AGRICULTURAL UNIVERSITY OF ATHENS

THE YIELD AND COMPOSITION OF DILL ESSENTIAL OIL IN RELATION TO N-APPLICATION, SEASON OF CULTIVATION AND STAGE OF HARVEST

D. Tsamaidi[1], H.C. Passam[1], D. Daferera[2], C. Kontopoulou[1], T. Karanissa[1], I. Karapanos[1], M. Polissiou[2]
[1]Agricultural University of Athens, Laboratory of Vegetable Production, Iera Odos 75, 11855 Athens, Greece
[2]Agricultural University of Athens, Laboratory of General Chemistry, Iera Odos 75, 11855 Athens, Greece

INTRODUCTION

Dill (*Anethum graveolens* L.) is an annual aromatic herb of the Umbelliferae family, grown widely throughout Europe, America and Asia for use as a fresh herb and for the production of essential oil, which is extensively used by the food industry for flavouring foods and beverages (Clark and Menary 1984).

Studies of aroma composition in dill have concentrated mainly on the seed, which is rich in carvone. Wander and Bouwmeester (1998) reported that dill biomass, seed and carvone yield increased with increasing nitrogen (N) fertilization. Moreover, Singh et al. (1987) concluded that oil content of the whole plant was highest at the time of seed filling after flowering and related to N application.

Dill foliage also contains essential oil, the main component of which is α-phellandrene (Huopalahti and Linko, 1983). Therefore, the aim of the present study was to examine the effect of growth factors (N-fertilization, season of cultivation and stage of harvest) on plant biomass and the yield and composition of essential oil derived from the foliage.

MATERIALS AND METHODS

Seeds of dill (*Anethum graveolens* L cv. Dukat) were sown in October (winter crop) and January (summer crop) and the plants were transplanted to a substrate of peat and perlite (1:1 v/v) 30 and 39 days later, respectively. Nitrogen (NH_4NO_3) was applied weekly at four levels (50, 150, 300, 450 ppm N) in a completely randomized experimental design. Plant height and leaf number were recorded at harvest, 158 and 83 days after the first and second sowings, respectively. The foliage was weighed and the essential oils were isolated by hydro-distillation in a Clevenger apparatus and analyzed by GC-MS as described for parsley by Petropoulos et al. (2009) using a Rtx-5MS capillary column (30m X 0.25mm, film thickness 0.25μm) with a temperature program gradually increased from 60°C to 220°C with a rate of 3°C/min.

RESULTS

The plants of the winter crop were taller at harvest than those of the summer crop due to the longer growth period. The foliage fresh weight and number of leaves per plant increased with increasing fertilization in the winter, whereas plant height decreased. By contrast, plant growth was not affected by N level in the summer.

Table 1: Mean height of plants (cm), leaf number per plant and plant weight (g).

CROP	NITROGEN	PLANT HEIGHT (cm)	LEAF NUMBER PLANT^{-1}	WEIGHT (g PLANT^{-1})
	CONTROL (N0)	130.65 a	6.00 d	58.19 d
WINTER	150 ppm (N1)	129.16 a	14.47 c	133.39 c
	300 ppm (N2)	111.46 b	18.45 b	162.48 b
	450 ppm (N3)	104.97 b	21.36 a	186.73 a
	CONTROL (N0)	52.13 a	9.03 ab	102.51 b
SUMMER	150 ppm (N1)	52.44 a	9.47 a	110.12 b
	300 ppm (N2)	55.00 a	9.47 a	143.74 a
	450 ppm (N3)	52.47 a	8.91 a	111.69 b

Means within its column followed by the same letter are not significantly different at *P*=0.05.

The essential oil concentration within the foliage was low (<0.3 ml/100 g fresh weight). Oil concentration was higher at 300ppm N than at the other N levels in the summer, but was independent of N application in the winter.

