JOURNAL OF AGRICULTURAL SCIENCE IN FINLAND
Maataloustieteellinen Aikakauskirja
Vol. 59: 11—17, 1987

Studies on fertilization of dill (*Anethum graveolens* L.) and basil (*Ocimum basilicum* L.) I Herb yield of dill and basil affected by fertilization

HÄLVÄ, S. & PUUKKA, L.

Dept. of Horticulture, University of Helsinki, SF-00710 Helsinki, Finland

Abstract. Fertilization of dill and basil was studied in 1984 and 1985 in Helsinki, both basic fertilization and N top-dressing being included. The total N doses were 0, 0.15, 0.3, 0.4, 0.8, 1.2 and 1.6 kg N/100 m² for dill and 0, 0.2, 0.4, 0.8, 1.2 and 1.6 kg N/100 m² for basil.

The optimum basic fertilization for dill and basil was a compound fertilizer of the rate (NPK) of 0.4—0.16—0.68 kg/100 m². In one year basil received a benefit from N top-dressing corresponding to total application of 0.8 kg N/100 m². Estimating the yield by the amount of N fertilizer indicated that dill yield would increase up to the fertilizing rate of 1.15 and basil yield up to 1.0 (in 1985) or 1.50 (in 1984) kg N/100 m² after which the herb yields will decrease.

The dry matter content of dill decreased and the nitrate concentration of both dill and basil increased as the fertilization increased. Basil was severely damaged by fungus diseases, the more fertilization was applied.

Index words: basil, calcium nitrate, compound fertilizer, dill, nitrogen

Introduction

Many studies have been carried out on the effects of the fertilization of herbal plants in Middle Europe, but only a few in nordic conditions. Thus research in this field is necessary, especially now that there is a growing interest in herb production in nordic countries. The influence of different levels of basic fertilization and nitrogen (N) top-dressing on dill and basil was studied in two sucsessive years in Finland. The effects on both the herb yield and aroma were investigated.

In general, the aim of the studies on fertilization of herbal plants has been to find the optimum application level in respect to both the herb yield and aroma content and composition. WEICHAN (1948), ATANASSOV et al. (1976), RUMINSKA (1978) and HORNOK (1980, 1983), among others, have studied the fertilization of dill and basil in Middle Europe.

According to FLÜCK (1954) the soil conditions have a stronger effect on the herb yield than on the aroma and, in addition, more influence on the amount of the total aroma than on the composition of aroma-causing compounds. N has the major effect. Also RUMINSKA (1978) has reported that fertilization increases the herb yield in particular. WEICHAN (1948) reported that especially phosphorus (P)

is of great importance for dill growing. HORNOK (1980) found that increasing N-fertilization will increase the dill yield. In Bulgaria, ATANASSOV et al. (1976) have found that equal doses of 0.7 kg/100 m² of both N, P and K will give the largest dill yield. Higher doses did not increase the yield.

According to the studies on basil WEICHAN (1948) reported that the optimum herb yield was reached by the compound fertilizer of 1.04—0.12—0.73 kg NPK/100 m². Dividing the total fertilizer application into basic fertilization and top-dressing gave the best result. High doses of P proved to hinder the growth and decrease the oil content. In Hungary WAHAB and HORNOK (1981) have reported that the rate of 1.2—1.0—1.0 kg NPK/100 m² gives the best result in respect to both the herb yield and aroma of basil.

Material and methods

The effect of fertilization on the herb yield of dill and basil was studied during 1984 and 1985 in the University of Helsinki, Finland. Five treatments including the unfertilized control were applied in 1984. The soil was fertilized by 4 kg/100 m² compound fertilizer (10-4-17) before sowing dill or planting basil. The N top-dressing by calcium nitrate (NO_3-N 16, Ca 20) was broadcast two weeks later except the largest dose for basil which was applied as a split application two weeks apart (the first two weeks after planting and the next after two more weeks). The total N rates were 0, 0.4, 0.8, 1.2 or 1.6 kg/100 m². In 1985 the effect of the lower doses was studied more accurately: dill was given two more treatments, 0.15 and 0.3 kg N/100 m², and basil 0.2 kg N/100 m², with the compound fertilizer (10-4-17) before planting or sowing. The treatments are presented in Table 1.

Dill ('Dura') was sown at the end of May at the rate of 200 g/100 m² in rows 12.5 cm apart. In 1984 the basil seeds were of a commercial supply and in 1985 the cultivar was 'Budakalasz'. Basil, sown in a greenhouse, was transplanted into the open-field in the middle of June in spacings of 20 × 25 cm. The soil was humous fine sand. The data on the soil analyses before the fertilization are presented in Table 2.

