

Comparative investigation into the effect of fertigation and of broadcast fertilization on the yield and nitrate content of lettuce (*Lactuca sativa* L.)

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Abstract. The effects of method of application of nitrogen on yield and nitrate content of lettuce (*Lactuca sativa* L.) were investigated. Plants grown by applying N through the irrigation system (fertigation) were compared with plants fertilized with broadcast nitrogen.

For the statistical analysis of the results the data were fitted into a 2nd-degree polynomial model. Fertigation proved to increase the availability and uptake of N, hence increasing the nitrate content of the crop compared to broadcast fertilization. Yield however was much less effected by method of fertilization.

Key-words: lettuce, *Lactuca sativa* L., fertigation, broadcast fertilization, yield, nitrate content, 2nd-degree polynomial model.

Introduction. High levels of nitrate in vegetables may have harmful effects on human health (Corré & Breimer, 1979). That is why the Dutch Government recently introduced standards for the admissible nitrate content of a number of vegetables (Breimer, 1982). One way of achieving lower nitrate is by optimizing the amount and timing of N fertilization. Lettuce grown in the Netherlands usually is fertilized by broadcast application of the total amount of estimated N need before planting. This could lead to luxury consumption of N, resulting in relatively high levels of nitrate in the crop. Applying N through the irrigation system during cultivation offers a means for a better adjustment of N fertilization to the nutritional need of the crop, thus limiting luxury consumption and nitrate content (Corré & Breimer, 1979; Breimer, 1982).

Material and methods. During spring and summer of 1983 successively three different cultivars of lettuce (*Lactuca sativa* L.) were grown on a sandy soil. For each of these experiments the treatments were: no N application (control) and fertilization with different amounts of ammonium nitrate either in split applications through the raining system or in single application, broadcast before planting. All experimental units received the same water supply.

After harvesting the yield was determined and dried plant material was analysed as described by Novozamsky et al. (1983); amongst others, NO_3 and N_{total} content

were measured. The effect of method of N application was statistically analysed by fitting the data into a 2nd-degree polynomial with the general equation $E(y) = a + b_1x_1 + b_2x_{11} + b_3x_2 + b_4x_{22}$. The terms b_1 and b_3 , and b_2 and b_4 , respectively represent the regression coefficients of the linear, and quadratic component of the curves describing either the effect of broadcast fertilization ($b_1x_1 + b_2x_{11}$) or of fertigation ($b_3x_2 + b_4x_{22}$). Differences resulting from the method of application should find expression in differences between the two curves. This was analysed by introducing a δ , changing the equation into $E(y) = a + b_1\delta x_1 + b_2\delta^2 x_{11} + b_3x_2 + b_4x_{22}$. By feeding of several arbitrary values of delta into this equation the curve corresponding with the data of broadcast fertilization could be shifted to obtain the best possible fit of the two curves. Values of $\delta \neq 1.00$ resulting in the best fit indicate the existence of significant differences between the two curves or, in other words, method of application resulted in a significantly different response by the crop.

Results. In the first cropping, yield was significantly higher when N was applied by fertigation, compared with broadcast application. In the following croppings, however, no significant differences in yield resulting from method of fertilization (Table I) were found. Although, because of a lack of fit of data into the 2nd-degree polynomial model, some of the findings are less reliable, the results concerning NO_3 and N_{total} content clearly indicate that application of N through the raining system leads to a comparatively high level of N in the crop (Table 1). This is also expressed in a relatively high N recovery percentage by the fertigated crop, especially at lower N fertilization levels. The portion of $\text{NO}_3\text{-N}$ in the N_{total} content is higher in fertigated crop, compared with broadcast fertilization.

Soil analyses at the end of the growth periods showed consistently higher levels of soil N ($\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) for the fertigated crop than for the crop fertilized with comparable amounts of broadcast N.

Discussion. The significant differences in yield resulting from the method of N application in Experiment 1 may be related to the extremely wet conditions under which this experiment took place (a rain surplus of 56 mm in contrast with a rain deficit of 105 mm and 116 mm during Experiments 2 and 3). Under these circumstances leaching of NO_3 from the upper soil layer is to be expected. A regular resupply of N by means of fertigation may have, at least partly, compensated for these losses, resulting in relatively higher yields.

In general however fertigation hardly seems to effect yield, compared with broadcast application of N.

On the other hand fertigation seems to increase the overall availability of soil N, resulting in an increased uptake of N, part of which is luxury consumption. Nevertheless, the highest levels of NO_3 in the crop obtained in these experiments were still well below the limit of 4000 mg/kg fresh weight laid down by the Dutch Government. This leads to the conclusion that fertigation, with a technique as used in these experiments, does not offer a means to lower the nitrate content in lettuce. A lower crop NO_3 content may be obtained by adjusting the fertilization regime, i.e. a total stop of N fertilization a few weeks before harvesting could be considered.

Table 1. N dressings (broadcast or fertigation, kg/ha), yield (fresh weight, kg/100 heads), NO₃ contents (mg/kg fresh weight) and N_{total} (mmol/kg dry weight) of lettuce (*Lactuca sativa* L.).

	Control			Broadcast			Fertigation						Significance ¹	
	N dressing	yield	NO ₃	N _{total}	0	60	120	180	240	47	82	119		164
<i>Crop 1</i>														
15 March-					8.7	17.0	19.0	21.9	22.8	15.2	15.3	20.7	22.6	27.8
24 May 1983		53	135	186	657	1019	288	674	1249	1773	2004	1773	2004	3262
		1307	1484	1766	2138	2291	1820	1911	2412	2937	3262	2937	3262	3262
<i>Crop 2</i>														
2 June - 11					0	60	120	180	240	71	124	188	256	328
July 1983		22.3	32.4	34.3	40.4	39.5	38.8	34.8	40.6	39.3	47.3	39.3	47.3	47.3
		245	499	895	1119	1597	1074	1679	1964	1815	2024	1815	2024	3389
		1888	2202	2653	2825	3128	2723	3239	3282	3528	3389	3528	3389	3389
<i>Crop 3</i>														
21 July - 24					0	60	120	180	240	49	89	133	189	264
August 1983		34.6	39.9	43.5	44.7	46.5	41.5	45.0	43.9	46.2	42.0	46.2	42.0	42.0
		788	1297	2113	2150	2514	1784	2422	2521	2488	2729	2488	2729	2729
		2590	2986	3417	3534	3593	3346	3540	3794	3610	3691	3610	3691	3691

¹ n.s. = not significant; * = significant at 95 % confidence level; *- = significant; data with a substantial lack of fit in the 2nd-degree polynomial.

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Book review

M. Menenti, Physical aspects and determination of evaporation in deserts. Institute for Land and Water Management Research (ICW), Wageningen, Netherlands, 1984.

Life in semi-arid and arid regions is often dependent upon wells for drinking water, industry and crops. Use is made, increasingly, of irrigation to raise crops in many parts of the world, including the Middle East and northern Africa. Particularly for irrigation are large quantities of water required. It is often obtained from aquifers: water-containing layers in the subsoil that were filled in times with much precipitation. The determination of the size of aquifers, and of their current rate of recharge and of discharge, has therefore attracted attention of development agencies and scientists. The West Lybian Aquifer System in Lybia and neighbouring countries extends over some 800 000 km². Most of it is hundreds of meters below the surface, but in depressions the water-table is less than a few metres deep. Oases are small depressions where the water-table is higher than the soil surface. These areas with easily accessible water have been known for ages. Evaporation has there continued to be in excess of the precipitation, which is only some dozens of millimetres per