Soil treatments and rootstocks for organic apple production.

Bodenbearbeitung und Unterlagen für den ökologischen Apfelanbau

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Abstract

6 different soil treatments: Mechanical weeding to the middle of the alleyway, mechanical weeding using 3 different equipments Clemens, Humus and a dish harrow, Soil covering with wheat straw and natural vegetation were combined with 3 rootstocks: M9, J9 and M26 to find the best combination for the apple variety 'Retina'. The trees were planted in the winter 1997/1998, only sprayed at primary RIMpro warnings and drip irrigated. The tree growth, nutrient content of the leaves in august, yield and fruit quality were determined.

The rootstock J9 had the highest yield and the biggest amount marketable fruit. Mechanical cleaning to the middle of the alleyways, tree row weed control using Humus or soil covering with straw gave the highest yield and marketable fruit. A one meter weeded strip in the tree row did not remove the competition of the clover grass alleyway. Natural vegetation (weed) in the tree row reduced the yield with more than 50 percent. There was a break down of the V_f resistance of 'Retina'

Keywords

Apple, organic, soil treatment, weeding, rootstocks, growth, leaf analysis, yield, fruit quality, Vf resistance.

Introduction

More machinery for mechanical weeding is available. Another method to control weed is soil covering with for example straw. Organic growers also discus the necessity of weed cleaning at all, therefore the natural vegetation in this trial is used as control treatment.

In apples it is possible to choose between several rootstocks. Maybe the rootstocks also react differently on soil treatments as they may have different root pattern or damage compensation mechanisms. The variety 'Retina' is recommended for organic production in Denmark and there is no knowledge regarding the optimal rootstock for this variety.

There is a demand for optimising the knowledge on production techniques as soil treatment and rootstocks.

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Material and methods

The German apple variety 'Retina' from Dresden-Pillnitz is recommended for organic apple production in Denmark. 'Retina' is an early variety with harvest in the first week of September (Kühn, 2002). 'Retina' has a good overall resistance to apple scab even the V_f resistance was broken (Lindhard Pedersen and Bertelsen, 2002).
One-year-old 'Retina' was planted in the winter 1997/1998 at Fejø, research orchard, Denmark at a planting distance of 3.5 x 1,5 m (1732 trees/ha). Every 11th tree was the pollinator Prima and white clover grass was established in the alleyways.
'Retina' was grafted on the rootstocks M9, J9 and M26 and 6 soil treatments were established in a one m wide strip in the tree row in split plot design with 3 replications.

1. Mechanical weeding to the middle of the alleyway, using the Humus 4-6 time each season.
2. Mechanical weeding in the tree row using Clemens 4–6 times each season.
3. Mechanical weeding in the tree row using Humus 4–6 times each season.
4. Mechanical weeding in the tree row using a dish harrow in 1998-2002, 3–5 times each year.
5. Soil covering with 15 cm of wheat straw in the tree row renewed every second year. The straw was removed just around the stem basis and 1 litter of crushed seashells was placed around the stem every year to prevent mice damage.
6. Natural vegetation in the tree row, cut down in June and end of august every season.

Every spring the trees were hand-hoed around the trunk. The trees were supplied with 25 kg nitrogen per ha coming from slurry every spring and 1½–2 litter water per tree from drip irrigation daily in the growing season. Vinasse containing 21 % potassium was used to increase the potassium content of the soil. The soil was low in potassium from the planting time as former used as arable land. Vinasse was supplied in very early spring 1998, 2000 and 2003.
Fruitlets were removed from the young tress the two first growing season given the trees a better establishment.
The trees were sprayed with 4 kg elementary sulphur 1–4 times per year in 2001-2003 at primary RIMpro warnings to prevent the breakdown of the V_f resistance of 'Retina'.
The stem diameter, weight of pruned branches, nutrients in leaf samples,. fruit yield and fruit size were assessed every year. Annual shoot infections caused by apple mildew (*Podosphaera leucotricha*) were assed in July on a scale 0–3, where 0 = no infection and 3 = severe infection in 2002 and 2003. The fruit quality assessed as skin colour and skin damage due to pest and diseases was assessed in 2003.

