NUTRIHORT

Nutrient management, innovative techniques and nutrient legislation in intensive horticulture for an improved water quality

September 16-18, 2013, Ghent

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editors

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PREFACE

Background

Growers urgently need to find and implement more sustainable strategies for the intensive production of vegetables, potatoes, flowers and ornamental trees. Plant production in the open field or in greenhouses is challenged by the need to balance high productivity and sometimes late harvests with fewer nutrient losses to the environment. The reasons for this are clear: the nutrient enrichment of soil and water disrupts the natural processes in agro-ecosystems and leads to decreased biodiversity. High concentrations of nitrate or phosphate can cause eutrophication of the surface and coastal water. Leaching of nitrate or phosphate to the groundwater can pose a problem for drinking-water production.

Aims of NUTRIHORT

NUTRIHORT presented the current knowledge of sustainable and innovative techniques in vegetable and ornamental plant production. The conference focused on innovative fertilization, crop residues management, crop rotation, organic matter management and soil quality practices in horticulture. Throughout this conference, the focus was on the conflict between crop quality demands and legislative requirements to protect water quality.

In addition to oral and poster presentations on these topics, working groups during dedicated sessions discussed 1) technical and economic benchmarking of sustainable and innovative cultivation and fertilization techniques in horticulture and 2) the implementation of environmental EU directives in different horticultural regions and opportunities for innovative nutrient legislation to control pollution and improve water quality.

Conference themes

The conference covers the following themes:

- Nutrient legislation in horticulture
- Nitrogen dynamics in relation to soil quality
- Nitrogen mineralization from soil organic matter in horticultural fields
- Good agricultural practices for vegetable crop residues
- Conflict between improving soil organic matter and legislative requirements, e.g. the Nitrates Directive
- Phosphorus, horticulture and the environment
- Conflicts between crop quality and legislative requirements
- Nutrient use efficiency and fertilization advice
- Catch crops and crop rotation alternatives in intensive horticultural production
- Innovative cultivation and fertilization techniques in horticulture
- Recirculation of nutrients in greenhouse horticulture

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(58) Influence of fertilisation and cultivation methods on the yield and essential oil content of thyme (*Thymus vulgaris* L.)

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Abstract: *The information in the literature concerning the influence of nutrient supply on the yield of biomass and essential oil of plants belonging to the Lamiaceae, in particular thyme, is very contradictory. However, it is well known that the quantity of fertilisers and their composition may influence not only the biomass and essential oil, but also the vitality and the hibernation of thyme. Therefore, a field experiment with the cv. 'Deutscher Winter' was carried out in order to investigate the effects of fertilisation during a three- years-cultivation period. Five treatments were applied ('standard fertilisation without N fertilisation', with 'double amount of N fertilisation', with 'double amount of K', 'covered with fleece', and with 'double plant density') and their effects on the content of essential oil, thymol, yield of thyme (dried leaves, leaf fraction on the plants), and influence on hibernation were analysed. The highest yield was recorded in the treatments 'covered with fleece' and at the 'double plant density with standard fertilisation' in average of the three years. The lowest yield of leaf drugs was determined in treatment 'without N-fertiliser', the highest at the 'double plant density'. The amount of essential oil was highest in the treatment 'double plant density', whereas the lowest essential oil quantity was determined when twice the quantity of N was applied. The content of thymol was highest in the treatment standard fertilisation without N-fertiliser. Concerning the vitality and effect on hibernation best results were determined in the treatments without N-fertilisation and covering with fleece. These results confirm the theory that nitrogen has a negative effect on the content of essential oil and its components as well as the vitality of the plants during the winter season.*

