growth for trees grown close to the grass alleyway. The shoot growth was significantly bigger in trees grown close to the clover grass, because of a higher nitrogen and water supply (Table 1). The higher nitrogen supply from the clover did not result in an increasing level of nitrate in the soil (Figure 1). The nitrate was used for tree growth. The annual covercrop gave the biggest shoot growth due to a bigger supply of nitrogen from the soil (Figure 1) and a sufficient water supply (Table 1). When the annual covercrop is mulched down in April the organic material becomes decomposed and the nutrient gets available for the tree roots. The release of nitrogen from the annual covercrop and the soil is bigger than the consumption of the

trees. The surplus of nitrate is potential for lacking to the ground water especially during autumn and winter.



Yield and fruit quality.

1996 was the first yielding year. The annual covercrop resulted in the highest gross yield, and the yielding of the two permanent covercrops were at the same level (Table 2). The fruit size was significant smaller for trees grown in the clover grass. In 1999 and 2000 the fruits where colour graded. There are no official size or colour regulations for these varieties.

Normally the reddest fruits obtain the best price. The fruits from trees grown close to the grass alleyway had the reddest skin colour. 57 percent of the fruits had more than 75 percent red surface (Table 2). The fruits from the annual covercrop were the greenest. 40 percent of the fruit had less than 25 percent skin colour (Table 2). 14 tons fruits form the grass covercrop had more than 75 percent red surface as average for 1999 and 2000; whereas only 8 tons fruits grown in the clover grass or the annual covercrop had more than 75 percent red surface (table 2). A lower nitrogen supply, especially during fruit development results in more red fruits (Oland, 1960).

Table 2. Yield (Tons/ha), Fruit size (gram/fruit) average of 1996-2000. Percent fruits with less then 25 pct skin colour, percent fruits with more than 75 pct skin colour. Yield and Yield with more than 75 pct skin colour (Tons/ha), sellable fruits due to disease and pest damage (Tons/ha), for 3 covercrops average of 10 varieties, 1999-2000.

Treatment	Yield 1996-2000	Fruit size 1996-2000	% fruits <25 pct colour	% fruits >75 pct colour	Yield 1999-2000	> 75 pct colour 1999-2000	Sellable fruits
Grass	14.11 b	143 a	17.4 c	56.6 a	25.10 b	14.21 a	16.31 a
Clover Grass	14.81 b	136 b	33.4 b	32.6 b	25.57 b	8.34 b	15.02 a
Annual	17.97 a	143 a	39.3 a	27.9 c	28.88 a	8.06 b	15.15 a

Values followed by the same letter in columns do not differ significantly at p<0.05.

Break down of the monogene apple scab resistance.

The fruits were graded for skin damages caused by diseases and pests.
In 1996 no fruit were infected by apple scab, but in 1997 and 1998 few infections on fruits were observed. In 1999 and 2000 large infection developed. The resistance to apple scab was broken down. Only the variety 'Florina' had no infection, and 'Vanda', 'Retina' and 'Redfree' were still reasonable resistant to apple scab. In the variety 'X6398' the resistance was totally broken down (Table 3).
The apple scab resistance origin from the V_f gene form *Malus floribunda* is over-comed by the new races 6 and 7 of *Venturia inaequalis.* Both races are present in Denmark (Bengtsson M., Lindhard H. and Grauslund J. 1999).

Table 3: Percent fruits of 10 original scab resistant apple varieties without apple scab infections, 1996-2000.

Variety	1996	1997	1998	1999	2000	*Average 1996-2000*
Delorina	100 a	99.7 b	98.3 ab	68.1 bc	49.1 d	*80.7 d*
Florina	100 a	100 a	100 a	100 a	100 a	*100 a*
Otava	100 a	99.8 ab	96.8 b	57.5 c	48.5 d	*76.3 d*
Prima	100 a	100 a	100 a	97.2 a	65.5 c	*92.2 bc*
Redfree	100 a	100 a	100 a	96.6 a	95.6 a	*98.5 a*
Retina	100 a	99.8 ab	100 a	74.6 b	95.9 a	*92.7 bc*
Rewena	100 a	100 a	99.9 a	96.7 a	83.4 b	*96.1 ab*
Saturn	100 a	100 a	99.9 a	79.7 b	70.3 c	*90.0 c*
Vanda	100 a	100 a	100 a	100 a	99.8 a	*100 a*
X6398	100 a	100 a	100 a	40.8 d	1.5 e	*64.0 e*
Average	*100*	*99.9*	*99.5*	*82.8*	*73.7*	

Values followed by the same letter in columns do not differ significantly at $p<0.05$.

