JOURNAL OF AGRICULTURAL SCIENCE IN FINLAND
Maataloustieteellinen Aikakauskirja
Vol. 59: 25—29, 1987

Studies on fertilization of dill (*Anethum graveolens* L.) and basil (*Ocimum basilicum* L.)

III Oil yield of basil affected by fertilization

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Abstract. Basic fertilization and nitrogen top-dressing of basil was studied in 1984 and 1985 at the Department of Horticulture, University of Helsinki. The total N doses applied were 0, 0.2, 0.4, 0.8, 1.2 and 1.6 kg N/100 m^2. In 1984 the plants were of a mixture of different fenotypes and two of those formed 85 % of the crop-stand. In 1985 the variety grown was 'Budakalasz'.

The optimum basic fertilization proved to be a compound fertilizer at the rate (NPK) of 0.4—0.16—0.68 kg/100 m^2. The content of volatile oils in dried herb ranged from 0.32 to 1.46 %. The total oil content was not significantly affected by fertilization except in 1984 when the fertilization decreased the oil content in the other of those two major fenotypes.

Index words: calcium nitrate, compound fertilizer, basil nitrogen

Introduction

The general aim of the studies on fertilization of herbal plants has been the optimizing of application level in respect to both the herb yield and aroma content and composition. The results found in different studies are, to some extent, conflicting. Flück (1954) has stated that increase in fertilization will first increase the aroma content, and after a certain optimum level decrease that. The studies of Hornok (1980, 1983) on herb plants confirm this. On the contrary, Nykänen (1986) has found that nitrogen (N) application will first decrease and in larger doses increase the aroma production and also change the aroma composition. The edafic factors have been found to influence more the herb yield than the aroma, and in addition, having more effect on the amount of the total aroma than on the composition of aroma causing compounds (Flück 1954).

Weichan (1948) has reported that the fertilization has minor effect on the aroma content of basil. Ruminska (1978), instead, reported that increasing NPK-fertilizing will increase both the basil yield and the amount of the volatile oils. Wahab and Hornok (1981) stated, according to the studies carried out in Hungary, that the rates of 1.2—1.0—1.0 kg NPK/100 m^2 give the best result in respect to both the herb yield and aroma of basil. Later HORNOK (1983) found that K is of minor importance and the optimum dose of NPK was higher, 2.4—1.5—1.2 kg/100 m^2. N decreased the linalool content, and K instead, increased the contents of linalool and estragol.

The effects of fertilization of herbal plants have been mostly studied in Middle Europe. Research in this field is necessary also in northern conditions especially now that there is a growing interest in herb production in Nordic countries. A study on the effects of different levels of basic fertilization and N top-dressing on basil was carried out in two successive years (1984—85) in Finland. The effects on both the herb yield and aroma was studied. The detailed results on herb yield are reported separately (HÄLVÄ and PUUKKA 1987).

Materials and methods

The effect of fertilizing on the herb yield of basil was studied during 1984 and 1985 at the Department of Horticulture, in the University of Helsinki. Five treatments including the unfertilized control were applied in 1984. The soil, humous fine sand, was fertilized by 4 kg/100 m^2 compound fertilizer (NPK 10—4—17) before planting basil. The nitrogen top-dressing by calcium nitrate (NO_3-N 16, Ca 20) was broadcast two weeks later, except the largest dose which was split in two applications. The first one was applied two weeks after planting and the second one after two more weeks. The total nitrogen rates were A: 0, C: 0.4, D: 0.8, E: 1.2 and F: 1.6 kg/100 m^2. In addition, in 1985 a treatment of B: 0.2 kg N/100 m^2 by the compound fertilizer (10—4—17) was applied before planting (HÄLVÄ and PUUKKA 1987).

In 1984 the basil seeds were of a mixture of several chemotypes, and in 1985 the variety grown was 'Budakalasz'. Basil, started in a greenhouse, was transplanted into the openfield after a month in spacings of 20 × 25 centimeters. The crops were grown using general farming practices and harvested at the beginning of flowering (HÄLVÄ and PUUKKA).

The amount and composition of aroma compounds in dried herb were analysed by the method of head space gas chromatography as described by HILTUNEN et al. (1985). In 1984 the fresh samples were also determinated by high resolution gas chromatographic mass spectrometry (NYKÄNEN 1986). The results on herb yields and nitrate concentrations (1984) are published separately by HÄLVÄ and PUUKKA (1987).

The field trials were set up according to the method of completely randomized blocks with four replications and plots of 3 m^2. The data was studied by analyses of variance and regression. The means were separated by Tukey's HSD or Student-Newman-Keuls's multiple range tests (STEEL and TORRIE 1980).

Results

The basil plants in 1984 consisted of six clearly different fenotypes two of which were of the majority. Those with either violet flowers and thin, light green leaves (fenotype 1) or those with white flowers and thick, shiny leaves (fenotype 2) formed 85 % of the total crop stand and the results of these were analysed separately.

