EFFECT OF DRIP IRRIGATION AND FERTIGATION ON GROWTH AND YIELD OF CELERIAC (*APIUM GRAVEOLENS* L. VAR. *RAPACEUM* (MILL.) GAUD)

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Summary

The influence of drip irrigation and traditional broadcast nitrogen fertilization as compared to drip fertigation was studied in field experiments. The yield of celeriac was highest with 1/3 preplant and 2/3 drip applied nitrogen, and lowest with broadcast nitrogen application without drip irrigation. Fertigated plants had greater leaf area, dry matter production, nitrate nitrogen and total N contents as compared to broadcast nitrogen application, both with and without drip irrigation. No significant differences in yield, dry matter production and contents of $NO_3^- - N$ and total nitrogen between surface and subsurface fertigation were stated.

key words: celeriac, nitrogen, fertilization, irrigation, fertigation

INTRODUCTION

Celeriac has high water and nutrient requirements. Especially high is the need for nitrogen. In traditional field growing, celeriac is usually sprinkler irrigated and fertilized broadcast. After Kaniszewski (1982), irrigation increased the yield of celeriac and the optimum nitrogen dose amounted 200 kg/ha for irrigated and 100 kg/ha for the non irrigated plants.

Recently sprinkler irrigation is frequently replaced by drip irrigation, also combined with fertilization (fertigation). Drip irrigation and weekly fertigation caused an increase of yield as compared to preplant fertilization and sprinklerd irrigation (Clough et al. 1990). According to McPharlin et al. (1995) and Hartz & Hochmuth (1996) fertigation allows for a precise matching of fertilization with plant requirements, and for a more efficient utilisation of nitrogen, due to reducing its losses caused by leaching. As compared to broadcast application of dry fertilizers, fertigation enables to limit the fertilizer doses (Swiader et al. 1994). As quoted by Chopade et al. (1997), fertigation of 50% of the dose recommended for broadcast fertilization secured optimum yield of onion. Kaniszewski et al. (1999) found that cabbage yield was by fertigation significantly higher than by broadcast fertilization, and that reduction of the fertigated nitrogen dose from

200 to 125 kg/ha did not significantly decrease the yield. As compared to broadcast-application of the nitrogen fertilizer, fertigation has favourably influenced the plant nutrient status, allowing for better and more uniform nutrient uptake during whole growth season. In work conducted by Locascio et al. (1997) with tomato planted on sandy soil, marketable yield was lowest when 100 % of the nitrogen dose was applied preplant, intermediate when 100% was drip applied, and highest when 40% was applied preplant and 60% in drip fertigation. On sandy loam soil instead, the yield was the highest by preplant nitrogen fertilization and lowest when whole nitrogen dose was drip applied only.

The present research was aimed at comparing drip fertigation of water soluble nitrogen or a complex fertilizer to traditional broadcast fertilization, with or without drip irrigation.

MATERIAL AND METHODS

Investigations on drip irrigation and drip fertigation of celeriac were conducted in 1997-1998. A single factorial experiment with four replications was carried out on sandy loam soil with 1.15% organic matter content and pH of 6.5. Considering high contents of phosphorus in the soil, this nutrient was not applied in fertilization. Potassium at rate of 200 kg K_2O/ha and a part of nitrogen at a rate of 75 kg/ha were applied preplant, whereas the remaining part of nitrogen was sidedressed. Experimental treatments and applied fertilization are presented in Table 1. Assessment of the effect of drip irrigation and drip fertigation with only nitrogen, was the subject of the first year of experiment. Irrigating pipes (T – Tape TSX 508-20-500) were applied for drip irrigation and fertigation. The pipes were placed at the soil surface (surface irrigation and fertigation) or at depth of 15 cm (subsurface irrigation and fertigation) in a double row arrangement (45 x 50 cm). The total dose of nitrogen in treatments either without irrigation or with drip irrigation was 200 kg/ha. On fertigated treatments nitrogen was applied either in rate as above mentioned but divided into 75 kg N/ha preplant and 125 kg N/ha in several drip applications, or only in rate of 125 kg N/ha only in several drip applications.

In the second year of experiment surface drip irrigation was compared to fertigation with nitrogen or with a complex fertilizer "Polyfeed", in surface and subsurface application. The total nitrogen dose was in that year 200 kg/ha in all treatments.

