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RESPONSE OF LEEK TO IRRIGATION, FERTIGATION AND BROADCAST NITROGEN FERTILIZATION

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Summary

Research on response of leek (*Allium porrum* L.) to trickle irrigation, fertigation and broadcast fertilization was conducted in 1997-1998 growing seasons. Fertigation with nitrogen or with a complex fertilizer "Polyfeed" significantly affected growth, yield and nitrogen content of leeks as compared to broadcast nitrogen application. Total and marketable yield of leek was highest with 1/3 preplant and 2/3 trickle applied nitrogen in the total dose of 200 kg $N \cdot ha^{-1}$. Reduced nitrogen rate to 125 kg $N \cdot ha^{-1}$, applied in several drip fertigations caused an insignificant reduction in leek yield. In 1997 lowest yield of leek was obtained with only broadcast nitrogen application (without trickle irrigation), in 1998 however, broadcast application of N, both with and without trickle irrigation, produced lowest yield of leek. Fertigated plants had greater leaf area and produced more fresh and dry matter, as compared plants with only broadcast nitrogen application. Leaf NO_3^- – N content in leek plants decreased during growing season and was highest under surface fertigation, intermediate under subsurface fertigation and lowest with only broadcast nitrogen application. No significant differences in total N content of whole leek plants, up to 80 days from transplanting, were found. In later growth stage however, fertigated plants showed higher total N concentration as compared these with only broadcast applied nitrogen.

key words: leek, nitrogen, fertilization, trickle irrigation, fertigation

INTRODUCTION

Trickle irrigation is an effective way to provide water for vegetable crops. It also allows precise timing and uniform distribution of fertilizer nutrients (Hartz and Hochmuth 1996). Nutrients applying through trickle irrigation system is widely used in vegetable growing under cover. Some research on fertigation was also done in open field grown vegetables. According to Locascio (1989, 1997), fertilizer N management with trickle irrigated tomatoes is important for highest yields. Nitrogen fertigation resulted in higher yield than with all N applied preplant, and on a fine sandy soil best results were obtained when 40% of N was

preplant and 60% drip applied. Fertigation of late cabbage with nitrogen or a complex fertilizer "Polyfeed" improved growth, nitrogen status of plants, and increased yield as compared to broadcast nitrogen application (Kaniszewski et al. 1999). Fertigation improved fertilizer efficiency in comparison to preplant and early-season sidedress application and allowed to reduce rate of applied fertilizers (Swiader et al. 1994, Chopade et al. 1997, Kaniszewski et al. 1999). Fertigation frequency is not as important as applying correct rate of nutrients to the crop during specified period (Cook and Sanders 1991). After Storlie et al. (1995), increased frequency of drip applied fertilizer, from 11 to 22 times did not influence yield of peppers when drip irrigation was managed to prevent leaching.

Field experiments comparing surface and subsurface fertigation are limited. Kaniszewski et al. (1999) report that no differences in yield, dry matter production, and nitrate and total nitrogen contents were found, between surface and subsurface fertigation.

The objective of this experiment was to evaluate response of leek to surface and subsurface trickle irrigation and fertigation in comparison to broadcast nitrogen application.

MATERIAL AND METHODS

Investigations on trickle irrigation and trickle fertigation of leek 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 rate of 75kg N/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 trickle irrigation and trickle nitrogen fertigation was the subject of the first year of experiment. Irrigating pipes (T-Tape TSX 508-20-500) were applied for trickle irrigation and fertigation. The pipes were placed on soil surface (surface irrigation and surface fertigation) or at depth of 15 cm (subsurface irrigation and subsurface 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 $N \cdot ha^{-1}$. On fertigated treatments, nitrogen was applied either in rate as above mentioned, but divided into 75 kg $N \cdot ha^{-1}$ preplant plus 125 kg $N \cdot ha^{-1}$ in several drip applications, or in rate of only 125 kg $N \cdot ha^{-1}$ in several drip applications. In the second year of experiment surface trickle 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 $kg \cdot ha^{-1}$ 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