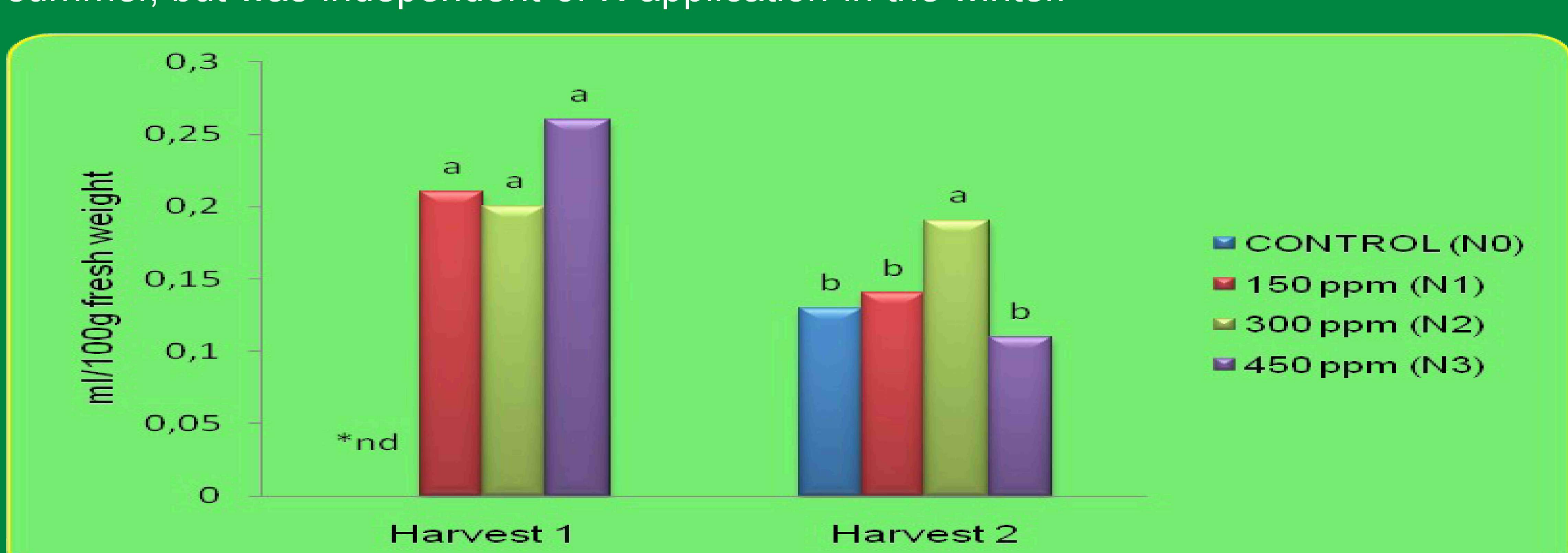

Figure 1: Quantitative analysis of essential oils (ml/100g fresh weight).
Means for each harvest with the same letter are not significantly different at *P*=0.05.
* nd: not determined.

The main components of the foliar essential oil were α-phellandrene, β-phellandrene, dill ether and π-cymene, followed by α-pinene, β-pinene, α-thujene and myrcene,.

In both crops α-phellandrene was the principal constituent (Figure 2), while β-phellandrene, dill ether and π-cymene had maximum content at 14, 21 and 27 mg/100g fresh matter, respectively (Figures 3-5). The substances α-pinene, β-pinene, myrcene and α-thujene had a maximum content of 2.0, 0.06, 0.6 and 0.2 mg/100g fresh matter respectively.

In the winter crop there was no statistically significant difference in the content of all substances in relation to N level, although it tended to be higher at 300 ppm N. In the summer crop all the main substances had a higher content at 300 ppm N. Comparing the content between the crops we see that in winter, α-pinene, myrcene, α-thujene, and π-cymene had a higher content at 150 and 450 ppm N than in the summer, while α-phellandrene was higher in the summer at 450 ppm N.