Dill was harvested before the formation of flower buds, and basil in the beginning of flowering. The plant height was measured, fresh herb yields were weighed and the amount and composition of aroma compounds were analysed. The nitrate concentrations and dry matter content (dill) of the crops were analysed in 1984. The nitrates were analysed as reported earlier (ANON. 1985).

The weather was rather cool and rainy in both years except for August 1984 which was unusually dry. The first fall frost came as early as in the beginning of September in 1984.

The field trials were set up according to the

Table 1. The fertilization treatments in dill and basil trials during 1984 and 1985.

	1984			1985		
	Basic (10-4-17) kg/100 m²	Calcium nitrate (N16, Ca20) kg/100 m²	Total N kg/100 m²	Basic (10-4-17) kg/100 m²	Calcium nitrate (N16, Ca20) kg/100 m²	Total N kg/100 m²
A	0	0	0	0	0	0
B	—	—	—	1.5	—	0.15[1]
C	—	—	—	2	—	0.2[2]
D	—	—	—	3	—	0.3[1]
E	4	0	0.4	4	0	0.4
F	4	2.6	0.8	4	2.6	0.8
G	4	5.2	1.2	4	5.2	1.2
H	4	7.8	1.6	4	7.8	1.6

[1] = dill, [2] = basil

Table 2. The data on soil analyses before fertilization.

Plant/ year	pH	Electrical conductivity 10 × mS/cm	Ca mg/l	K mg/l	P mg/l	Mg mg/l	B mg/l
DILL							
1984	6.4	0.9	1750	310	19	75	0.7
1985	6.2	0.5	1350	110	28	35	—
BASIL							
1984	7.3	0.7	1650	245	55	160	1.1
1985	6.8	0.7	1400	260	53	155	—

method of completely randomized blocks with four replications and plots of 10 m² for dill and 3 m² for basil. The data were studied by analyses of variance and regression. In the dill trial in 1985 weighted linear regression (STEEL and TORRIE 1980) was applied because of the heteroscedasticity of residual variances.

Results

Dill

The unfertilized dill was yellowish and developed more slowly than the fertilized one. At harvest time (July 16.) the average height (30—35 cm) of the unfertilized crop was 10 (1984) or 4 (1985) cm less than the height of dill in fertilized plots. The growing period was 53—55 days.

The dill grown on control plots yielded 110—120 kg/100 m². In 1984 the smallest fertilizing rate (0.4 kg N/100 m²) gave fresh yields of 325 kg/100 m². Further increase in N application did not increase the yields significantly. In 1985 the herb yields were generally smaller, the fertilized plots producing fresh herb 140—210 kg/100 m² (Fig. 1).

The effect of top-dressing with calcium nitrate did not prove to be significant. Thus the variability of the yields was accounted for by the basic fertilizer. The linear relations are presented in Fig. 2.

In 1984 the relation between the yield and the amount of the N applied proved to be quadratic (Fig. 3). The estimated maximum herb yield was reached with the N level of 1.15 kg/100 m².