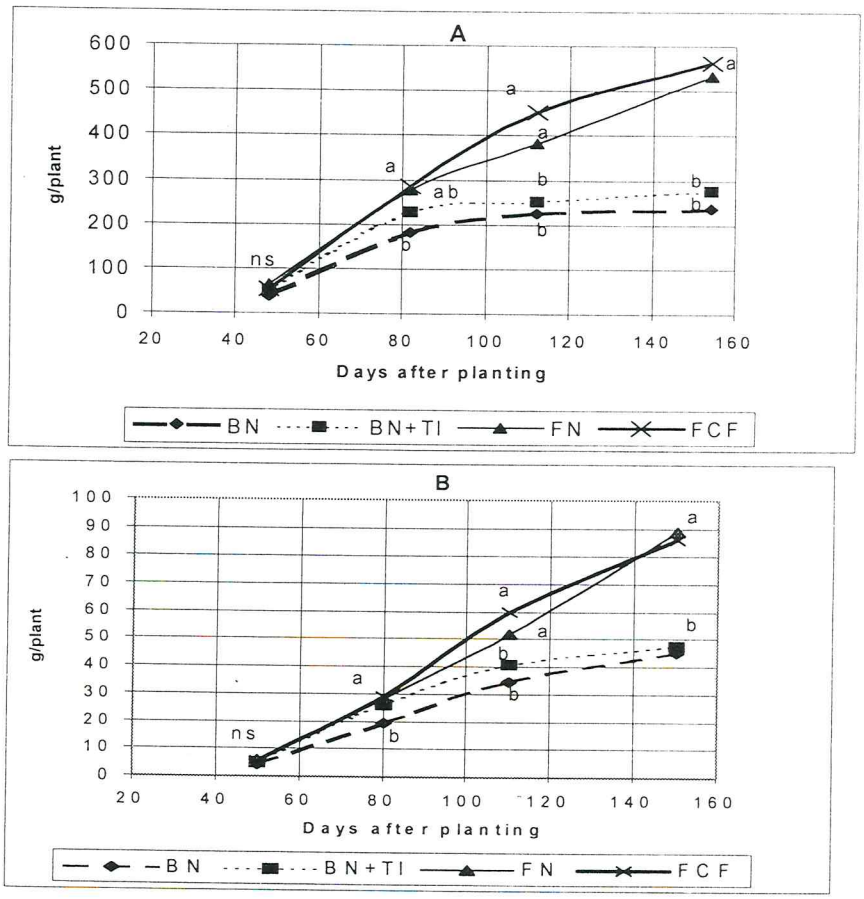
For nitrogen fertigation, a solution of ammonium nitrate was used. In treatments with "Polyfeed" fertigation, preplant potassium was not applied. As far as nitrogen is concerned, its concentration in the fertigation solution was 200 mg of $N \cdot l^{-1}$. The frequency of trickle irrigation and fertigation depended on soil moisture, assessed by measurements of soil water potential by means of Watermark Soil Moisture Meters. Irrigation and fertigation started when the water potential reached -40 kPa. Single nutrient solution dose amounted 10 l/running meter/h. Fertigation proceeded at few day intervals until the intended nitrogen dose was reached.

Leek cv. Lincoln in the 1997 and cv. Bandit in the 1998 experiment was planted at spacing of 45 x 11,5 cm, on May 16 and 14 respectively, whereas harvesting took place on September 23 or October 23 respectively. The area of a single plot was 8.1 m^2. Sampling of whole plants and young, fully developed leaves for analysis, was made during the growth season 50, 80, 110 and 150 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, samples were dried in temperature of 65°C and ground. Total nitrogen was determined by micro-Kjeldhal method,

whereas the $NO_3^- - N$, content was assessed after extracting with 3% ace acid (modified Spurway method) by means of Orion specific electrode. All resu (leaf area, dry matter production, total and nitrate nitrogen contents a marketable yield) were elaborated statistically by means of the Student's t-tes

