EFFECT OF NITROGEN FERTILIZATION AND IRRIGATION ON YIELD, NITROGEN STATUS IN PLANTS AND QUALITY OF FRUITS OF DIRECT SEEDED TOMATOES

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Abstract

The effect of N fertilization at rates from 37.5 to 300 kg N ha^{-1} and irrigation was studied in field conditions on tomatoes cv. New Yorker. On irrigated plots N fertilization up to the rate of 225 kg N ha^{-1} resulted in significant increases of total and marketable yield, whereas without irrigation, the yield increased up to the rate of 150 kg N ha^{-1}. Irrigation increased marketable yield of fruits by 32 to 79 percent. With irrigation weight and flesh firmness of fruits increased, whereas skin hardness, the content of dry matter, soluble solids and NO_3-N of fruits decreased. N fertilization decreased vitamin C content, skin hardness, flesh firmness and, in the absence of irrigation, also the weight of fruits.

1. Introduction

The area of tomatoes grown from direct seeding in Poland increases rapidly, especially in the production centres of the processing industry, where until recently only transplant tomatoes were grown.

In the growing conditions of Poland direct sown tomatoes mature about 2 weeks later as the transplanted ones. Some cultural practices like high nitrogen fertilization and irrigation may cause further delay in maturity and also affect the quality of fruits. Nicklow and Downes /1971/ stated that N-fertilization applied preplant or sidedressed delayed the single harvest of seeded tomatoes and decreased the yield. Similarly Kaniszewski and Rumpel /1983/ working on multiple harvested transplant tomatoes found that with the increase of N-fertilization the early yield decreased.

Nitrogen fertilization and irrigation may affect some quality traits of tomato fruits, such as dry matter, vitamin C and nitrate nitrogen contents and change their color, viscosity, acidity e.t.c. /Williams and Sistrunk, 1979, Rudich et al., 1979, Kaniszewski and Rumpel, 1983/.

2. Material and methods

Field experiments were conducted in the years 1982-1984 in Skierniewice central Poland on a sandy - loam soil /pH 6, organic matter content 1.16 %, available water capacity 12.5 mm /0.1 m/. Tomatoes cv. New Yorker were grown in a randomized block design consisting of 14 treatments replicated three times. Seeds were sown at the end of April in clumps/7 seeds/clump/ in double rows at distance of 25x35x120 cm. Seedlings were thinned to 3 plants per clump. The area of a single plot was 5 square meters. The phosphorus and potassium fertilization was applied each year according to the results of soil tests by bringing up the soil fertility to 80 mg P and 200 mg K per litre of soil. Nitrogen fertilization was applied at rates of 37.5;

75; + 75 /preplant and top dressing/; 150; 150+75; 225 and 150 + 150 kg N ha^{-1}. The top dressing was performed at the onset of blooming. Irrigation was applied from the stage of blooming to the beginning of fruits ripening, when soil water tension at the depth of 30 cm reached 0.04 MPa. A single water rate amounted 20 mm. Depending on year the water used in irrigation was equivalent to 140-160 mm of rainfall.

Tomatoes were multiple harvested as ripening progressed. Whole yield was divided into total yield /yield of all fruits produced on the plant/, marketable yield /yield of healthy, mature red fruits of diameter above 3.5 cm/, and into early yield /yield of marketable fruits harvested at the first 1/3 part of the harvest period/. Indicative plant samples /5-th leaf from top/ were taken at blooming, fruit setting on 1 and 3-4 cluster and at ripening of the first fruits. The plant tissue was oven dried at 60 °C and NO_3-N was determined after extraction in 2 % acetic acid using the NO_3 specific ion electrode.

For determining the quality traits of tomato fruits such as dry matter, sugars, vitamin C and nitrate content and also the color intensity, skin hardness and fruit firmness routine methods were applied. All results were analyzed statistically by means of Student´s "T" test.

3. Results

As shown in Table 1 the total yield of tomato fruits increased with the increase of N fertilization up to the rate of 225 kg N ha^{-1}. The 300 kg N ha^{-1} rate resulted in a slight depression. Consequently the average total yield was highest by the rate of 225 kg N ha^{-1} applied either preplant or split into preplant and top dressing.

The marketable yield increased significantly only up to the rate of 150 N ha^{-1}, as also did the total yield, regardless of the way of nitrogen application. The observed with the rates 225 and 300 kg N ha^{-1} yield increments were statistically insignificant.