The infections of apple scab appeared at first in the annual cover crop. Not until 2000 more severe scab infection occurred on the fruits of trees grown in the permanent cover crops. The infections were more numerous on apples grown in the annual cover crop (table 4).
The breakdown of the scab resistance in former resistant varieties was earlier and more severe in the annual cover crop treatment, which gave the largest supply of nitrogen to the trees. This was the case even the level of total nitrogen in the leaves was within the optimum level for fruit production. Buchter-Weisbrodt (1996) found that high nitrogen supply reduces the phenolic synthesis in the trees and this was the mechanism behind the increased susceptible to apple scab infections.

Table 4. Percent fruits with skin damage caused by apple scab, fly speck, sooty blotch, tortrix, codling moth, apple saw fly, pct sellable fruit due to damage and sellable fruit (tons/ha) for tree covercrops average of 10 varieties 1998-2000.

Treatment	Apple scab	Fly speck	Sooty blotch	Tortrix	Codling moth	Apple saw fly	Pct Sellable fruit	Sellable fruit Tons/ha
Grass	2.3 c	16.8 b	8.0 b	9.6 a	1.9 a	4.6 c	75.6 a	15.19 a
Clover Grass	8.9 b	17.8 b	8.7 b	10.7 a	0.8 c	5.8 b	74.3 a	15.11 a
Annual	17.3 a	22.3 a	11.8 a	6.4 b	1.4 b	8.4 a	65.8 b	14.79 a

Values followed by the same letter in columns do not differ significantly at p<0.05.

Damages caused by other diseases and pests.

The diseases fly speck *(Leptohyrium pomi*) and sooty blotch (*Gloeodes pomigena*) have increased during the years. The fruits grown in the annual covercrop were more infected probably due to a denser tree, caused by a larger shoot growth and thereby more moist conditions.

The most severe pests were different species of tortrix infesting the fruit skin close to harvest and apple sawfly (*Hoplocampa testudinea*). Codling moth (*Cydia pomonella*) was not an important pest (Table 4). The covercrops had significant different percent damaged apples. This was probably due to different populations of predators, but this was not investigated further.

The fruits were sorted in sellable fruits due to disease and pest damages. Overall the fruits from the permanent covercrops had the highest percentage of sellable fruits. Even the gross yield was bigger from trees grown in the annual covercrop the crop of sellable fruits due to damages from diseases and pests were at the same level for fruits from the three covercrops (Table 2 and 4).

Conclusion.

The annual covercrop caused the highest content of nitrogen in leaves and soil, the smallest competition with the trees concerning soil water, the longest shoot growth and the highest gross yield of the lowest quality. The resistance to apple scab was broken down in most varieties.

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Den her følgende tabel skal ikke med, idet der ikke er plads.

Table: Yield (Tons/ha) and fruit size (grams/fruit), 1996-2000. Nitrogen, potassium and calcium in the leaves (pct. of dry matter), percent soil water in the upper 50 cm and bitter pit for two covercrops with and with out mulching, average of two varieties (Prima and Vanda). 1998-2000.

Treatment	Mulching	Tons /ha	Fruit Size	Nitrogen	Potassium	Calcium	Soil Water in the tree row	Bitter pit
Grass	+	17.18 a	177 a	2.12 a	1.47 a	1.20 a	21.3 b	0.3 a
	-	14.81 a	160 a	2.00 a	1.64 a	1.10 a	22,2 a	0.8 a
Clover grass	+	17.97 a	145 a	2.65 a	1.27 a	1.34 a	23.5 a	0.6 a
	-	18.24 a	148 a	2.63 a	1.34 a	1.45 a	21.8 b	0.4 a

Values followed by the same letter in columns and for treatment do not differ significantly at $p<0.05$.

Optimum level Nitrogen: 2.0-2.5.

Optimum level potassium: 1.3-1.7.

Optimum level calcium: 0.7-1.2.