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The Effect of Nitrogen Fertilization on the Herb Yield of Dragonhead

B. GALAMBOSI[1] and Y. HOLM[2]

[1] *Agricultural Research Centre, South Savo Research Station, Karila, 50600 Mikkeli*

[2] *University of Helsinki, Department of Pharmacy, Pharmacognosy Division, Fabianink. 35, SF-00170 Helsinki, Finland*

Abstract. The influence of a top-dressing of nitrogen fertilizer (calcium nitrate, $CaNO_3$) on the individual plant height and weight, herb yield and nitrate content of dragonhead (*Dracocephalum moldavica* L.) was studied in 1987 in Puumala, Finland. The nitrogen doses applied ranged from 0 to 270 kg/ha.

Nitrogen fertilization increased both the individual plant height and weight, the fresh and dry herb yield and the nitrate content of the plants. However, no optimum nitrogen dose could be found since the maximum was not reached in most of the cases. An exception was the herb yield (d.w.) of transplanted plants, harvested at the flowering stage, where a nitrogen dose of 70—80 kg/ha gave the highest yield. If the plants were allowed to grow a few weeks more the yield was four fold compared to the earlier harvesting. Sown plants gave a yield two times higher than the transplanted plants, but this was partly due to the greater plant density on the sown plots.

Index words: nitrogen fertilization, dragonhead, herb yield

Introduction

Dragonhead (*Dracocephalum moldavica* L., Lamiaceae) is an annual, 30—70 cm high, soft-stemmed plant with a bluish-purple or sometimes white inflorescence. The dried herb has antiseptic, analgesic and anticolic effects (Csedö 1980), and is used against headaches, colds and kidney complaints (spasms). It is also used in the food industry and for manufacturing perfumes (Halasz-Zelnik *et al.* 1988). Dragonhead is native to south Siberia and the Himalayan area. It was introduced in Europe via Moldavia in the sixteenth century and was earlier also called Melissa turcica (Hegi 1964). Dragonhead has been cultivated in the Soviet Union, Romania and Bulgaria for a long time. Cultivation has recently been started also in Yugoslavia, Czechoslovakia, Poland, Hungary and Finland (HALASZ-ZELNIK *et al.* 1988, Von SCHANTZ *et al.* 1987). In spite of its widespread cultivation, there are very few data available about the agrotechnical methods used. Factors that have been investigated include: optimal harvesting time, weed control, the raising of seedlings contra field sowing, and mulching of the soil (HALASZ-ZELNIK *et al.* 1988, VON SCHANTZ *et al.* 1987, HOLM *et al.* 1988. Fertilization, and especially nitrogen fertilization, is dealt with in two papers (CSEDÖ 1980, GALAMBOSI *et al.* 1989). Since nitrogen is one of the most important nutrients for plant growth, careful studies are required on this subject. Nitrogen fertilization of other Lamiaceae plants, such as peppermint and basil, has proved to have an increasing effect on the herb yield (HORNOK 1974, HÄLVÄ and PUUKKA 1987, FRANZ 1971, WAHAB and HORNOK 1981). The effect of nitrogen fertilization on the plant height, weight, herb yield (fresh and dry), the proportion of leaves and the accumulation of nitrogen was studied in this work.

Material and methods

Plant material

Dragonhead seeds were initially obtained from Romania, where it is commonly cultivated in 1983, and in subsequent years from our own plants. The plants investigated in this study all originated from our own seed. The cultivation site was Pirttimäki, Puumala (61°40′N, 28°15′E), Finland. The plot size was 10 m^2. A randomized block design was used and each treatment was replicated four times. The plant height and weight was measured from 5 plants in each replication and the mean was calculated. The herb yield (both fresh and dry) represents the average of the four replications.

Soil and fertilization

The soil on the plots was stony till, and soil analysis made before the fertilization tests (1986) gave the following results: pH 5.9 and plant-available Ca 1500, K 95, P 12.6, Mg 130 and N 25 mg/l (Viljavuuspalvelu Oy, a soil analysis company).