The contents of volatile oils ranged from 0.32 to 1.46 % in 1984, and from 0.93 to 1.14 % in 1985 (Fig 1). The fertilization had significant ($p < 0.05$) effect only on the oil content of fenotype 2: the total oil content in the herb decreased the more fertilized the crop was. The response to nitrogen application is presented in Figure 2. The oil composition was not affected by the fertilization.

The oil content was significantly ($p < 0.01$) higher in the herb of fenotype 1 than in fenotype 2. The highest figure was reached with the smallest fertilization application (0.4 kg N/100 m^2) and the lowest one with the

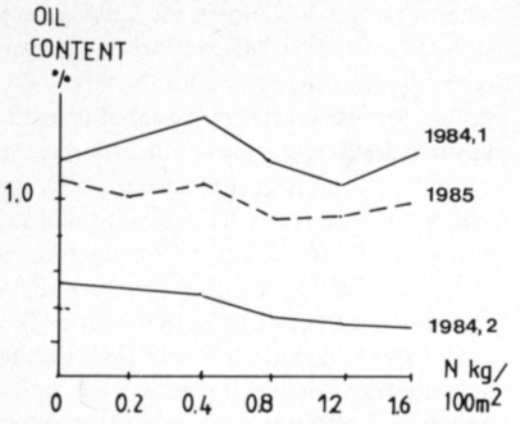

Fig. 1. Volatile oil contents in basil herb affected by nitrogen application (1984: fenotypes 1 and 2, 1985 'Budakalasz').

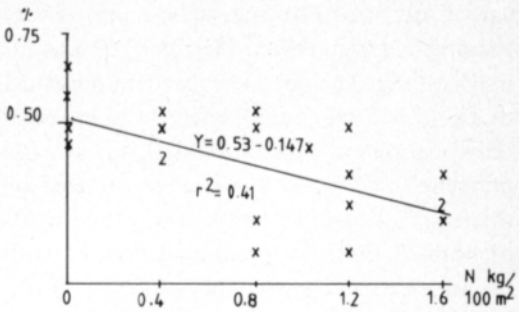

Fig. 2. Response of the volatile oil contents (fenotype 2) to the nitrogen applications (1984).

largest application (1.6 kg N/100 m^2) (Fig 1). Compounds methyl chavicol (estragol), linalool, β-caryophyllene and eugenol were in highest amounts among the 14 compounds identified. The oil composition of the two major fenotypes was clearly different. Fenotype 1 was of methyl chavicol-type, and linalool and eugenol were in highest amounts in fenotype 2 (Table 1).

In 1985 there were no significant differences in aroma content of the variety 'Budakalasz'

Table 1. The main compounds in the volatile oils of basil herb in 1984—85 according to the fertilization treatments.

TRIAL/ compound	A	B	C	D	E	F	F-values*		
							a	b	c
FENOTYPE 1/1984									
Methyl chavicol	68.6	—	75.9	75.3	73.8	78.6	2.22	271.5^{xxx}	0.63
β-caryophyllene	6.6	—	7.2	5.1	4.9	5.2	0.48	2.0	1.22
Germacrene-D	4.7	—	3.6	3.2	3.2	3.5	1.26	0.2	0.96
Borneol	1.7	—	1.2	1.2	1.4	1.4	1.07	24.0^{xxx}	0.27
1,8-Cineol	2.0	—	2.4	1.9	1.9	1.6	0.54	0.1	1.60
Eugenol	0.7	—	0.3	0.2	0.0	0.0	3.36	63.7^{xxx}	2.03
Linalool	0.3	—	0.4	1.3	0.1	0.0	1.79	477.2^{xxx}	1.73
FENOTYPE 2/1984									
Methyl chavicol	2.1	—	19.0	20.5	16.8	14.7			
β-caryophyllene	5.0	—	4.1	4.0	6.0	5.3			
Germacrene-D	3.5	—	4.0	2.8	3.3	3.8			
Borneol	3.3	—	2.4	2.5	2.1	3.1			
1,8-Cineol	1.9	—	1.8	2.1	1.3	2.5			
Eugenol	3.5	—	4.0	2.8	3.3	3.8			
Linalool	46.7	—	34.7	38.8	40.7	33.9			
'BUDAKALASZ'/1985									
Linalool	57.4	56.8	55.8	59.4	59.6	58.5	0.18		
Eugenol	14.6	13.6	12.5	11.6	10.9	9.1	0.55		
Thymol	5.8	5.8	5.9	5.1	6.4	6.9	1.20		
Methyl chavicol	4.1	3.4	3.8	3.9	4.8	4.6	1.31		
β-caryophyllene	1.6	1.4	1.5	1.5	1.5	1.3	0.22		
1,8-Cineol	1.2	1.2	1.1	1.3	0.8	0.9	0.68		
γ-terpinene	0.4	0.3	0.6	0.4	0.3	0.3	0.72		