RESULTS AND DISCUSSION

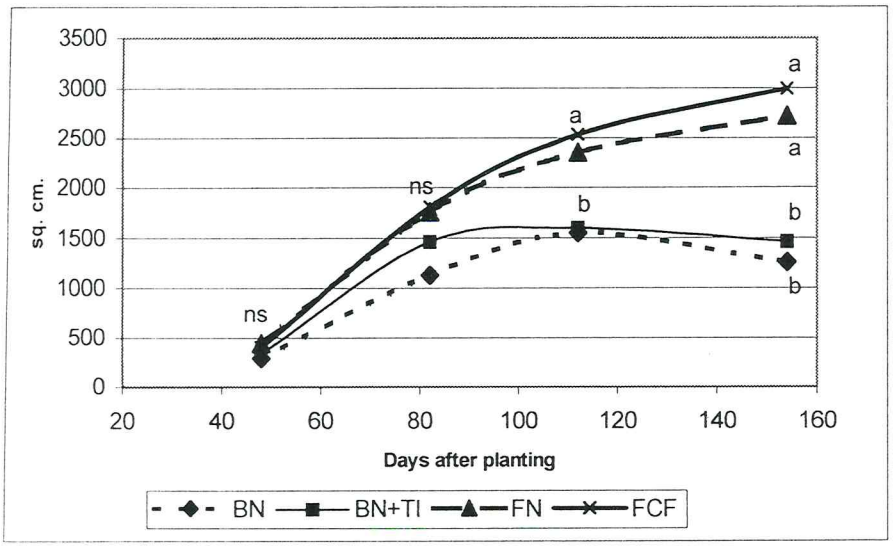
Growth response and tissue N concentration. Fertigation with nitrogen or wi a complex fertilizer significantly influenced fresh and dry matter production leek (Fig. 1 A,B). Fertigated plants produced more fresh and dry matter compared the broadcast fertilized ones.



BN - broadcast N application, TI - trickle irrigation, FN - nitrogen fertigation, FCF - complex fertilizer fertigation

Fig. 1. Effect of fertigation and broadcast N application on fresh matter (A) and dr matter (B) production of leek (1998)

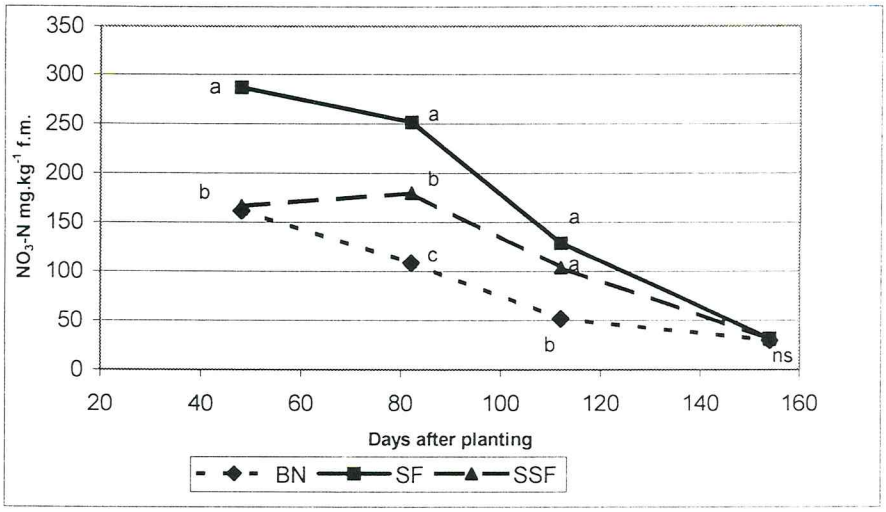
These differences were significant after 80 days from planting, till end of season. Trickle irrigation in conditions of broadcast N application had little influence on fresh and dry matter production, and its positive effect was observed only at the beginning of the growing season up to 80 days from planting. Fertigation influenced significantly also the leaf area of leek plants (Fig. 2). The leaf area of plants fertigated with nitrogen or with the complex fertilizer was greater as compared that of the broadcast nitrogen fertilized ones. No significant differences in leaf area could be stated between irrigated and not irrigated plants.



BN - broadcast N application, TI - trickle irrigation,
FN - nitrogen fertigation, FCF - complex fertilizer fertigation

Fig. 2. Effect of trickle irrigation and fertigation on leaf area of leek plants (1998)

Leaf $NO_3^- - N$ concentration generally decreased during the growing season and responded significantly to the manner of fertilization (Fig. 3). Highest nitrate nitrogen concentration in leaves was stated in surface fertigated plants, intermediate in subsurface fertigated, and lowest in plants with broadcast nitrogen application. At harvest time leaf concentration of $NO_3^- - N$ was for all compared treatments on similar level.



BN - broadcast N application, SF - surface fertigation, SSF - subsurface fertigatio

Fig. 3. Effect of trickle irrigation and fertigation on nitrate nitrogen content of leeks (19

The content of total nitrogen in whole leek plants decreased during grow period (Table 2). Generally, up to 80 days from planting no significant differenc in total nitrogen between compared treatments were stated. In later grow stage however (110 days from planting) and at harvest time, fertigated plar contained significantly higher total N concentration as compared plants wi only broadcast nitrogen application. The lowest contents of total nitrogen leeks were recorded in conditions of trickle irrigation.