Table 1. Treatments and nitrogen doses applied

Treatment	Amount of nitrogen applied kg/ha			
	Preplant	Sidedress		Total
		Broadcast	Fertigation	
1997				
1. Broadcast N application (BN)	75	75 + 50(125)	-	200
2. BN + Surface Trickle Irrigation (STI)	75	75 + 50(125)	-	200
3. BN + Subsurface Trickle Irrigation (SSTI)	75	125(75 + 50)	-	200
4. Surface Fertigation of N(SF-N)	75	-	125	200
5. Subsurface Fertigation of N(SSF-N)	75	-	125	200
6. SF of reduced N dose (SF-N125)	0	-	125	125
1998				
1. BN	75	75 + 50(125)	-	200
2. BN + STI	75	75 + 50(125)	-	200
3. SF-N	75	-	125	200
4. SSF-N	75	-	125	200
5. SF of complex fertilizer (SF-CF)	75	-	125	200
6. SSF of complex fertilizer (SSF-CF)	75	-	125	200

For nitrogen fertigation, a solution of ammonium nitrate was used. In treatments with "Polyfeed" fertigation, preplant potassium was not applied. As far as nitrogen from "Polyfeed" is concerned, its concentration in the fertigation solution was 200 mg of N/l. The frequency of drip irrigation and fertigation depended on soil moisture assessed by measurements of soil water potential by means of a Watermark Soil Moisture Meters. Irrigation and fertigation started when the water potential reached — 40 kPa. Single nutrient solution dose amounted 10 l/running m/h. Fertigation proceeded until the intended nitrogen dose was reached.

Celeriac cv. Mentor was planted at spacing of 45 x 22.5 cm, on May, 19 and 13, in subsequent research years, respectively, whereas harvesting took place on October, 3 or 10 respectively. The area of a single plot was 8.1 m^2. Sampling of whole plants and young, fully developed leaves for analysis of nitrate and total nitrogen, was made during the growth season, 48, 82, 118 and 145 days after planting of transplants into the field. Whole plants were used for leaf area measurements by means of LI 3000 leaf area meter, and for total nitrogen determination, whereas samples of young, fully developed leaves were used for NO_3^- – N determination. After weighing, the samples were dried in a temperature of 65°C and ground. Total nitrogen was determined by means of the

micro-Kjeldhal method, whereas the $NO_3^- - N$, after extracting of plant material in 3% acetic acid (modified Spurway method) with the help of Orion specific electrode. The results (leaf area dry matter production, total and nitrate nitrogen contents and marketable yield) were elaborated statistically by means of the Student's t-test.

RESULTS AND DISCUSSION

Growth response and tissue N concentration. Fertigation and drip irrigation significantly influenced the leaf area and the dry matter production of celeriac plants (Figs. 1 and 2). The largest leaf area showed plants fertigated with nitrogen or with the complex fertilizer. On treatments where both, the preplant broadcast fertilization and fertigation were applied, already after 48 days from transplanting, the plants showed significantly higher leaf area as compared these with only broadcast nitrogen fertilization (Fig. 1). Decreased leaf area at only broadcast nitrogen fertilization was observed in both, the irrigated and the nonirrigated treatments. In the nonirrigated version of the only broadcast applied nitrogen, leaf area remained stable after 82 days from planting.

Similar relationships were stated in dry matter production (Fig. 2). Highest dry matter resulted fertigation with nitrogen or with a complex fertilizer, and lowest one the broadcast N application, without drip irrigation. In comparison to broadcast N application, the increment of dry matter resulted from fertigation was higher already after 82 days from transplanting and the differences became statistically significant after 118. and 145 days from transplanting. In conditions of drip irrigation and broadcast N application, a significantly higher dry matter production was stated after 118 and 145 days from transplanting.