Keywords: *N-supply, K-supply, hibernation, plant vitality, thymol*

Introduction

Integrated cropping of *Thymus vulgaris* L. requires nutrient supply based on the uptake in relation to the yield. The nutrient supply should be carried out following the nutrient uptake and the nutrients available in the soil up to 60 cm depth, in particular in case of the mineral nitrogen content (Bomme et al., 1993). There are calculations for the necessary quantity of the macronutrients in relation to the yield and uptake of thyme. For a mean yield of 15 t ha^{-1} fresh mass, an amount of 60 kg N, 17 kg P_2O_5, 115 kg K_2O, 10 kg MgO and 40 kg CaO per hectare should be applied to most of the soil types. The nitrogen fertiliser has to be applied in two dosages, the first half of the entire amount should be applied three weeks after the germination or planting and the second half after the thyme population covered the soil completely (Bomme et al., 1993; Bomme and Nast, 1992; Bomme and Nast, 1998; Bomme and Wurzinger, 1990).

The influence of fertilisation on the (internal) quality of thyme has been in the focus of scientific research since the beginning of the field production of thyme. Currently, in the literature very contradictory information exists regarding the right amount and frequency of fertilisation, in particular concerning the amount of essential oil content of thyme. Weichan (1948) and Kästner (1966) observed in experiments with different levels of fertilisation for herbs belonging to the family Lamiaceae, the highest amount of active substances when cultivated in a clay-loamy soil. Shalaby and Razin (1992) investigated the influence of different dosages of N and P on different thyme densities on the yield and internal compounds. Their finding showed a significant influence on the plant height, fresh and dry matter, but no significant effect on the essential oil content in the leaves. Although, the total oil content in whole thyme plant (stem and leaves) was significantly influenced by the different fertilisation dosages. The highest fresh matter and total essential oil yield was obtained if 105 kg N ha^{-1}; 57 kg P_2O_5 ha^{-1}; 57 kg K_2O ha^{-1} were applied and plant density was two times higher than normal. Omidbaigi and Arjmandi (2001) investigated the influence of six different dosages of nitrogen and phosphorus on growth parameters, flowering, leaves and oil yield of thyme. Thyme with treatments of 250 kg N ha^{-1} and 200 kg P ha^{-1} were flowering 5 days later. The essential oil and thymol content was slightly influenced. Similar results were obtained for other medicinal and aromatic plants. Röhricht et al. (1999) did not discover an influence of additional phosphorus fertilisation on the essential oil content in coriander. In oregano, investigation of Kadner et al. (1999) showed that more N-fertilisation enhances the seed yield, but no significant effects on the essential oil content in oregano were detected. Trivino and Johnson (2000) detected correlations between the quantity of fertilisation and the leave yield, but no significant influence on the quantity and composition of the essential oil. Ozguven et al. (2006)

investigated the influence of 0, 40, 60 and 80 kg nitrogen fertilisation per ha on the yield and essential oil content in *Origanum syriacum* (L.). The highest fresh herb yield (19.86 t ha^{-1}) was obtained at full blooming period with a N rate of 40 kg ha^{-1}, whereas the highest dry herb yield (8.95 t ha^{-1}) was obtained at the end of blooming also with a N rate of 40 kg ha^{-1}. The highest essential oil content (6.16%) was obtained in the first year of the experiment when harvested at full blooming period with the N rate of 60 kg ha^{-1}. Similar results were described by Baranauskiene et al. (2003), they concluded that different fertilisation doses do not result in significant differences on the internal compounds of thyme herbs except the vitamin C content.

After evaluation of the cited literature, it can be concluded that past results regarding the influence of fertilisation on the growth parameters and essential oil content were contradictory.

Therefore an experiment was conducted in order to understand the effect of different nitrogen and potassium fertilisation as well as different density of the plants and using fleece as a protection cover.

Materials and Methods

Thyme cultivar, Deutscher Winter' was sown in a container filled with sieved green compost in week 8 and placed in a greenhouse. The seeds were covered with a layer of approximately 1 mm quartz sand. Three weeks after germination the seedlings were hardened in a cold frame. The experimental plot consisted of four repetitions of 8.75 m^2 each. The treatments were placed in a randomized block design. The plants were transplanted in week 17. Seven plants were planted together in a cluster, in six rows with 462 plants per plot in a distance of 30 x 40 cm. In the treatment ‚double plant density' the plant distance was 15 x 40 cm. In this treatment 924 plants were planted. The plants were cultivated for three years.