Results

Growth

Natural vegetation in the tree row reduced the vegetative growth i.e. trunk diameter and weight of pruned material (Table 1). Mechanical weed cleaning to the middle of the alleyway using the Humus equipment (Treatment 1) and mechanical cleaning in the tree row using Humus (Treatment 3) produced the largest vegetative growth (Table 1). The rootstock M26 had the most vigorous growth, whereas M9 had a slightly smaller growth than J9 (Table 1). No differences in mildew infection occurred on annual shoots due to rootstocks or soil treatments. In general the infection was high, 70–80 percent of the shoots had small infections and 10–20 percent shoots had severe infections (Data not shown).

Table 1. Growth measured as trunk diameter (mm/tree) after growing season 2002 and weight of pruned branches (g/tree) average of 2000–2002. Fruit size (g/fruit), average of 2000–2003 for 6 soil treatments and 3 rootstocks for the apple variety 'Retina'.

Treatment	Trunk diameter	Weight pruned branches	Fruit size.
1. Mechanical to the middle of the alley way	40 a	785 a	158 ab
2. Mechanical, Clemens	38 a	546 c	164 a
3. Mechanical, Humus	40 a	719a	154 b
4. Mechanical, Dish harrow	38 a	582 bc	157 ab
5. Straw	40 a	677 ab	159 ab
6. Natural vegetation	33 b	238 d	154 b
Rootstock			
M9	34 c	449 b	162 a
J9	38 b	519 b	153 b
M26	42 a	777 a	157 ab

Values followed by the same letter in columns do not differ significantly.

Leaf analyses

The content of total nitrogen in the leaves varied from higher than the optimum range from 2.0–2.5 percent nitrogen of dry matter in leaf samples (Vang-Petersen, 1989) to just lower than recommended. Natural vegetation in the tree row gave the lowest nitrogen content in the leaves. There were no significant differences between the other treatments (Fig. 1).

The content of potassium in the leaf samples was low or in the optimum rage of 1.3–1.7 % of leaf dry matter in 1999–2002. Especially in 2002 the content was low for some of the treatments. There were no clear difference between the soil treatments and rootstock over years (data not shown).

