3rd QLIF Congress, Hohenheim, Germany, March 20-23, 2007
Archived at http://orgprints.org/view/projects/int_conf_qlif2007.html

Effect of Rapid or slow release nitrogen supply and cover crop/weed management on crop yield, pest incidence and fruit quality in intensive organic apple production.

H. Lindhard Pedersen[1]

Key words: apple growing, planting system, nitrogen supply, fruit quality

Abstract

Apple is the commercially most important top fruit crop grown in the European Union. In spring 2001 one-year-old trees of the apple variety 'Ingrid Marie' were established in an organic production system with 3.0 m between the tree rows. Each plot consisted of three semi-plots at planting distances 0.6m (5555 trees ha^{-1}), 0.9 m (3333 trees ha^{-1}) and 1.2 m (2777 trees ha^{-1}). Tree growth, soil moisture, soil-, leaf- and branch analysis, diseases, fruit production, outer and inner fruit quality were measured.

The healthiest trees with the best coloured fruits were produced on trees grown in weed. But the yield was so low that production was not economical. A high production combined with trees less infected with fruit tree canker and with a satisfactory colouring was produced on trees grown in intensive production system of 5555 trees per ha with no nitrogen supply.

Introduction

Fruit yield, fruit quality and disease occurrence in organic apple production are controlled by a multitude of interacting agronomic factors, the most important being supply of water and nutrition, especially nitrogen input levels and availability pattern during the growing season.

The objectives of this research were to compare single spring application of standard "rapid release" organic fertilisers (chicken manure pellets) commonly used in organic production systems and traditional "organic" approach based on mineralization driven N-supply from inputs such as compost, which contains very low levels of water-soluble forms of nitrogen, with respect to nutritional status, yields, disease incidence and fruit quality characteristics of apple trees.

Materials and methods

The experimental orchard is located at the Danish Research Centre Aarslev (10^0 27´ E, 55^0 18´N), on a sandy loam soil, with a clay content of 11-15 %.

In spring 2001 one-year-old trees of the apple variety 'Ingrid Marie' was established in an organic production system with 3.0 m between the tree rows.

Six fertiliser treatments were established in spring 2004 in four blocks in a randomised complete block design. No irrigation was carried out.

The fertiliser treatments were:

1. No weed control between the trees in the row and no nitrogen supply.
2. Mechanical cleaning, no nitrogen supply.

[1] Danish Institute of Agricultural Sciences. DK-5792 Aarslev, Denmark, E-mail Hanne.Lindhard@agrsci.dk, Internet www.agrsci.dk

3. Mechanical cleaning, chicken manure pellets applied at levels equivalent to 25 kg N per Ha.
4. Mechanical cleaning, chicken manure pellets applied at levels equivalent to 50 kg N per Ha.
5. Mechanical cleaning, dairy manure-based compost applied at levels equiv. To 25 kg N per Ha.
6. Mechanical cleaning, dairy manure-based compost applied at levels equiv. to 50 kg N per Ha.

Each plot consisted of three semi-plots of four trees separated by guard trees on rootstock M9 at planting distances 0.6m (5555 trees ha^{-1}), 0.9 m (3333 trees ha^{-1}) and 1.2 m (2777 trees ha^{-1}). The order of planting distances within the semi-plots was randomised.

A permanent cover crop of *Festuca rubra* and *Poa pratensis* was sown in the alleyways, the mixture was chosen because it improved fruit quality in a previous experiment (Pedersen and Bertelsen, 2002).

Elementary sulphur was used to control apple scab (*Venturia inaequalis*) in primary apple scab infections periods due to RIMpro apple scab warning programme (http://www.biofruitadvies.nl/RIMpro/rimpo_schurft_e.htm). Quassia was applied to control apple sawflies (*Hoplocampa testudinea)* and oil applied to control rosy apple aphids (*Dysaphis plantaginea*), pheromone disruption was used against *Cydia pomonella, Archips rosana, Hedya dimidioalba* and *Archips podana.*

The diameter of the stem was measured 20 cm above the grafting during winter. The trees were pruned according to standard. The pruned material was weighed per tree. The content of plant available inorganic nitrogen was measured in the 0-50 cm top soil layer in mid April, June and September. Nitrate-N and ammonium-N were determined colorimetrically.

The soil moisture was measured in the upper 50 cm top soil in the centre of the tree row in June-September. Leaf samples were collected four-times during the growing season in June, July, August and September and analysed for content of Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg). Infection of fruit tree canker (Nectria galligena) and apple powdery mildew (Podosphaera leucotrica) was assessed every summer per tree and infected material was removed from the orchard. Apple scab (Venturia inaequalis) infections on all leaves on a single annual shoot on each tree in July 2005. Leaves are graded in 6 classes: Leaf missing, no infections, 1, 2-4, 5-9 or >10 spots per leaves.

Fruit production was measured as kg and number of fruit per tree. Fruit drop, rotten fruits and fruits infested with Rosy apple aphids was counted at harvest. Bloom, and thereby yield potential, was assessed during flowering in the spring of 2005 and 2006 by giving a score per tree from 1-9, where 1=no flowers.

Ten fruits per tree were evaluated for percentage red skin colour and examined for skin damages caused by apple scab (*Venturia inaqualis*), Monilia (*Monilia fructigena*) Fly speck (*Leptothyrium pomi*), Sooty blotch (*Gloedes pomigena*), Tortrix (different species), Codling moth (*Cydia pomonella*) and Apple sawfly (*Hoplocampa testudinea*) in 2004 and 2005.