The experiment was set up in loamy sand (podsol) with pH 6.4 and organic carbon content of 1.4%. The average year temperature at this location was 8.7°C and the average precipitation 566 mm. Additional watering with an amount of 15 mm water was conducted if the tensiometer-value was 400 hPa.

The treatments of this experiment are described in table 1. The entire amount of additional N or K was applied between two and four times during the experimental year depending on soil analyses, plant growth and weather conditions. Harvesting of the herbs was carried out seven times, one time in the first year and three times in the second and third year.

The nutrient elements in the soil were analysed following the VDLUFA methods. Total nitrogen was analysed by using the Kjeldahl-method, nitrate by using an ion selective electrode after extraction with a potassium-sulphate solution.

The analysis of the essential oil content was carried out by the steam-extraction method in a Neo Clevenger apparatus. Leaves of thyme (30 g) were placed in 400 ml distilled water in a 1000 ml flask, the distillation lasted 2 hours.

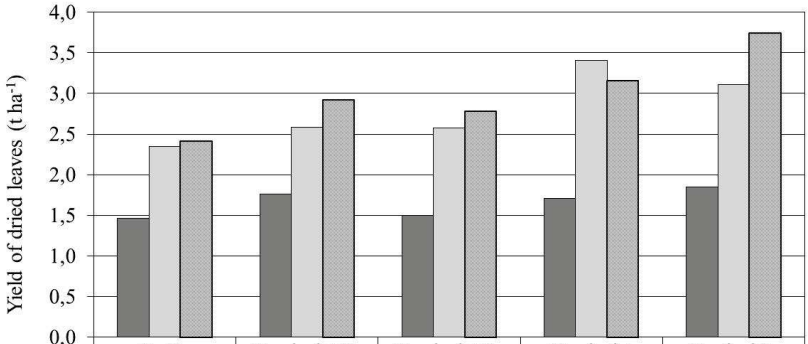
SPSS programme was used to calculate the data in a mono factorial analyse. Tukey-Test was used for comparison of standard aviation with a significance level of $P<0.05$. For evaluation of treatments tested parameters were ranked using a non-parametric test (Kruskal-Wallis test).

Results and Discussion

The highest yield of dried leaves was obtained during all three year in the treatment ‚Standard fertilisation + fleece cover' followed by ‚Standard fertilisation + double plant density'. The lowest herb yield was harvested in the treatment 'no nitrogen fertiliser'. Additional nitrogen and potassium fertilisation enhanced tendentially the yield of fresh herbs as well (Figure 1).

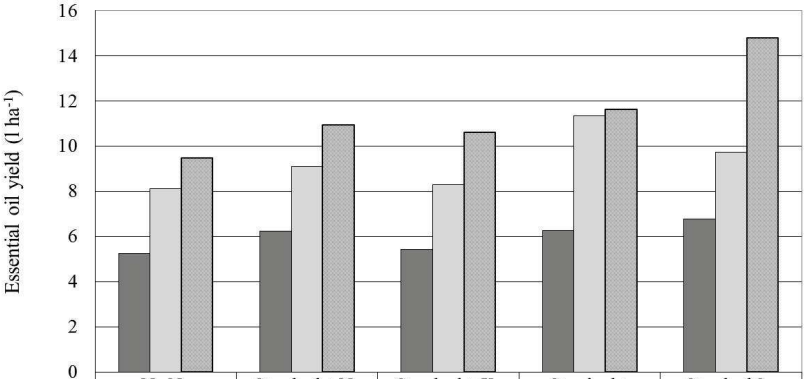
The nutritive and economical value of thyme is mainly characterised by the content of essential oil, therefore this parameter was analysed (Figure 2). Only slight differences could be detected between the treatments. In the first year of the experiment no significant effect of the different fertilisation treatments on the essential oil yield was discovered, therefore these results could not confirm the negative influence of a higher nitrogen fertilisation. Significant higher yield of essential oil in the first year, however, was detected in the treatment with 'double density of thyme plants'. In the second year protecting the plants with fleece showed significantly higher oil content than all other treatment. In the third year significantly higher essential oil yield was only detected in the treatment with the double amount of thyme plants. Beside the yield of essential oil per area, also the quantity of essential oil in 100 g dried leaves is an important parameter. In the first year of the experiment the essential oil yield in the dried leaves of thyme was in average between 2.74 and 2.83 ml 100 g^{-1}. In the second year in average of all three harvests an average yield of essential oil between 2.82 and 3.09 ml 100 g^{-1} was detected. The essential oil yield increased in comparison to the first year of the