Table 2. Effect of fertigation and broadcast N application on plant total-N concentrati (% dry wt.) at 50, 80, 110 and 150 days after transplanting (1998)

Treatment	Days from transplanting			
	50	80	110	150
1. Broadcast N	2.94 a	2.34 a	1.63 cd	1.43 bc
2. BN+TI	2.48 b	2.27 a	1.36 d	1.11 d
3. SF	3.30 a	2.94 a	1.84 bc	1.75 ab
4. SSF	3.20 a	2.73 a	2.27 a	1.71 b
5. SF complex fertilizer	3.15 a	2.57 a	2.10 ab	2.00 a
6. SSF complex fertilizer	3.07 a	2.45 a	2.08 ab	1.85 ab

Means within a column followed by the same letter are not significantly different at 1 5% level

Yield response. The response of leek to trickle irrigation and nitrogen fertilization and fertigation was differing in particular years (Figs. 4 and 5). In 1997 highest total and marketable yield of leek was obtained with surface and subsurface N fertigation in rate of 200 kg $N \cdot ha^{-1}$ and with broadcast N application at the same rate but in conditions of trickle irrigation. Reduced to 125 kg $N \cdot ha^{-1}$ rate of nitrogen, applied in fertigation, gave a slight reduction in yield of leeks as compared to rate of 200 kg $N \cdot ha^{-1}$ applied on surface. The yield difference however was statistically insignificant. Lowest leek yield was obtained with broadcast N application without trickle irrigation or fertigation (Fig. 4).

In 1998 lowest yield of leek was obtained with broadcast N application both in conditions with and without trickle irrigation (Fig. 5). Highest yield was gave treatments fertigated with ammonium nitrate or with the complex fertilizer "Polyfeed", after preplant broadcast application of 75 kg $N \cdot ha^{-1}$. No differences between surface and subsurface fertigation were found when ammonium nitrate was used for fertigation. When the complex fertilizer "Polyfeed" was used, yield of leek with subsurface fertigation was significantly higher as compared to surface fertigation with that fertilizer.

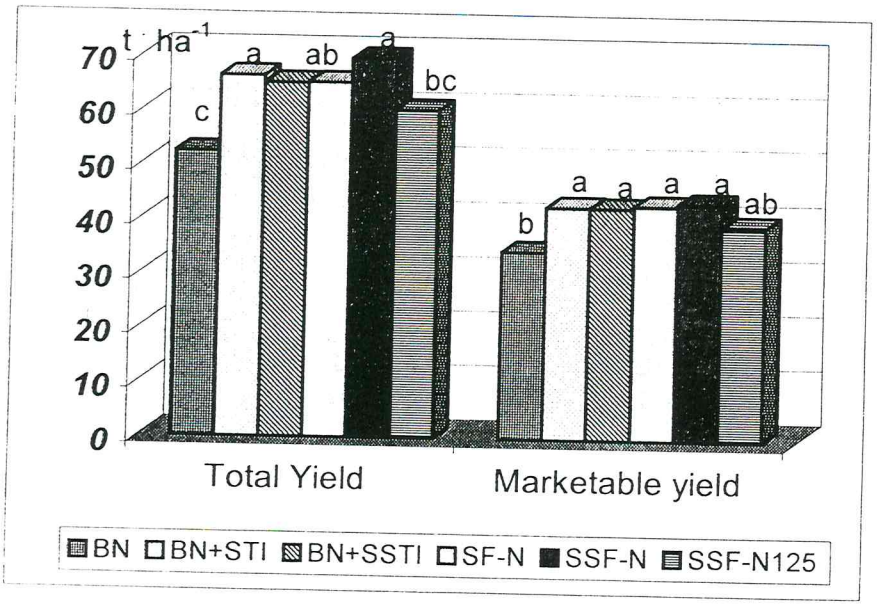


Fig. 4. Effect of trickle irrigation and fertigation on total and marketable yield of leek (1997)

