Alleyway groundcover management and scab resistant apple varieties

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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 cover crops 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 cover crop 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, cover crop, nitrogen, soil water, scab resistance, varieties, fruit quality, diseases, pests.

Introduction

In Denmark most organic pesticides are not registered. Copper has not been on the market for 6 years. Based on a questionnaire, organic growers estimated a yield reduction of at least 86 percent compared to conventional production (Lindhard et al. 1998). The estimation was based on production of the most common conventional grown varieties. The main reason for this low productivity is lack of control measurements against 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 an organic production system at the Research Centre Årslev, Denmark. The varieties were: „Delorina", „Florina", „Otava", „Prima", „Redfree", „Retina", „Rewena", „Saturn", „Vanda" and „X6398". Three different cover crops where established in the alleyways.

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1. **Grass:** A permanent weak grass mixture of red fescue (*festuca rubra*) and meadowgrass (*Poa pratensis*).
2. Clover grass: A permanent clover grass mixture consisting of white clover (*Trifolium repens*) and perennial ryegrass *(Lolium perénne)*..
3. Annual: An annual cover crop 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.

Weed cleaning in the tree row (1-meter width) 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.

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 cover crops, 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	22.1 b	1277 c
Clover Grass	2.51 a	1.29 b	21.9 c	23.0 a	1715 b
Annual	2.58 a	1.29 b	27.4 a	22.7 ab	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 nitrogen content was in trees grown with a grass alleyway, whereas both annual and perennial clover grass alleyways contributed positively to the nitrogen fertilization of the trees (Table 1).

The potassium levels in the leaves were within the optimum level for all trees, but significantly higher in trees grown with a grass alleyway cover crop (Table 1). Grass contains potassium, which is released from the clippings when it becomes moist and decomposes.

The clover grass utilised more water than a sward of pure grass (Table 1). Even in dry periods in summer the clover grass was green, whereas the weak grass suffered water deficiency and withered. The highest water content was found in the tilled soil where the annual cover crop was established during the latter part of the summer. Alleyway management had little effect on the soil water content within the mechanical cleaned tree rows (table 1) (measured between trunks). Generally, the soil water content was much lower in the vegetation free tree strip than was the case in the tilled soil and more surprisingly also lower than was the case under a grass sward.

Shoot growth was weakest for trees managed with a grass alleyway, intermediate for the clover grass alleyway and nearly twice as vigorous when trees were grown with an annual cover crop.

Yield and fruit quality.

1996 was the first yielding year. Trees managed with an annual cover crop produced the highest gross yield, while the yield of the two permanent alleyway cover crops were at the same lower level (Table 2). The fruit size was significant smaller for trees grown with the clover grass alleyway. In 1999 and 2000 the fruits where colour graded on a commercial grader. There are no official colour regulations for these varieties, and fruits were therefore graded in 25% colour intervals.

Fruits produced on trees managed with a grass alleyway obtained the best coloration and in average of the 10 varieties more than 50 percent of the fruit had more than 75 percent red surface (Table 2). The fruits from the annual cover crop management system were the greenest with 40 percent of the fruit having less than 25 percent skin colour (Table 2). A lower nitrogen supply, especially during fruit development results in more red fruits (Oland,1960).

In terms of production of quality fruit, the grass alleyway system was the most efficient and superior to the higher producing and more vigorous perennial and annual clover grass management system. 14 tons fruits form the grass cover crop 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 cover crop had more than 75 percent red surface (table 2).

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), marketable fruits due to disease and pest damage (Tons/ha), for 3 cover crops 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	Marketable 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 more varieties became infected and the infections were more severe. The resistance to apple scab had broken down. At the end of the 2000 season only the variety „Florina" remained free of scab, while „Vanda", „Retina" and „Redfree" were still reasonable resistant to apple scab having less than 5 percent infected fruits. 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 overcomed 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 on trees managed with an annual cover crop. Not until 2000 did more severe scab infection occur on the fruits of trees grown in the permanent cover crops. The infections continued to be more numerous on apples grown in the annual cover crop, which gave the largest supply of nitrogen to the trees (table 4). This was the case although 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 marketable fruit due to damage and marketable fruit (tons/ha) for tree cover crops average of 10 varieties 1998-2000.

Treat-ment	Apple scab	Fly speck	Sooty blotch	Tor-trix	Cod-ling moth	App-le saw fly	Pct marke-table fruit	Marke-table 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 cover crop management system were more infected probably due to a denser tree, and vigorous shoot growth causing 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 cover crop alleyways gave significant different percent damaged apples. This was probably due to different populations of predators, but this was not investigated further.

The fruits were graded in marketable and discarded fruits on the basis of the severity of the disease and pest damages. Overall the fruits from the permanent cover crops had the highest percentage of marketable fruits. Even though the gross yield was bigger from trees grown in the annual cover crop, the crop of marketable fruits were at the same level for the three alleyway management systems due to different levels of pest attack (Table 2 and 4).

Conclusion.

The use of an annual cover crop management system resulted in the highest content of nitrogen in leaves and soil, the smallest competition with the trees concerning soil water, and the most vigorous shoot growth and the highest gross yield. However, it was combined with the lowest fruit quality and highest proportion of discarded fruits.

The resistance to apple scab was broken down in most varieties.

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