experiment with 7.58%. In the third year the essential oil content decreased distinctly to 2.63 – 2.72 ml 100g^{-1} dried leaves with –10.4 %. The fertilisation treatments, in particular the nitrogen fertilisation weren't influencing the quantity of essential oil and thymol content (data not shown). Similar results were obtained also from other authors (Shalaby and Razin, 1992; Omidbaigi and Arjmandi 2001; Baranauskiene et al., 2003).



	No N-fertilization	Standard + N-fert.	Standard + K-fert.	Standard + fleece cover	Standard 2x plant density
1st year	1,5 b	1,8 ab	1,5 b	1,7 ab	1,8 a
2nd year	2,4 c	2,6 c	2,6 c	3,4 a	3,1 bc
3rd year	2,42 b	2,92 b	2,78 b	3,16 ab	3,75 a

Figure 1 Dried leave yield of thyme (mean of three years) cultivated with three different fertilisations, protection with fleece and double plant density. Different letters indicate significant differences according to Tukey (P<0.05).



	No N-fertilization	Standard + N-fert.	Standard + K-fert.	Standard + fleece cover	Standard 2x plant density
1st year	5,26 b	6,23 ab	5,43 ab	6,25 ab	6,76 a
2nd year	8,13 b	9,09 ab	8,29 ab	11,35 a	9,74 ab
3rd year	9,45 b	10,91 b	10,58 b	11,62 b	14,78 a

Figure 2 Essential oil yield of thyme (mean of three years) cultivated with three different fertilisations, protection with fleece and double plant density. Different letters indicate significant differences in one year according to Tukey (P<0.05).

The aim of this study was also to investigate the effect of different treatments (Table 1) on the hibernation of the thyme plants. Therefore, the dead plants in all plots, the damaged plants in the cluster and the healthy plants were recorded two times, one time in winter and one time in spring (Figure 3). The lowest number of damaged and died plants was obtained in the treatment 'standard fertilisation and covered with fleece' followed by 'no N-fertilisation'. In the treatments 'double density of thyme plants' and additional K fertilisation, was the hibernation influence equivalent. Double amount of nitrogen fertilisation was negatively affecting the hibernation, many plants died during the winter. This negative effect of higher nitrogen supply on the hibernation resistance was also mentioned in other publications (Baranauskiene et al., 2003).

Table 1 Treatments to investigate the effect of N and K fertilisation, plant density and fleece cover on the essential oil yield and hibernation

Treatments	Comments
1. Standard fertilisation[1], no N-fertilisation	Plant spacing 30 x 40 cm
2. Standard fertilisation[1] with additional N-supply	Additional 60 kg N ha^{-1}, Plant spacing 30 x 40 cm
3. Standard fertilisation[1] with additional K-supply	Additional 100 kg K_2O ha^{-1}, Plant spacing 30 x 40 cm
4. Standard fertilisation[1] and fleece cover	Fleece cover (weight 30g m^{-2}) November-March; Plant spacing 30 x 40 cm
5. Standard fertilisation[1] and double plant density	Plant spacing 15 x 40 cm
[1] **Standard fertilisation** 60 kg N ha^{-1}, 17 kg P_20_5 ha^{-1}, 115 kg K_2O ha^{-1}, 10 kg MgO ha^{-1} and 40 kg CaO ha^{-1}	