The plots were treated with PK fertilizer (phosphor-potassium) 54—84 kg/ha in autumn 1986. Nitrogen top-dressing ($CaNO_3$, NO_3-N 15.5 %, Ca 20 %) was applied on 24. 5. 1987 (sown plots) and 15. 6. 1987 (planted plots). The nitrogen doses were 0, 15, 30, 45, 75 and 120 kg/ha. The sown plots were treated on 15. 6. 1987 with a further 150 kg N/ha to give the following total nitrogen doses: 150, 165, 180, 195, 225 and 270 kg/ha.

Weather conditions

The temperature and precipitation were measured at Sorjola meteorological observatory (Institute of Meteorology) about 3 km from Pirttimäki, where the experiments were carried out.

Propagation

Sowing in the open field was done on 28. 5. 1987. The row spacing was 50 cm (5 kg seeds/ha, 80 plants/m^2). The seedlings were grown in a plastic greenhouse for 4 weeks (sown 8. 5. 1987) and transplanted in the field on 5. 6. 1987. The planting density was 50×25 cm (8 plants/m^2).

Harvesting

The sown plants were harvested on 13. 9. 1987 in the full-flowering stage.

Half of the planted plants were harvested on 30. 7. 1987 (full flowering) and the other half on 21. 8. 1987 (post flowering).

The herb material was dried at 40°C for 14 h in an Orakas dryer (Marlemi Ky, Lemi, Fin-

Table 1. Regressions of the individual plant height and weight on the amount of nitrogen fertilizer.[1]

	Inter-cept	Slope	t-value	Proba-bility	Coeff. of determination
Height					
— planted I[2]	0.578	35.3	7.621	0.0016	0.967
— planted II[3]	0.308	42.1	2.646	0.0572	0.798
Weight					
— planted I[2]	2.738	40.3	5.091	0.0070	0.931
— planted II[3]	11.962	118.5	11.926	0.0003	0.986

[1] based on square root transformed data (nitrogen doses)
[2] harvested 30. 7. 1987
[3] harvested 21. 8. 1987

land), in which the warm air passes through the plant material from beneath. Leaves and stems were separated using a sieve (3 mm ø holes). The material was weighed in both the fresh and dry condition.

Analyses

The nitrate content of the plant samples was measured at the Partala Center for Rural Development (Juva) from water extracts using an ionspecific electrode (Orion 93-07, Finland).

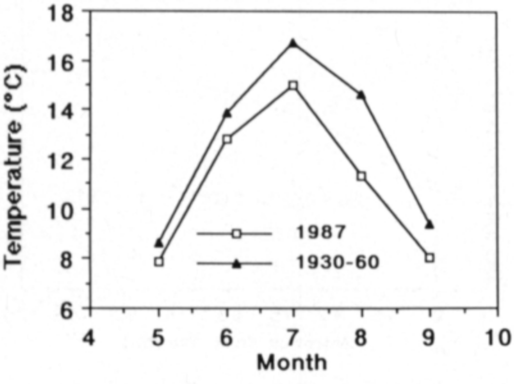
The dependence between the nitrogen dose and the herb yield, plant height and weight was tested using regression analysis. If the dependence was curvilinear, second order equations were used or the data were square-root transformed (nitrogen doses, Table 1).

Results and discussion

Figs. 1 A and 1 B show the mean temperature and precipitation for the growing season 1987 and the long term averages (30 years). Although the summer of 1987 was cooler than normal with quite heavy precipitation, the dragonhead plants still grew well. The length of the growing period (counted from the sowing date) was 105 days for the sown plants, and 77 days (counted from the transplanting date) for the planted plants. The seed ripening was considered as the end of the growing period in both cases.

Transplanted plants

The transplanted plants were treated with nitrogen doses ranging from 0 to 120 kg/ha.