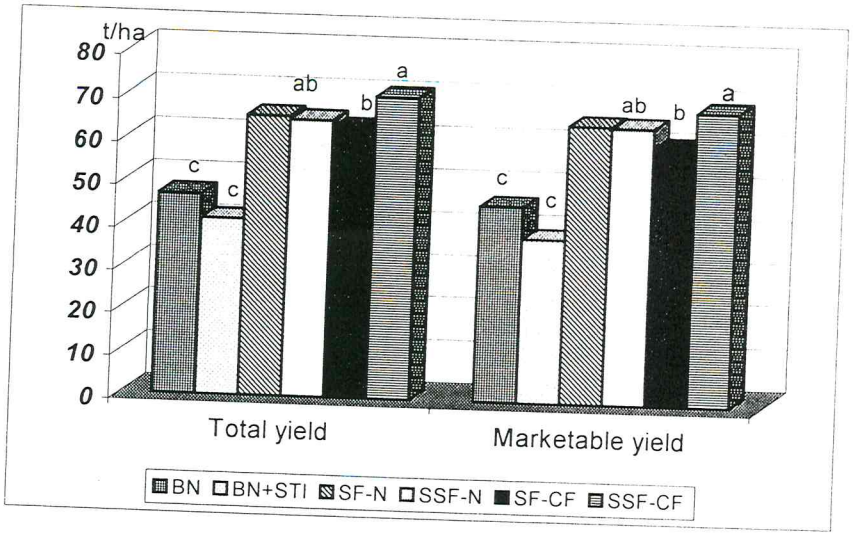


Fig. 5. Effect of trickle irrigation and fertigation on total and marketable yield of (1998)

Generally, highest yield of leek in both years of experiment was obtai when nitrogen was split into two parts, with the first 1/3 part applied broadc before planting and the second, 2/3 one applied as sidedress fertigation in forn ammonium nitrate or as a complex fertilizer. This confirms earlier result other authors noting yield increase after fertigation. (Locascio et al.1989, 1 Kaniszewski et al. 1999). Increase of yield with fertigation seems to be resul better nutrient utilisation as compared by broadcast fertilization (Swiader e 1994, Hartz and Hochmuth 1996, Kaniszewski et al. 1999). This was confirn in present work by higher NO_3^- – N and total N contents in fertigated plant compared to broadcast fertilization. Better nutrient uptake in condition fertigation and trickle irrigation seems to be also the cause of observed hig fresh and dry matter production.

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REAKCJA PORA NA KROPLOWE NAWADNIANIE, FERTYGACJĘ I POSYPOWE STOSOWANIE AZOTU

Streszczenie

W latach 1997-1998 prowadzono badania nad reakcją pora (*Allium porrum* L.) na kroplowe nawadnianie, fertygację i posypowe stosowanie azotu. Fertygacja azotem lub mieszanką wieloskładnikową "Polyfeed" w istotny sposób zwiększyła plonowanie i wzrost roślin oraz zawartość azotu w roślinach w porównaniu do posypowego stosowania azotu. Najwyższy plon ogólny i handlowy pora uzyskano stosując 1/3 dawki azotu posypowo przedwegetacyjnie i 2/3 pogłównie za pomocą systemu kroplowego w łącznej ilości 200 kg $N \cdot ha^{-1}$. Obniżenie dawki azotu do 125 kg $\cdot ha^{-1}$ zastosowanej wyłącznie pogłównie w postaci płynnej tylko nieznacznie obniżyło plon pora. W 1997 r. najniższy plon pora uzyskano stosując azot posypowo, bez kroplowego nawadniania, natomiast w 1998 r. plon pora był najniższy, przy posypowym stosowaniu azotu zarówno w warunkach kroplowego nawadniania jak i bez nawadniania. Rośliny nawożone płynnym roztworem nawozów miały większą powierzchnię liści oraz dawały większy plon świeżej i suchej masy w porównaniu do roślin nawożonych posypowo. Zawartość $N\text{-}NO_3$ w liściach spadała w okresie wegetacji i była najwyższa przy stosowaniu fertygacji powierzchniowej, pośrednia przy fertygacji podpowierzchniowej i najniższa przy posypowym stosowaniu azotu. Nie stwierdzono istotnych różnic w zawartości N-ogólnego w całych roślinach pora do 80 dnia od wysadzenia roślin w pole, natomiast w późniejszym okresie wzrostu stwierdzono wyższą zawartość N-ogólnego u roślin nawożonych płynnym roztworem nawozów niż u roślin nawożonych posypowo.