In 1985 the effect of N fertilization ac-

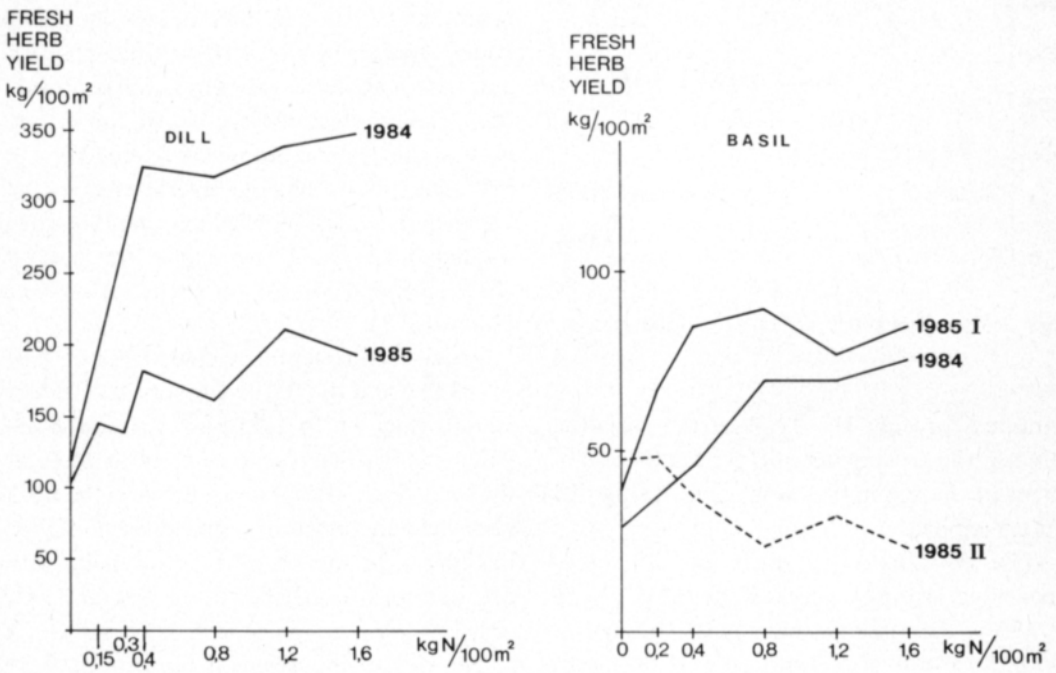

Fig. 1. Fresh herb yields of dill and basil (I the first yield and II the second yield) in 1984—1985 (Helsinki).

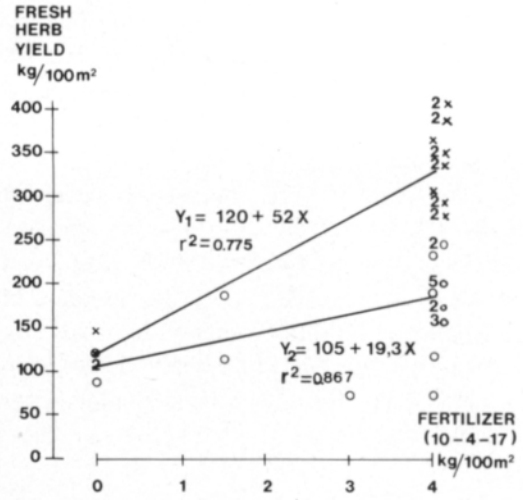

Fig. 2. Response of dill yield to basic fertilization in 1984 (y1, observations marked with x) and 1985 (y2, observations with o).

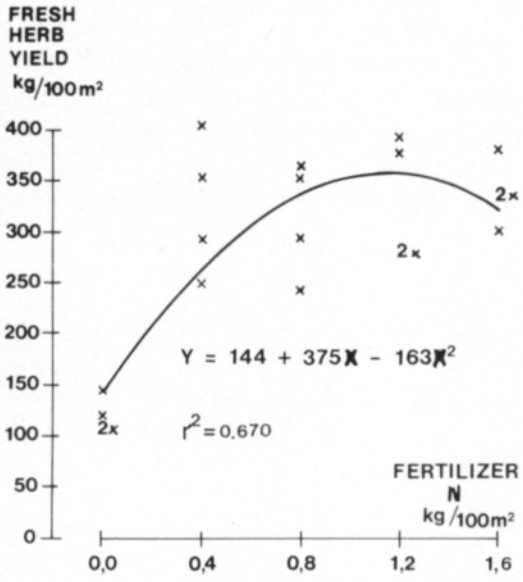

Fig. 3. Response of dill yield to N fertilization (1984).

counted for only 31—37 % of the variation among the treatments and no better coefficient of determination was found using different models.

The dry matter content of dill herb, measured in 1984, decreased from 10.7 % to 7.9 % as the rate of N increased. The figures with the nitrate concentration were opposite. The smallest concentration, 111 mg NO_3/kg

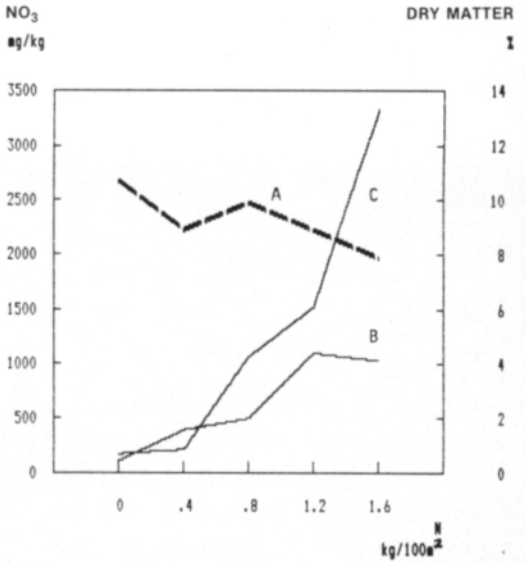

Fig. 4. The dry matter content of dill (A) and nitrate concentrations of dill (B) and basil (C) in respect to N fertilization (1984).

fresh herb, was measured in the unfertilized crop (Fig. 4).