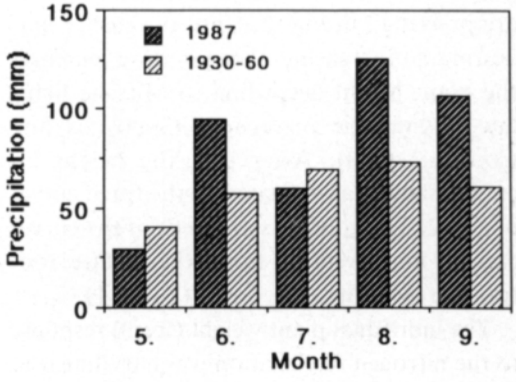


Fig. 1. A and B. Mean temperature and precipitation in Puumala 1987 and the long time average 1930—1960. Months: 5 = May, 6 = June, 7 = July, 8 = August and 9 = September.

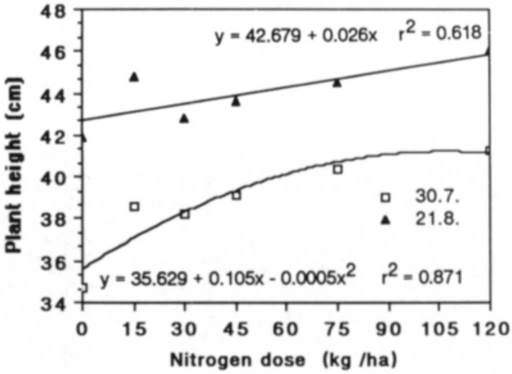


Fig. 2. Response of dragonhead plant height to N fertilization (transplanted plants).

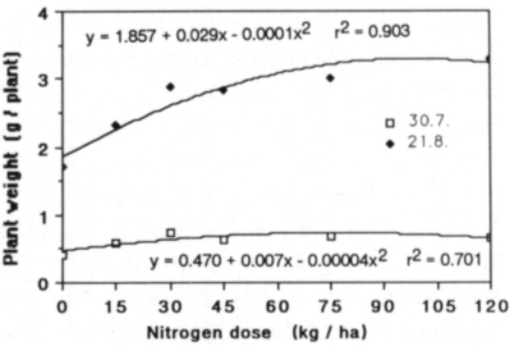


Fig. 3. Response of dragonhead individual plant weight (fresh) to N fertilization (transplanted plants).

The average plant height varied from 35 cm to 46 cm at the earlier harvesting (30. 7. 1987) and from 42 cm to 49 cm at the later harvesting (21. 8. 1987). The changes in the plant height as a result of the nitrogen fertilization are presented in Fig. 2. Until the earlier harvesting an increasing nitrogen dose increases the plant height according to Mitscherlich's law (asymptotic regression) (Snedecor and Cochran 1973). After that the height increase is linear as indicated by the fitted curves in Fig. 2. The goodness of the fit of the curves can be improved by using the square root transformed nitrogen doses (Table 1).

The individual plant weight (fresh) response to the nitrogen fertilization was curvilinear at both harvestings (Fig. 3). As mentioned above the goodness of the fit of the curves can also in this case be improved by using the square root transformed nitrogen doses (Table 1). The maximum individual plant weight was reached by the later harvesting. The average plant weight was three times greater at the later harvesting than at the earlier. This intensive accumulation of weight is due to the rapid growth of branches following flowering. Nitrogen fertilization explained 80 to 99 % of the increase in plant height and weight (Table 1).

The herb yield (dry weight) response to the nitrogen fertilization is presented in Figs. 4 A and 4 B. Also in this case the response was quadratic. At the later harvesting the coefficient of determination was, however, better (0.966) when the square root transformed nitrogen doses were used. The herb yield at the later harvesting was about four times greater than at the earlier harvesting.