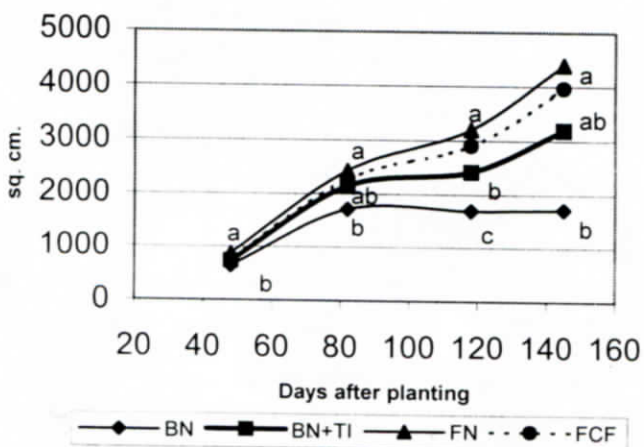

Fig. 1. Effect of drip irrigation, and fertigation on leaf area of celeriac (1998)

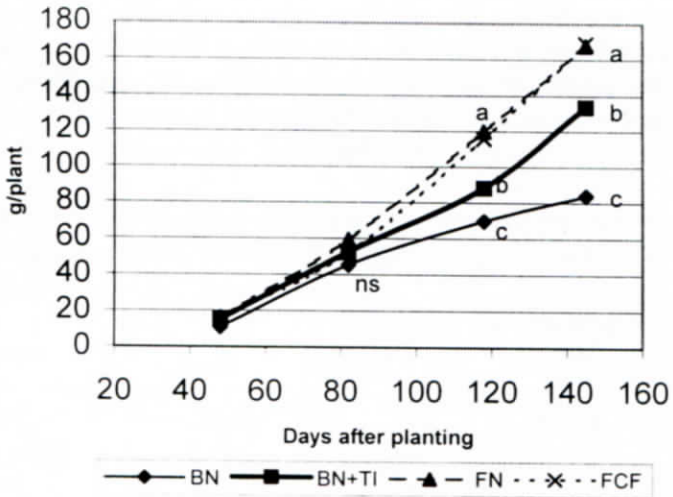

Fig. 2. Effect drip irrigation and of fertigation on dry matter production in celeriac (1998)

As far as nitrogen is concerned, the nutrient status of plants depended on application manner of this element (Fig. 3). Generally, the content of nitrate nitrogen in indicatory plant parts was higher with fertigation, and steadily declined in course of the growing season. During harvest time the nitrate nitrogen approached a similar level, in conditions of fertigation and broadcast fertilization.

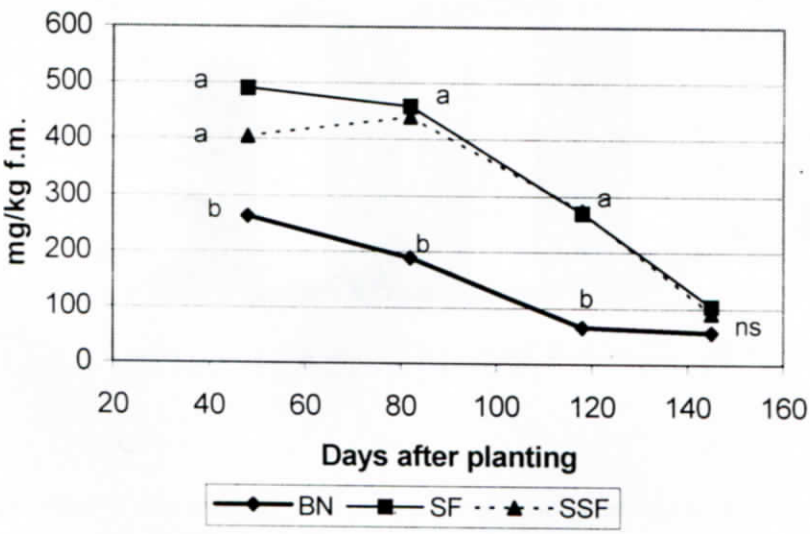

Fig. 3. Effect of drip irrigation and fertigation on nitrate nitrogen content in celeriac plants (1998)

The content of total nitrogen decreased during the growth period too (Table 2). In conditions of fertigation with nitrogen only or with a complex fertilizer, as compared to broadcast applied N fertilization, a significantly higher total nitrogen content in all growth stages of the celeriac plants was observed. The lowest contents of total nitrogen in celeriac plants was recorded in conditions of drip irrigation applied after broadcast N fertilization.

Table 2. Effect of drip irrigation and fertigation on contents of total nitrogen (% dry wt.) in celeriac plants in the course of the 1998 growth season.