Basil

The growing period for basil was 92 days in 1984 and 75 days in 1985. In 1984 the plants had an average height of 18 cm when planted, and they reached 26—30 cm at harvest (July 25.). The crop stand froze before the second harvest, in the beginning of September. In 1985 the plants had an average height of 11 cm at the time of transplanting and reached the height of 23—27 cm at the first harvest (July 18.), and 18—20 cm at the second one (August 27.).

The unfertilized plots yielded fresh herb of 29—39 kg and the fertilized plots 46—91 kg/100 m² (Fig. 1). In 1985 basil was harvested twice: the first harvest accounted for 70 % of the total yield. The relations between the fresh herb yield and fertilizers applied are presented in Figures 5a and 5b. The top-dressing with calcium nitrate affected the yield in 1984, only.

The yield responses of N application were non-linear in both years (Fig. 6a and 6b). The

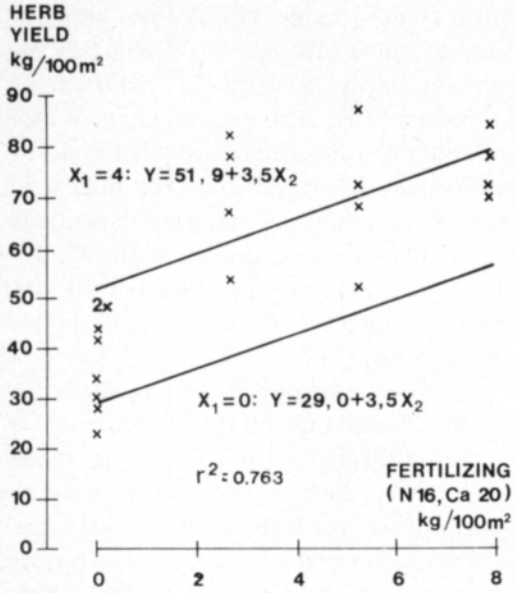

Fig. 5a. Response of basil yield to N application on unfertilized plots (x1 = 0) and the plots with basic fertilization (x1 = 4 kg compound fertilizer/100 m²) (1984).

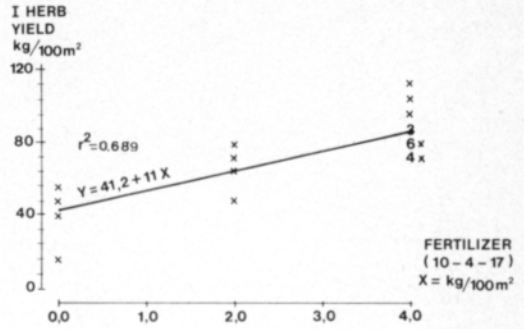

Fig. 5b. Response of basil yield to basic fertilization (1985).

estimated maximum yield was reached in 1984 with 1.5 kg N/100 m², and in 1985 with 0.97 kg N/100 m². In 1985 the N top-dressing did not increase the herb yield but increased the susceptibility to fungus-diseases (*Pythium* sp., *Fusarium* sp., *Sclerotinia sclerotiorum*). In particular, the second crop was damaged (Fig. 7). The heavier fertilized the crop-stand, the more infected plants there were in both years.

The nitrate concentration of the unfertilized crop was 173 mg/kg fresh herb. The concentration grew from 213 to 3331 mg NO_3/kg with increasing N-fertilization (Fig. 4).