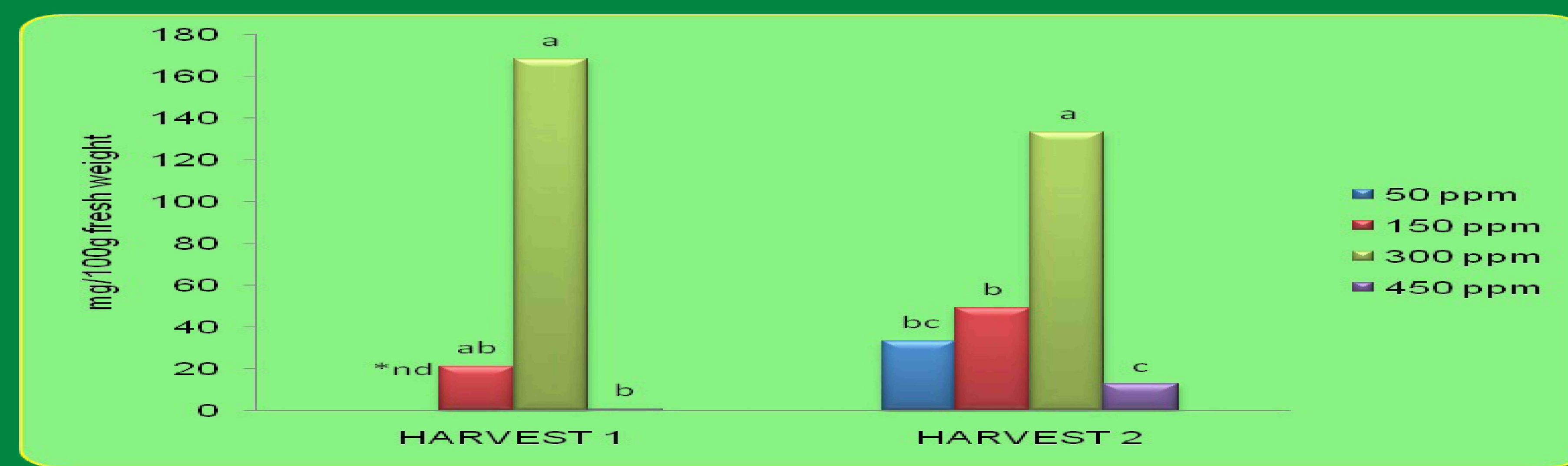

Figure 2. Means of the foliage content of α-phellandrene (mg/100g fresh weight).
Means for each harvest with the same letter are not significantly different at *P*=0.05.
* nd: not determined.

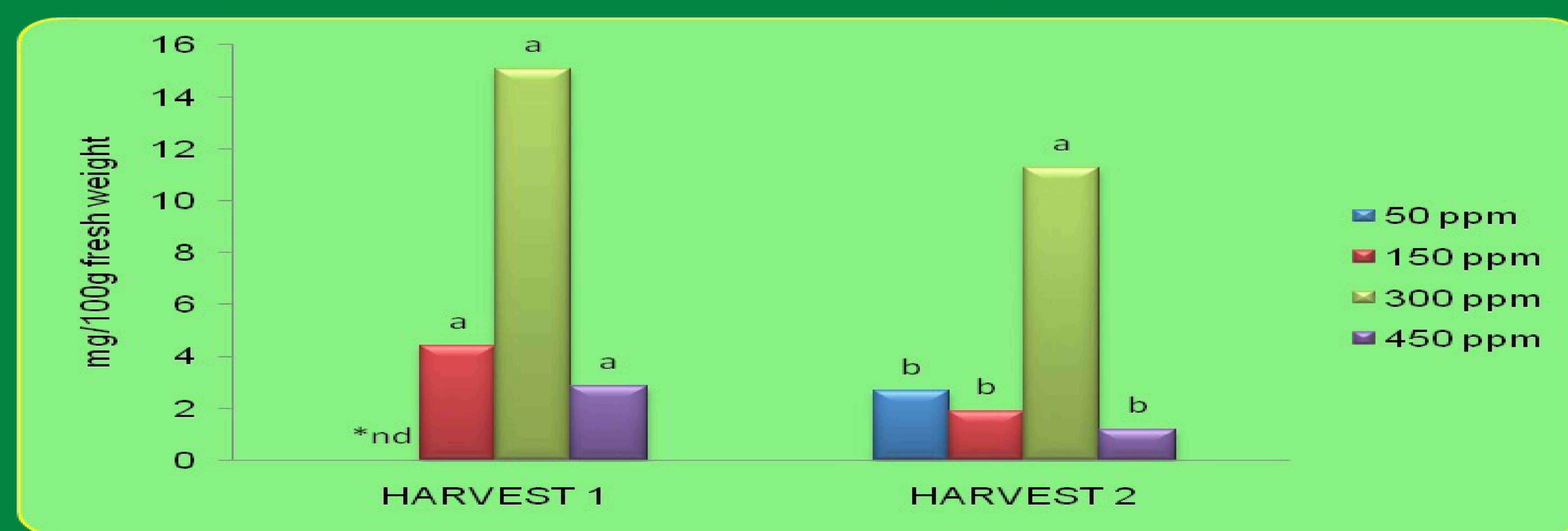

Figure 3. Means of the of the foliage content of β-phellandrene (mg/100g fresh weight).
Means for each harvest with the same letter are not significantly different at *P*=0.05.
* nd: not determined.