The internal fruit quality was examined three weeks after harvest, on three fruits per tree. Fruit firmness was measured with a penetrometer. Soluble solids were determined with a digital refractometer. The starch pattern index (SPI) was estimated. The streif index was calculated. The content of major and minor minerals in the fruits was determined after removing core and stalk.

Results and discussion

Table 1: Trunk diameter, nitrogen in leaves, canker infected trees, fruits without apple scab, yield, fruit size and % surface colour as average of 2004 and 2005 for the apple variety 'Ingrid Marie' grown in 6 fertiliser systems.

	Trunk diameter 2004-2005	Nitrogen* 2004-05	Canker infection 2004-05	No apple scab infections 2004-05	Yield average 2004-05	Fruit size average 2004-05	Skin colour 2005
Soil treatments in the tree row	Mm diameter trunk^{-1}	% of dry matter	% infected trees	% fruits	Kg tree^{-1}	Gram fruit^{-1}	% surface
1. Weed, No nitrogen	32,57 d	1,53 c	36,1 c	63,5 a	0,86 b	95 b	96,3 a
2. No nitrogen	38,56 c	2,17 b	58,3 b	49,6 b	3,24 a	131 a	85,6 b
3. Poultry manure pellets 25 kg N	40,47 bc	2,29 a	76,4 ab	46,6 bc	3,60 a	135 a	79.7 d
4. Poultry manure pellets 50 kg N	42,97 ab	2,30 a	88,9 a	43,3 bc	3,01 a	133 a	78,8 d
5. Dairy compost 25 kg N	45,52 a	2,26 a	88,9 a	41,2 c	3,06 a	138 a	78,3 d
6. Dairy compost 50 kg N	41,17 bc	2,23 ab	81,9 a	43,0 bc	3,54 a	133 a	82,0 c
LSD	2,694	0,077	16,61	7,39	0,741	7,76	2,26

Numbers followed by the same letter in columns do not differ significantly for P<0,05.
* Optimum level Nitrogen in August: 2.0-2.5 % of leaf dry matter.

Table 2: Trunk diameter, nitrogen in leaves, canker infections, yield per tree and per ha, fruit size and % surface colour as average of 2004 and 2005 for the apple variety 'Ingrid Marie' planted on three planting distances in the row.

	Trunk diameter 2004-05	Nitrogen* 2004-05	Canker infections 2004-05	Yield	Yield	Fruit Size	Skin colour 2005
Planting distance	Mm diameter Trunk^{-1}	% of dry matter	% infected trees	Kg tree^{-1}	Ton ha^{-1}	Gram fruit^{-1}	% surface
0.6	37,41 b	2,12 a	69,4 a	2,34 b	13,0 a	126 b	82,9 a
0.9	41,47 a	2,12 a	73,6 a	2,85 b	10,5 b	127 b	83,1 a
1.2	41,72 a	2,15 a	72,2 a	3,47 a	9,6 b	134 a	82,4 a
LSD	1,905	0,054	13,16	0,524	2,066	5,45	1,60

Numbers followed by the same letter in columns do not differ significantly for P<0,05.

Weed in the tree row competed with the trees for nitrogen, compared to mechanic weed cleaning in the tree row. This caused a smaller growth and a low yield. The slow growth also resulted in a reduced infection of fruit tree canker (*Nectria galligena*) and small strong colored fruits with reduced infections of apple scab (*Venturia inaequalis*) and monilia (*Monilia fructigena*) (Table 1).
Nitrogen supply in the tree row given as 25 or 50 kg N dry poultry manure pellets in spring caused a slightly stronger growth but not an increased yield compared to no nitrogen supply. Nitrogen supply in the tree row given as 25 or 50 kg N dairy compost in spring caused a stronger growth, but not an increased yield compared to no nitrogen supply. There was no significantly additive effect on yield or growth supplying 50 kg nitrogen compared to 25 kg. Nitrogen supply increased infections of fruit tree canker (Table 1).

A planting distance of 0,6 m between the tress in the tree row reduced vegetative growth measured as trunk diameter and weight of pruned material compared to a distance of 0,9 m. The tress had the same level of available rainfall to share per ha. Trees on a 1,2 m planting distance in the tree row had a higher supply of water per tree than trees on 0,9 m. In a high density planting water may more often become limited compared to systems with fewer trees per ha. Therefore irrigation systems are stressed in high-density plantings.
There is competition for nutrition and water in the densest planting system. The competition for space caused fewer resources for flower bud formation and fruit growth. But due to the higher number of tress per ha in the high-density system yield per ha was bigger for the trees planted with 0,6 m between the trees in the tree row.

High-density orchards are expensive to establish, because expenses for trees is high. In this trial yield reduction occurred per tree on the most dense planting distance after the first two yielding seasons. For that reason it is not likely that the high density of 5555 tress per ha is profitable on the long run.

Conclusions

The healthiest trees with the best coloured fruits were produced on trees grown in weed. But the yield was so low that production was not economical. A high production combined with trees less infected with fruit tree canker and with a satisfactory colouring was produced on trees grown in intensive production system of 5555 trees per ha with no nitrogen supply.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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