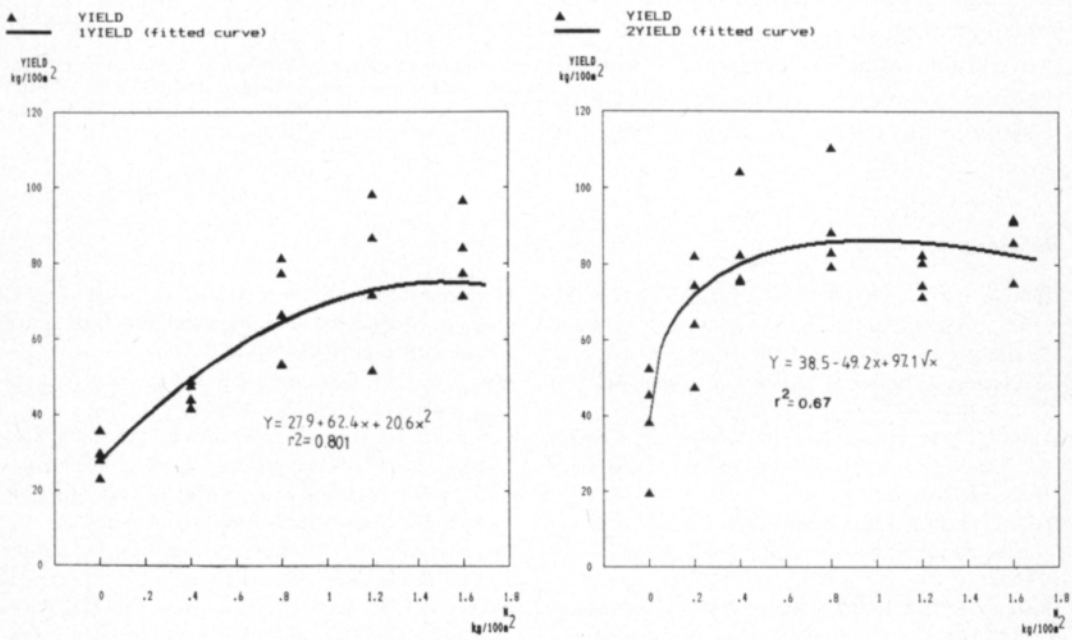

Fig. 6. Response of basil yield to N fertilization in 1984 (a) and 1985 (b).

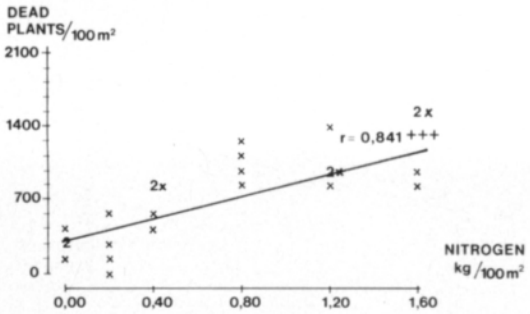

Fig. 7. Response of basil to N application indicated by the death of the plants caused by fungus diseases (1985).

Discussions

In this study the herb yields of dill were larger than the national averages, 65—100 kg/100 m² (ANON. 1986, HÄLVÄ 1985). The basil yields, instead, were rather small compared with those reported earlier in Finland (RAUTAVAARA et al. 1953, HUUHTANEN 1984) and Middle Europe (MAGHAMI 1979).

The optimum basic fertilization for dill and basil was a compound fertilizer application of 0.4—0.16—0.68 kg/100 m². In addition, basil received a benefit from the calcium nitrate top-dressing of 2.6 kg/100 m² (total rate of N 0.8 kg/100 m²). Thus, the optimum fertilizer application in respect to the herb yield proved to be rather low compared with those reported in more southern countries by ATANASSOV et al. (1976), HORNOK (1980) and WAHAB and HORNOK (1981). The disparity with the dill results reported in Hungary was probably partly due to the later harvest (after blooming) there. Also the cultivation of basil in Middle Europe differs from that in northern regions where most of the plants are started in greenhouses and transplanted outdoors. The growing period in the field is shorter, the plants develop more slowly, and thus the intake of nutrients is smaller in a cooler climate.

The forecasting of the yields by the N fertilizer indicated that dill yield will increase up to the fertilizing rate of 1.15 and basil yield up to 1.0 (in 1985) or 1.50 (in 1984) kg N/100 m² after which the yields will decrease. Differences in plant material of basil in the two years may also have affected the results.

The increasing N fertilization seems to impair the quality of the herb yields as far as dry matter content and nitrate concentrations are concerned. RAUTIAINEN (1974) and LIUKKONEN et al. (1976) include dill in the species that accumulate nitrate. The decrease in the dry matter content with the increase in fertilization is also reported by SCHUPHAN (1972) and HANSEN (1978). The larger fertilization applications also caused serious fungus infection.

Acknowledgements. We would like to express our gratitude to the Finnish Academy of Sciences, Ministry of Agriculture and Forestry, and to the TIURA foundation for their financial support.

References

ATANASSOV, Z., ZLATEV, S., ZLATEV, M. & STOYANOV, M. 1976. [In Bulgarian] Summary: Green mass yield and essential oil content of dill (*Anethum graveolens*) as influenced by mineral fertilization. Plant Sci. 13: 138—143.