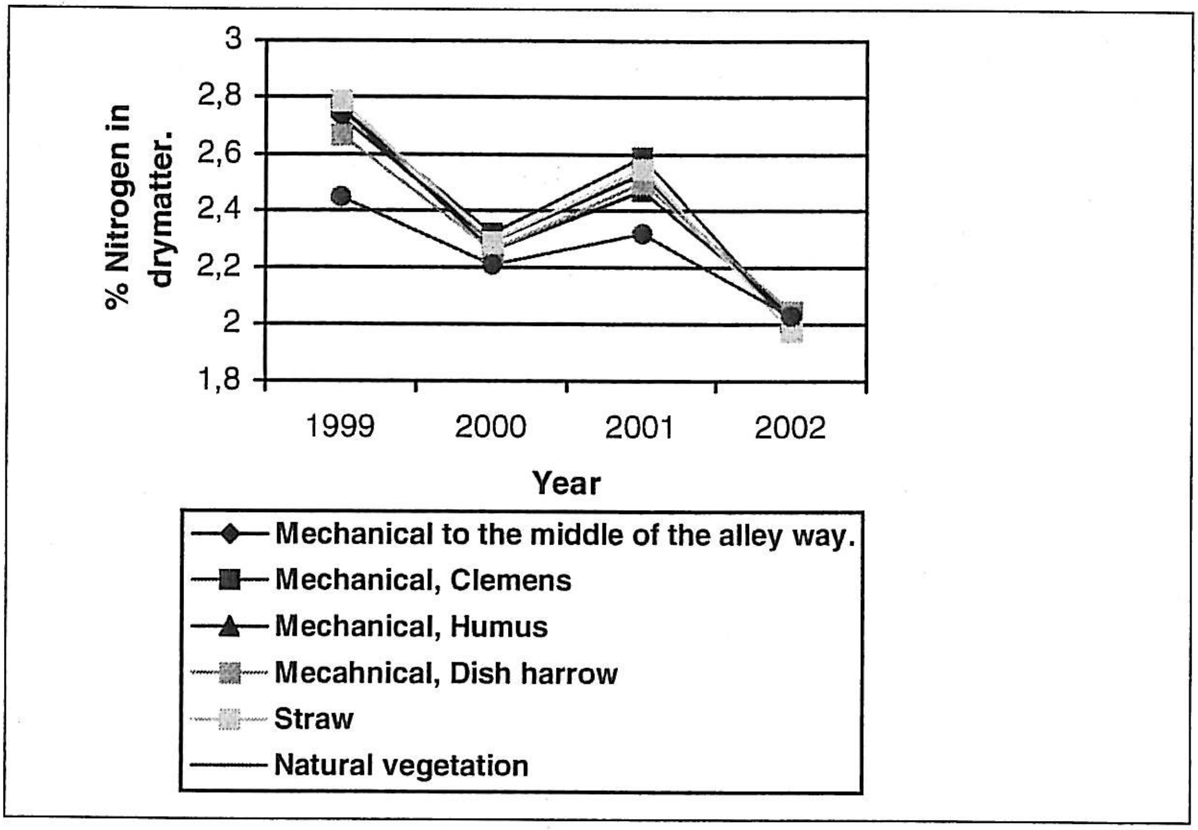

Fig 1: Nitrogen in leaves for 6 soil treatments, average of 3 rootstocks, in 1999–2002.

Yield

2000 was the first cropping year. The rootstocks M9 and J9 gave the biggest yield, until 2002 the yields were similar for the two rootstocks, but in 2003 J9 had the highest yield.

M26 gave in total a 13–16 t/ha smaller crop over the period (Fig 2).

Trees grown in natural vegetation (weed) in the tree row obtained for all rootstocks the lowest yield (Fig 2) and small fruits (table 1) and mechanical cleaning to the middle of the alley way resulted in the highest crop for all rootstocks. Until 2003 soil covering with straw was at the same level as mechanic cleaning in the tree row, but in 2003 the yield on trees grown in soil covered with straw were at the same level as trees grown in soil with mechanical cleaning to the middle of the alley way. Mechanical weed cleaning using dish harrow resulted in the lowest yield of the 5 treatments, where weed were controlled (Fig 2).