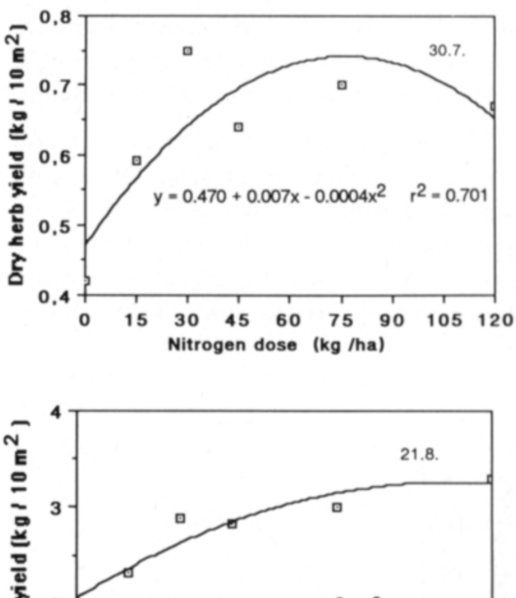


Fig. 4. A and B. Response of dragonhead yield (transplanted plants) to N fertilization, harvesting 30. 7. 1987 (A) and 21. 8. 1987 (B).

Table 2. The effect of nitrogen fertilization on the herb yield (dry weight) and proportion of leaves of transplanted dragonhead.

Nitrogen kg/ha	Earlier harvesting			Later harvesting		
	Dry weight		Proportion of leaves	Dry weight		Proportion of leaves
	kg/10 m²	%	%	kg/10 m²	%	%
0	0.42	14.9	69.0	1.70	18.6	60.6
15	0.59	13.9	67.7	2.32	17.7	59.9
30	0.75	15.6	62.7	2.88	14.3	59.4
45	0.64	13.6	68.8	2.83	17.4	59.0
75	0.70	13.4	67.1	3.00	17.0	58.3
120	0.67	12.9	68.7	3.29	16.6	58.4
Mean		14.1	67.3		16.9	59.3
S.d.		1.01	2.39		1.46	0.89

The proportions of dry weight yield in percents are presented in Table 2. The nitrogen fertilization did not have any effect on the proportion of dry weight neither at the earlier nor at the later harvesting. However, the proportion of dry weight was significantly higher ($p<0.05$) at the later harvesting.

The proportion of leaves out of dry material was constant at the earlier harvesting, being on average 67.3 %. At the later harvesting the proportion of leaves decreased significantly ($p<0.05$) as the nitrogen dose increased. The proportion of leaves at the later harvesting was significantly smaller ($p<0.01$) than at the earlier harvesting (Table 2).

The effect of nitrogen fertilization on the nitrate (NO_3) content of dragonhead herb increased linearily at the earlier harvesting from 2 900 to 16 500 mg/kg d.w. and quadratically at the later harvesting from 1 450 to 10 000 mg/kg d.w. The nitrate content reached its maximum with the highest nitrogen dose. The uptake of nitrate was more effective at the beginning and during the middle of the vegetation period, when the temperature was higher and the nitrogenase activity thus also higher (Figs. 1 A and 1 B). According to the dry weight percentages in Table 2, the nitrate content in the fresh material varied between 270 and 2 129 mg/kg. Since no nitrate measurements are available for herb spices, these results will be compared to those for vegetables. Fresh Brussels sprouts contain 123—202 mg/kg and beetroot 1 643—2 723 mg/kg nitrate (Hansen 1978). Carrot has been found to contain 39—744 mg/kg, Chinese cabbage 230—2 126 mg/kg and lettuce 89—3 898 mg/kg nitrate (Ahonen, Kuokkanen and Penttilä 1987). The nitrate content of

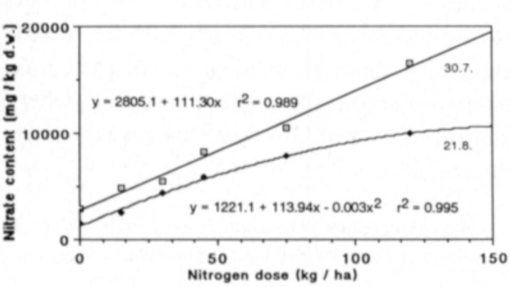


Fig. 5. The nitrate content of dry dragonhead herb in respect to N fertilization (transplanted plants).