FLÜCK, H. 1954. The influence of the soil on the content of active principles in medicinal plants. J. Pharmacy Pharmacology 6: 153—163.

HANSEN, H. 1978. The influence of nitrogen fertilization on the chemical composition of vegetables. Qual. Plantarum 28: 45—63.

HORNOK, L. 1980. Effect of nutrition supply on yield of dill (*Anethum graveolens* L.) and the essential oil content. Acta Hort. 96, 1: 337—342.

HUUHTANEN, P. 1984. Maustekasvien viljely- ja laatututkimus. [A study on cultivation and quality of herbal plants.] Puutarha 87: 592—593.

HÄLVÄ, S. 1985. Consumption and production of herbs in Finland. J. Agric. Sci. Finl. 57: 231—237.

LIUKKONEN, H., RAJAMA, J. & NIKKILÄ, O. E. 1976. Kasvisten ja kasvisvalmisteiden nitraattipitoisuuksia. [Nitrate concentration in vegetables and vegetable products.] Ympäristö ja Terveys 7: 640—643.

MAGHAMI, P. 1979. Culture et cueillette des plantes mèdicinales. 222 p. Hachette.

RAUTAVAARA, T., VAARAMA, A. & VALLE, O. 1953. Maustekasvien viljely. [Handbook of herb cultivation.] Puutarhavilj. Liiton Julk. 98. 56 p. Helsinki.

RAUTIAINEN, I. 1974. Nitraatti- ja nitriittimäärityksiä ravintokasveista. [Nitrate and nitrite analyses of edible plants.] Elintarvikkeiden Tutk.säät. Julk. 1: 9—16.

RUMINSKA, A. 1978. Der Einfluss der Düngung auf den Wirkstoffgehalt und den Ertrag von Heil- und Gewürzpflanzen. Acta Hort. 73: 143—164.

SCHUPHAN, W. 1972. Effects of the application of inorganic and organic manures on the market quality and on the biological value of agricultural products. Qual. Plantarum 21: 381—398.

STEEL, R. & TORRIE, J. 1980. Principles and prosedures of statistics. 631 p. 2nd Ed. New York.

WAHAB, A. S. A. & HORNOK, L. 1981. [In Hungarian] Summary: Effect of NPK fertilization on yield and essential oil content of sweet basil (*Ocimum basilicum* L.). Sep. Publ. Iniv. Horticult. 45: 73.

WEICHAN, C. 1948. Der Gehalt an ätherischem Öl bei aromatischen Pflanzen in Abhängigkeit von der Düngung. Pharmazie 3: 464—467.

ANON. 1985. Kotimaisten vihannesten nitraattipitoisuus. [Nitrates in vegetables grown in Finland.] Elinkeinohall. Kuluttaja-asiain Os. Julk. A 7/85: 1—27.

—, 1986. Avomaan vihanneskasvitaulukko. [Statistics on field vegetables.] Puutarhakalenteri 45: 342—343.

SELOSTUS

Tillin (*Anethum graveolens* L.) ja basilikan (*Ocimum basilicum* L.) lannoitus

I Lannoituksen vaikutus tillin ja basilikan satoon

Hälvä, S. ja Puukka, L.

Helsingin yliopisto, puutarhatieteen laitos, 00710 Helsinki

Tillin ja basilikan lannoitusta tutkittiin vuosina 1984 ja 1985 Helsingin yliopiston puutarhatieteen laitoksella. Tarkoituksena oli selvittää eri peruslannoitusmääriä ja lisälannoitusta. Kokonaistyppimäärät olivat tillikokeessa 0, 0.15, 0.3, 0.4, 0.8, 1.2 ja 1.6 kg N/a ja basilikakokeessa 0, 0.2, 0.4, 0.8, 1.2 ja 1.6 kg/a.

Optimiperuslannoitus oli 0.4—0.16—0.68 kg NPK/a molemmille lajeille, basilika hyötyi toisena koevuonna myös lisälannoituksesta (0.4 kg N/a). Ennustettaessa satoa typpilannoituksen avulla havaitaan, että tillin sato kasvaa lisättäessä typpilannoitusta 1.15 kiloon asti, ja basilikasato 1.0 (1985) tai 1.5 (1984) kiloon asti. Näitä suuremmat lannoitemäärät vähentävät satoa.

Kasvien nitraattipitoisuus kasvoi lisättäessä typpilannoituksen määrää. Basilika saastui pahoin sienitauteihin, kun sitä lannoitettiin runsaasti.