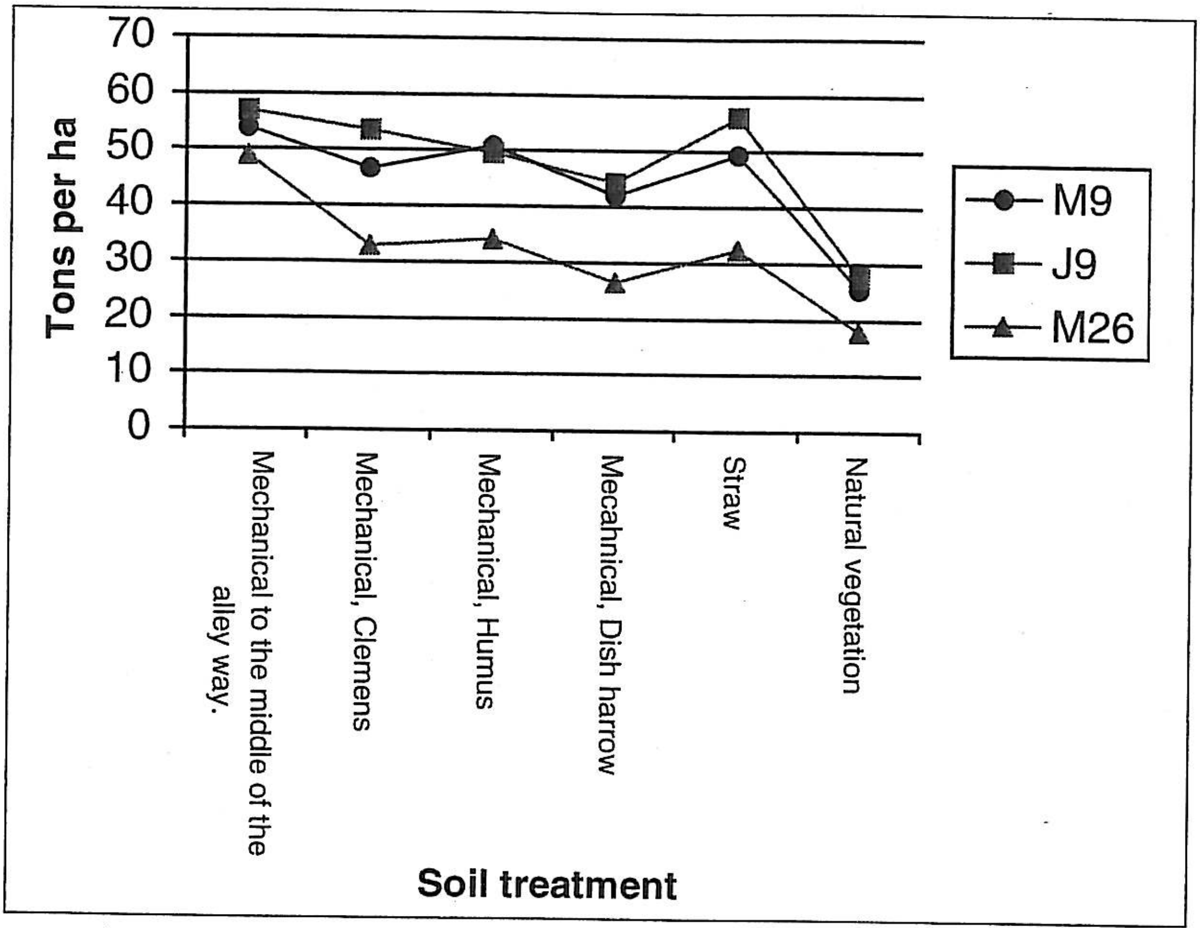

Fig 2. Total yield, sum t/ha in 2000–2003. Combinations of rootstocks and soil treatments.

Fruit quality

No significant differences were observed between soil treatments and rootstocks concerning the percentage of marketable fruit due to fruit size and skin damages. But there was a tendency towards a lower percentage of marketable fruit from trees grown in natural vegetation (Treatment 6) and a higher percent marketable fruit from trees grown in mechanical weed cleaning with Humus in the tree row (Treatment 3) and trees grown in straw (Treatment 5) (Table 2).

Table 2. Marketable fruit due to damage (pct and tons/ha), percent fruits with more than 50 pct skin colour, percent fruits with skin damage caused by apple scab, tortrix, codling moth, apple sawfly, red apple aphid and hail for 6 treatments and 3 rootstocks for the apple variety 'Retina' in 2003.