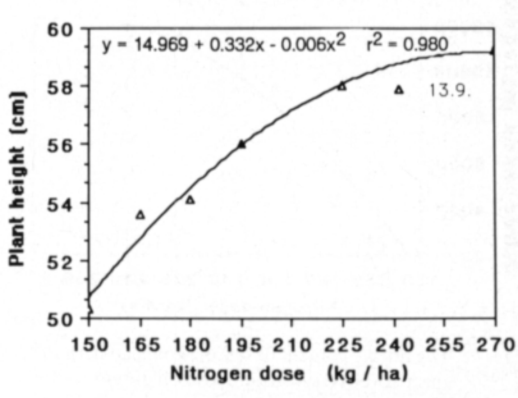


Fig. 6. Response of dragonhead plant height to N fertilization (sown plants).

Table 3. The effect of nitrogen fertilization on the yield (dry weight) and proportion of leaves of sown dragonhead.

Nitrogen kg/ha	kg/10 m²	Dry weight %	Proportion of leaves %
150	3.84	15.9	47.7
165	3.95	15.9	47.3
180	3.93	15.8	46.1
195	3.89	15.1	47.6
235	4.42	15.6	48.6
270	3.76	14.5	45.7
Mean		15.5	47.2
S.d.		0.56	1.08

dragonhead is quite high compared to these vegetables, but the single dose used for tea or as a spice is very small.

Sown plants

The sown plants received nitrogen doses ranging from 150 to 270 kg/ha. The average plant height varied from 50 cm to 59 cm. The bigger plant height of the sown plants is partly due to the higher plant density of the sown plots. The plant height response to the nitrogen fertilization is quadratic (Fig. 6) as was the case with the transplanted plants at the earlier harvesting. Both the sown and transplanted plants were in flowering when the harvesting was performed. However, the sown

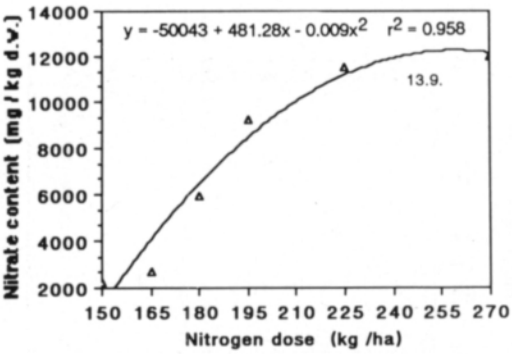


Fig. 7. The nitrate content of dry dragonhead herb in respect to N fertilization (sown plants).

and transplanted plants cannot be directly compared since they received different nitrogen doses.

The herb yield obtained from the sown plots varied between 3.84 and 4.42 kg d.w./10 cm² (Table 3). The herb yield response to the different nitrogen doses does not differ significantly, which can be explained by the fact that the plants were not able to utilize all the given nitrogen. The nitrogen fertilization did not affect the proportion of dry weight.

The proportion of leaves was constant, being on average 47.2 %, determined on the dry weight. This is clearly lower than the proportion of leaves of the transplanted plants (67.3—59.3 %). The lower proportion of leaves can be partly explained by the fact that the plant density was higher on the sown plots, why the plants were forced to grow straight upwards. Thus the stems, which contain hardly any volatile oil, grew longer.

The nitrate content of the plants increased quadratically as the nitrogen doses were increased and varied between 2 250 and 12 000 mg/kg d.w. The response of the nitrate content to the nitrogen fertilization was curvilinear and resembles the corresponding response obtained for the transplanted plants at the later harvesting. The nitrate amounts, on the other hand, are almost the same as those measured from the earlier harvesting of the transplanted plants, although these received smaller nitrogen doses. This indicates that the nitrate is mostly incorporated in the leaves.