Treatment	Days from transplanting			
	48	82	118	145
1. BN	2.58 bc	1.77 bc	1.29 b	1.59 bc
2. BN + STI	2.49 c	1.68 c	1.24 b	1.34 c
3. SF-N	2.89 a	2.10 a	1.66 a	1.84 ab
4. SSF-N	2.83 a	1.99 ab	1.82 a	1.77 ab
5. SF-CF	2.80 ab	2.01 ab	1.80 a	1.94 a
6. SSF-CF	2.71 abc	2.06 a	1.80 a	1.81 ab

Means within a column followed by the same letter are not significantly different at the 5% level

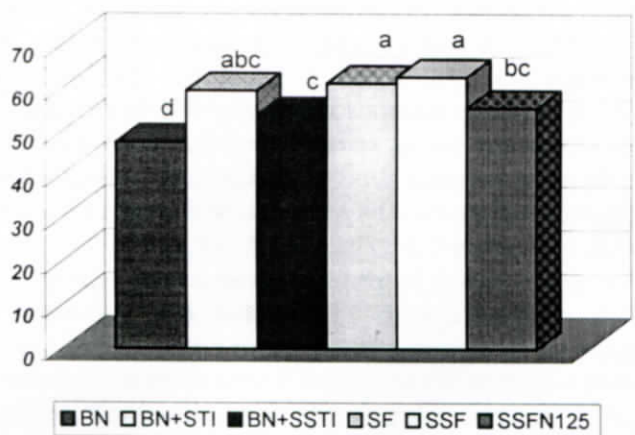

Fig.4. Effect of drip irrigation and fertigation on yield of celeriac (1997)

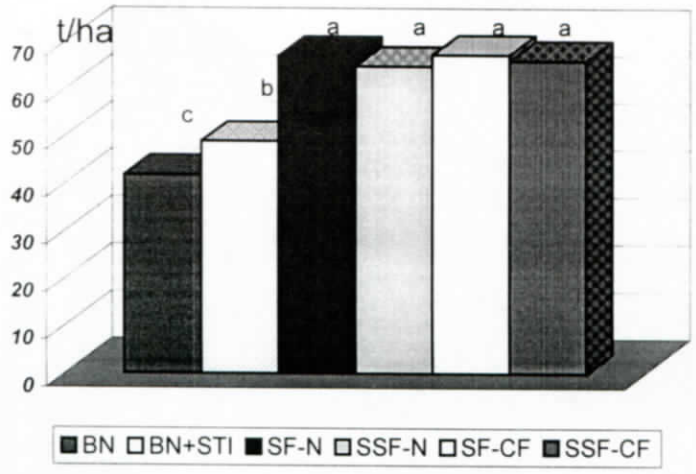

Fig. 5. Effect of drip irrigation and fertigation on yield of celeriac (1998)

Yield response. The response of celeriac to drip irrigation, fertigation and nitrogen fertilization was differing in particular research years (Figs. 4 and 5). The lowest yield in both research years was obtained in conditions of broadcast N application, without drip irrigation. In 1997 among the 2 treatments with drip irrigation, the surface one gave slightly higher yield of celeriac than the subsurface one. The difference however was not significant. Surface drip irrigation allowed also for obtaining a similar yield of celeriac as that resulting from fertigation. In 1998 instead, drip irrigation was in yield quantity inferior to all of the fertigation treatments. In both research years the highest yield was obtained when fertigation was performed after preplant broadcast application of nitrogen in rate of 75 kg/ha. A reduced to 125 kg/ha rate of nitrogen, applied in 1997 in fertigation, gave celeriac yield equal to that obtained with 200 kg N/ha, applied broadcast, and followed by drip irrigation. The latter treatment however, gave significantly lower yield as compared the fertigation treatments, where total nitrogen amounted 200 kg N/ha (75 kg/ha preplant plus 125 kg N/ha in fertigation). Fertigation with the complex fertilizer "Polyfeed", in amount equivalent to nitrogen rate of 125 kg/ha, had similar effect on yield of celeriac, as compared nitrogen in the same rate, both in surface and subsurface fertigation.

In the research conducted, highest celeriac yield was obtained after splitting the nitrogen dose into two parts, with the first part of about 1/3 applied preplant and second one of about 2/3 applied as fertigation, in form of ammonium nitrate or complex fertilizer "Polyfeed". The results obtained are consistent with these of other authors, noting an increase of yield after applying fertigation (Clough et al.