Treatment	Pct marketable fruit.	Market-able fruit T/ha	% fruits >50 pct colour	Apple scab	Tortrix	Codling moth	Apple sawfly	Red apple aphid	Hail
1. Mechanical to the middle of the alley way	60,2 a	10,6 a	45,3 a	5,0 a	15,6 a	10,6 a	35,0 a	14,2 ab	29,7 a
2. Mechanical, Clemens	58,4 a	8,7 ab	47,3 a	2,0 ab	24,2 a	8,7 a	34,2 a	8,1 b	18,2 ab
3. Mechanical, Humus	70,4 a	11,9 a	36,7 a	2,4 ab	13,9 a	20,2 a	26,4 a	6,7 b	13,0 b
4. Mecahnical, Dish harrow	55,3 a	5,3 bc	45,8 a	1,1 b	22,6 a	8,4 a	29,2 a	19,5 a	32,3 a
5. Straw	67,1 a	10,7 a	45,6 a	0,6 b	15,2 a	16,0 a	32,0 a	6,3 b	23,0 ab
6. Natural vegetation	52,7 a	3,4 c	52,8 a	0,0 b	22,0 a	8,3 a	31,7 a	9,3 ab	30,5 a
Rootstock									
M9	61,3 a	8,7 ab	50,6 a	2,0 a	19,3 a	16,5 a	33,4 a	13,9 a	20,7 a
J9	62 a	11,5 a	44,5 a	1,2 a	17,3 a	7,8 a	29,6 a	10,4 ab	28,4 a
M26	59,1 a	5,9 b	43,2 a	1,5 a	20,7 a	11,4 a	31,5 a	6,5 b	24,1 a

Values followed by the same letter in columns do not differ significantly.

Marketable fruit per ha was highest for the rootstock J9 and from trees grown in treatment 1, where mechanical weeding was done to the middle of the row, treatment 3 with mechanical weeding in the tree row using Humus and treatment 5 where soil was covered with straw (Table 2).

Fruit colour was not significantly different for the soil treatments or the rootstock but there was a tendency towards more red fruits from trees grown in natural vegetation and less red fruits on trees grown with mechanic cleaning in the tree row using equipment from Humus (Table 2).

Tortrix, codling moths, apple sawflies and red apple aphids heavily infested the fruits. There was a break down of the V_f resistance of 'Retina', especially in the most vigorous growing trees (Table 2).

Discussion

The rootstock M 26 gave the best yield grown in a soil treatment, where the clover grass alleyways were weeded. The competition for water and nutrients between the clover grass and the rootstock M26 probably reduced the yielding potential for M26 even the vegetative growth still was higher than for M9 and J9. For the rootstocks M9 and J9 the same tendency was observed, but covering the soil with straw gave better growing and production possibilities increasing yielding level (Fig 1).

Straw decreases the potential water evaporation from the soil surface. Even in this trial where we used drip irrigation the water saving using soil covering with straw had an additional effect on increasing growth and yield. We had no problems with mice.

Weed cleaning using dish harrow was not satisfying compared to the other equipments as weed cleaning up to one month before harvest had to be avoid due to damage risk on low hanging fruits.

Fruits grown on trees in natural vegetation had a lower vegetative growth and a lower content of nitrogen in the leaves. This resulted in more red fruits (Table 2) in accordance with results by Oland (1960) and Lindhard Pedersen and Bertelsen (2002). The fruits were heavily infested with pests and as a consequence, the percentage of marketable fruits was low, 52–70 % in 2003. In Denmark nearly no pesticides are allowed in organic production. The price per kg sold fruit is normally around 1.3 Euro when costs for packaging and storage are paid.

The break down of the V_f resistance of 'Retina' in Denmark was also fund at Aarslev research station in 1999 (Lindhard Pedersen and Bertelsen 2002) but is not seen before at Fejø, research orchard.

Conclusion

1. The rootstock J9 had the highest yield and the biggest amount marketable fruit of 'Retina'.
2. Mechanical cleaning to the middle of the alleyways (Treatment 1), tree row weed control using Humus (2003) (Treatment 3) or soil covering with straw (treatment 5) gave the best yield and ton marketable fruit for organically grow 'Retina'.
3. A one meter weeded strip in the tree row did not remove the competition of the clover grass alleyway.
4. Natural vegetation in the tree row reduced the yield with more than 50 percent.
5. There was a break down of the V_f resistance of 'Retina'

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7,5×1,3
910
65
9,75

1,4×7,5
750
300
10,50