* 1984: F(4,12) a = fertilization, F(1,15) b = fenotype, c = interaction
1985: F(5,23) a = fertilization

caused by basic fertilization, calcium nitrate top-dressing or nitrogen. The main compounds in the oil were linalool and eugenol as presented in Table 1. Two components found in traces only, β-pinene ($r = -0.701{+}{+}{+}$) and myrsene ($r = -0.532{+}{+}$), were affected by the fertilization doses applied — the contents of both of these compounds decreased with the increase in nitrogen application. The methyl chavicol content slightly increased with nitrogen fertilization ($r = 0.407{+}$).

Discussion

The optimum fertilization application for basil in the Finnish climate on a soil in good nutritional condition proved to be a basic fertilization at the rate of 0.4—0.16—0.68 kg NPK/100 m^2 which is smaller than what has been reported in southern countries. In the north low temperatures and a short growing season restrict the growth of cold-sensitive plants like basil. These plants must be first grown in greenhouses and later transplanted out-of-doors shortening thus the growing period in the field. Accordingly, less fertilization is needed outdoors than in the southern conditions.

The average volatile oil content and composition were not considerably affected by the fertilization applied. The plants without fertilization had the highest amount of the volatile oils. Nykänen (1986) also found the highest total oil contents in the herbs grown without fertilization. The comparison between the results in different studies is most complicated because of different analysing methods. In addition, the variation between the contents of the individual samples in the above mentioned report was extremely wide, and the conclusions on the effect of fertilization remains indistinctive. Neither the two main fenotypes were separated in the work of Nykänen (1986), and the oil was thus named linalool-estragol while in the present study fenotype 1 was found to be of estragol-type and fenotype 2 of linalool-eugenol-type.

The decrease in the volatile oil content (fenotype 2) by increase in fertilization conflicts with the results reported by Ruminska (1978) and Wahab & Hornok (1981) who have stated that increasing fertilization will also increase the aroma. Many scientists like Guenther (1949), Gildmeister and Hoffmann (1961) and Jansen (1981) have reported earlier on the different oil composition of different basil chemotypes. This feature stresses the importance of plant breeding and variety testing of herb plants. Basil with significant amount of linalool and estragol or just estragol are preferred by the food industry (Zola and Garnero 1973).

Acknowledgements. The author wishes to thank Leena Puukka and Heikki Vuorela for the technical assistance. The work was supported by the Academy of Finland and the Tiura foundation.

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SELOSTUS

TILLIN JA BASILIKAN LANNOITUS

III Lannoituksen vaikutus basilikan öljysatoon.

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Basilikan lannoitusta tutkittiin vuosina 1984 ja 1985 Helsingin yliopiston puutarhatieteen laitoksella. Kokeissa selvitettiin peruslannoituksen (NPK 10—4—17) ja kalkkisalpietarina annetun typpilisän (N03—N 16, Ca 20) vaikutusta basilika satoon ja haihtuvan öljyn määrään ja koostumukseen. Vaikutukset yrttisatoon raportoidaan erikseen (Hälvä ja Puukka 1987). Kokonaistyppimäärät olivat 0, 0.2, 0.4, 0.8, 1.2 ja 1.6 kg N/100 m^2. Peruslannoitteet (Puutarhan Y3), 0.2 ja 0.4 kg N/100 m^2, levitettiin ennen basilikan istutusta ja lisälannoitteet annettiin kahden viikon kuluttua, paitsi suurin erä, joka annettiin kahdessa osassa kahden viikon välein.

Sato korjattiin juuri basilikan kukinnan alkaessa. Haihtuva öljy analysoitiin Helsingin yliopiston farmasian laitoksella kaasukromatografisesti head space -menetelmällä. Vuonna 1984 basilikakasvusto koostui pääasiallisesti kahdesta muista selvästi poikkeavasta fenotyypistä, joiden haihtuvan öljyn määrä oli 0.32—1.46 %. Toinen näistä oli pääkomponenttien mukaan estragoli-tyyppiä ja toinen linaloli-eugenolityyppiä. Vuonna 1985 viljelty lajike oli 'Budakalasz'. Sen öljypitoisuus oli 0.93—1.14 % ja koostui etupäässä linalolista ja eugenolista.

Lannoitus vaikutti merkitsevästi vain toisen fenotyypin öljypitoisuuteen: sen määrä väheni sitä mukaa kuin lannoitusta lisättiin. Lannoitus ei muuttanut basilikan öljyn koostumusta. Fenotyyppien öljypitoisuudet poikkesivat huomattavasti toisistaan. Tästä syystä maustekasvien lajikejalostukseen tulisi lisätä huomiota, sillä vain harvoista lajeista on olemassa lajikkeita.