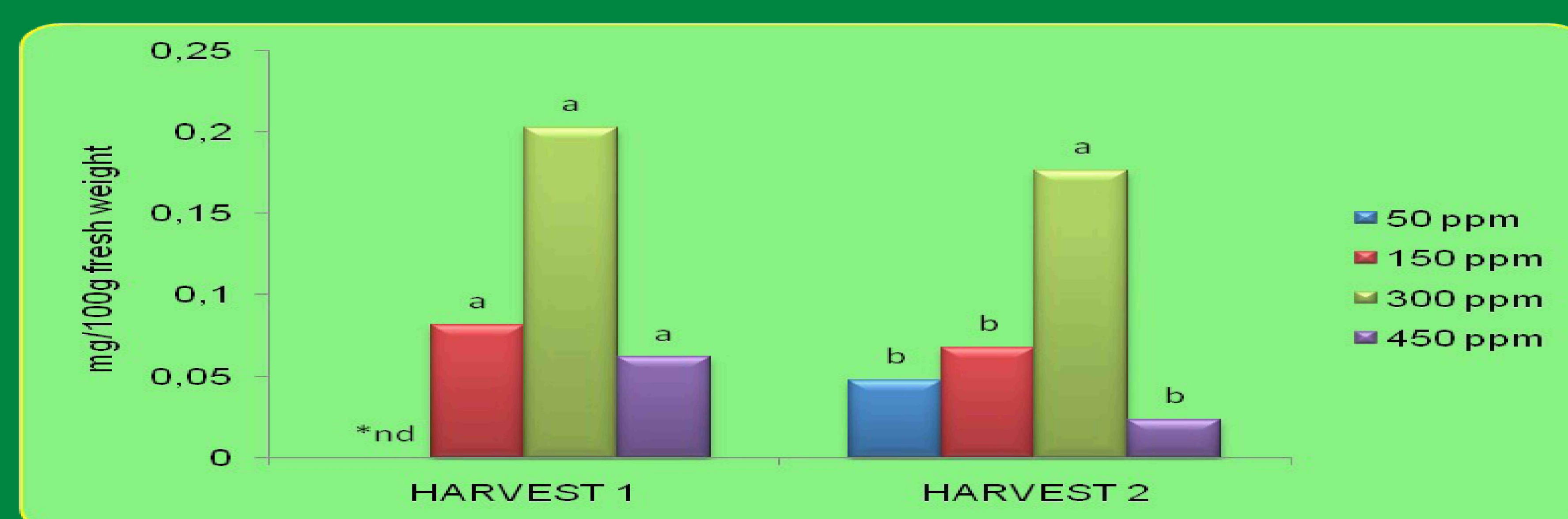

Figure 4. Means of the of the foliage content of dill ether (mg/100g fresh weight).
Means for each harvest with the same letter are not significantly different at *P*=0.05.
* nd: not determined.

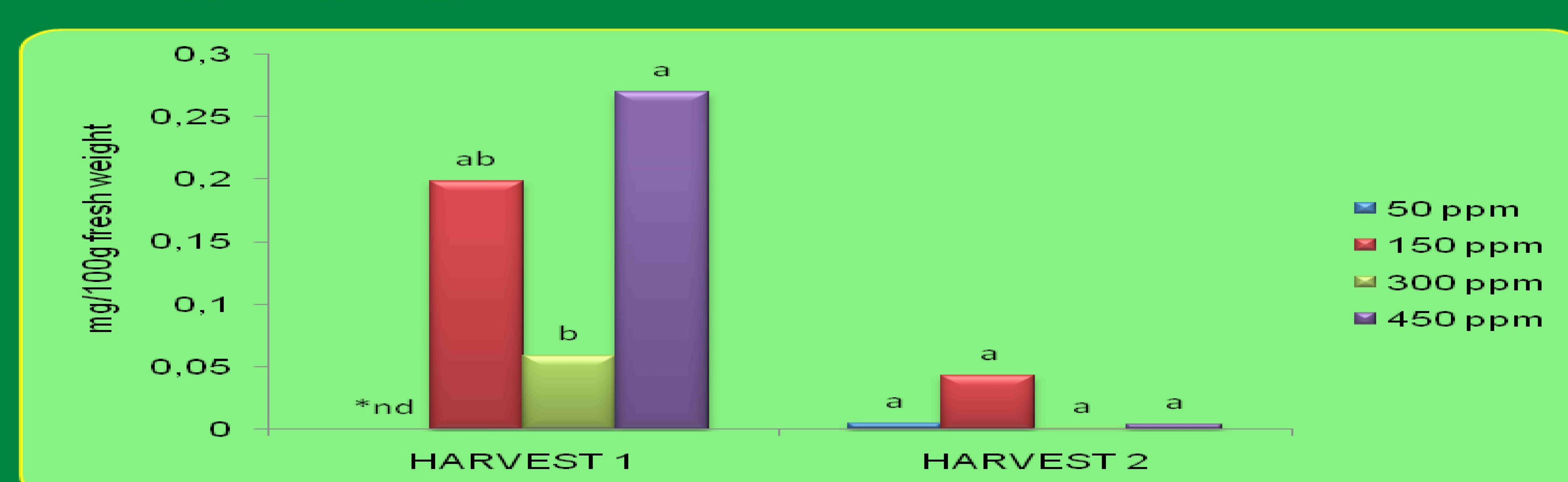

Figure 5. Means of the of the foliage content of π-cymene (mg/100g fresh weight).
Means for each harvest with the same letter are not significantly different at *P*=0.05.
* nd: not determined.

CONCLUSION

Based on the N rates used here, it is concluded that for a long-cycle winter crop (158 days) 300-450 ppm N is optimal for biomass and foliar oil yield (biomass x oil concentration) whereas in a shorter summer crop (83 days duration) a lower N rate may be employed.

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