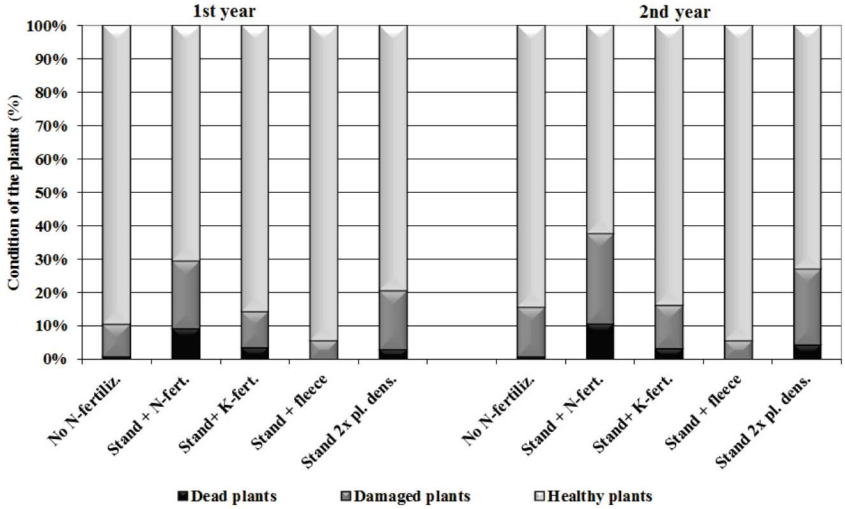


Figure 3 Condition of the thyme plants after 1st and 2nd year of hibernation, cultivated with three different fertilisations, protection with fleece and double plant density.

In order to evaluate the influence of the different treatments on all quantitative and qualitative parameters measured and detected a ranking was conducted (Table 2). In result of this statistically ranking it was proved that the best treatment was 'standard fertilisation and double plant density' and on the second place the treatment 'standard fertilisation and fleece cover' was discovered.

Table 2 Evaluation of ranking the influence of treatments on different parameters obtained in the experiment with thyme (Kruskall-Wallis-Test)

Treatments	Yield of dried leaves	Leaf fraction on the plant	Essential oil content	*Thymol-content*	Ranking
No N-fertilisation	5.46	15.87	8.50	12.38	3
Standard fert. + N-fertilisation	11.50	12.12	7.04	10.25	4
Standard fert. + K-fertilisation	7.79	9.54	11.16	10.54	5
Standard fert. + fleece cover	14.96	11.50	10.71	8.66	2
Standard fert. + double plant density	16.35	11.75	11.58	11.34	1

Nevertheless, in the treatment 'no N-fertilisation' the highest leaf fraction on the plant could be obtained, whereas in this treatment the produced biomass and essential oil per ha was the lowest.

Comparing the results obtained in the three experimental years, sometimes high differences were observed, but the correlation coefficient between the years and the leaf fraction on the plants was with 0.34% not very high.

Conclusion

It seems that the percentage of leaves per produced biomass cannot be influenced by additional nutrient supply. But because of the very different results for this parameter in the three years of cultivation influences of the climate conditions and frequency of harvesting should considered in further experiments. Also the content of essential oil in the thyme plants seems to be not dependent on the nutrient supply. Other factors as harvesting frequency, average temperature and precipitation are more important. The essential oil yield is depending on the interaction between fertilisation, number and time of harvesting and the weather conditions. While there were no effects of fertilisation on yield the hibernation was clearly affected especially by N-fertilisation. Based on this a reduced N-fertilisation seems to be recommended. In further experiments plant density and covering with fleece should investigated in more detail.

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