The results of this study can be summoned up as follows: nitrogen fertilization increased all the studied parameters. *i.e.* the plant height, weight, herb yield and nitrate content. No optimum nitrogen dose could be found, except for the herb yield (d.w.) of the transplanted plants at the earlier harvesting, where a nitrogen dose of 70—80 kg/ha gave the maximum yield.

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SELOSTUS

Typpilannoituksen vaikutus ampiaisyrtin satoon

B. Galambosi ja Y. Holm

Helsingin yliopisto, Farmasian laitos, Farmakognosian osasto, Fabianink. 35, 00170 Helsinki

Ampiaisyrtti (*Dracocephalum moldavica* L.) on yksivuotinen, 30—70 cm korkea haihtuvaa öljyä sisältävä ruohokasvi, jolla on sinipunaiset tai harvemmin valkoiset kukinnot. Se on kotoisin Siperiasta ja Himalajan alueelta, mistä se on Moldavian kautta kulkeutunut Eurooppaan 1500-luvulla. Ampiaisyrttiä on viljelty kauan Neuvostoliitossa, Romaniassa ja Bulgariassa. Viljely on viime aikoina aloitettu myös Jugoslaviassa, Tsekkoslovakiassa, Puolassa ja Unkarissa. Suomessa ampiaisyrttiä viljeltiin ensimmäisen kerran v. 1945 Maatalouskoelaitoksen puutarhaosastolla, Piikkiössä ja käytännön viljelmällä (0.5—1 ha) v. 1984 lähtien Puumalan Pirttimäen koetilalla. Vaikka tämä kasvi on laajalti viljelty, niin siihen liittyvästä viljelytekniikasta on vähän tietoja. Tässä työssä tutkittiin typpilannoituksen vaikutusta kasvien korkeuteen, painoon, satomäärään, lehtien osuuteen ja nitraattipitoisuuteen.

Typpilannoitekokeet tehtiin kesällä 1987 Puumalassa. Koepalstoille annettiin syksyllä 1986 PK-peruslannoitusta (54—84 kg/ha). Typpilannoitus suoritettiin 24. 5. 1987 (kylvetyt kasvit) ja 15. 6. 1987 (istutetut kasvit). Typpilähteenä oli kalkkisalpietari (NO_3-N 15.5 %, Ca 20 %) ja annetut typpimäärät olivat 0, 15, 30, 45, 75 ja 120 kg/ha. Kylvetyille kasveille annettiin lisäksi 15. 6. 1987 150 kg N, joten lopulliset typpimäärät olivat siinä tapauksessa 150, 165, 180, 195, 225 ja 270 kg/ha. Keskimääräinen sato vaihteli 0.42—0.75 kg/10 m^2 (kuivapaino) aikaisemmassa sadossa. Myöhemmin kerätyssä sadossa määrä oli 1.70—3.29 kg/m^2 (istutetut kasvit). Kylvetyistä kasveista saatu sato oli 3.76—4.42 kg/10 m^2.

Typpilannoitus lisäsi selvästi sekä tuore- että kuivasatoa. Kylvetyt kasvit, jotka saivat suuret typpimäärät, eivät kuitenkaan pystyneet hyväksikäyttämään kaikkea typpeä, koska sadot eivät enää kasvaneet typpimäärän lisääntyessä.

Kasvien nitraattipitoisuus nousee kun typpilannoitemäärää lisätään. Tuoreen kasvimateriaalin nitraattipitoisuus vaihteli 270—2 129 mg/kg.

Typpilannoituksen optimimäärää ei voitu tämän tutkimuksen avulla selvittää, koska maksimia ei saavutettu, paitsi istutettujen kasvien satomäärän kohdalla aikaisemmassa sadossa. Tällöin sato oli suurin kun käytetyt typpimäärät olivat 70—80 kg/ha.