Nitrogen fertilization influenced negatively the early yield of tomato fruits. Highest early yield of 0.8 kg m^{-2} was obtained with lowest nitrogen rate of 37.5 kg N ha^{-1}. The rate of 300 kg N ha^{-1} gave the lowest early yield of 0.5 kg m^{-2}.

Irrigation influenced significantly the tomato yield in all years of experiment. Depending on year the results from irrigation increase reached 36 to 53 % of the total yield and 32 to 79 % of the marketable yield.

The three year average total yield obtained with irrigation amounted 8.1 kg m^{-2} as compared to 5.7 kg m^{-2} for the nonirrigated treatments. The average marketable yield was 5.5 kg m^{-2} and 3.4 kg m^{-2} for the irrigated and nonirrigated treatments respectively. This means an average increase of 42 and 64 percent for the total and marketable yield respectively. No influence of irrigation on the early yield was noted /Table 1/.

In all years of experiment a significant interaction between irrigation and nitrogen fertilization was observed. In conditions of irrigation the total and marketable yield increased with the nitrogen fertilization up to the rate of 225 kg N ha^{-1}. Without irrigation the total yield increased only to the rate of 150 kg N ha^{-1}, whereas the marketable yield did not differ significantly and was similar by all levels of N-fertilization /Fig. 1/.

Nitrogen fertilization and irrigation influenced the chemical composition of tomato fruits. The highest dry matter content was observed by the rate of 150 kg N ha^{-1} and the lowest by the rate of 37.5 kg N ha^{-1}. The dry matter content from the other nitrogen rates did not differ significantly /Table 2/. Nitrogen rates above 150 kg N ha^{-1} and that of 37.5 kg N ha^{-1} decreased the sugar content in tomato fruits. Highest sugar content in tomato fruits was associated with the rates of 75 and 150 kg N ha^{-1}. The rate of 37.5 kg N ha^{-1} as well as rates above 150 kg N ha^{-1} resulted in a significantly lower sugar content. The applied nitrogen fertilization had a strong effect on the vitamin C content of tomato fruits. With increase of the N-fertilization the vitamin C content decreased, from 313.6 mg/ 100 g by 37.5 kg N ha^{-1} to 178.6 mg/100 g of dry matter by the rate of 300 kg N ha^{-1} /Table 2/. The content on nitrates increased with the increase of nitrogen fertilization but the highest NO_3-N content of 145.1 mg kg^{-1} of dry matter was found by the rate of 150 kg N ha^{-1} applied preplant.

The color of fruits was not affected by the applied N-fertilization but affected were skin hardness of fruits and fruit firmness /Table 3/. Highest skin hardness was detected by divided fertilization at rate of 150 kg N ha^{-1} and lowest at rate of 300 kg N ha^{-1} whereas highest fruit firmness was found at rates of 75 to 150 kg N ha^{-1}. Higher as well as lower N-rates decreased the fruit firmness.

Irrigation reduced significantly the contents of dry matter and NO_3-N but did not affect the sugars and vitamin C content /Table 2/. The color of fruits was not influenced but the firmness of fruits increased and skin hardness decreased with irrigation /Table 3/.

For determining the status of N-nutrition of the tomato plants the relation between total yield and NO_3-N content in indicative leaf samples was calculated and expressed by means of the regression equation. The relation had a parabolic character for all of the tested growth stages /Fig. 2/ and it was found that the correlation coeficients r^2 were highest at the blooming and fruit setting stage /0.54-0.95/. In conditions of irrigation the correlation coeficients r^2 were higher. The elaborated curves showing relation between yield and NO_3-N content were used for preparing the diagram of plant nutrition status in the different growth stages /Figure 3/. In this diagram NO_3-N contents by which the yield did not differ significantly were recognized as luxury consumption contents. Similarly NO_3-N contents by which yield significantly decreased were low critical whereas those associated with highest yield - as upper critical contents.

Thus the low critical NO_3-N contents for blooming varied from 0.25 to 0.35 %, for fruit setting - 0.1-0.25 % and for the stage of fruit ripening 0.02-0.1 %. On the other hand the upper critical NO_3-N contents for both blooming and fruit setting and for fruit ripening were 0.63 to 0.9 % and 0.3 to 0.63 % respectively.

Conclusions

1. With irrigation, nitrogen fertilization up to the rate of 225 kg N ha^{-1} resulted in a significant increase of both total and marketable yield of tomatoes, whereas without irrigation total yield increased only to the rate of 150 kg N ha^{-1} and marketable yield was

unaffected.

2. With irrigation the total yield of tomatoes was 36-53 percent greater and the marketable yield 32-79 percent greater than without irrigation.
3. With increase of the nitrogen fertilization the early yield of tomato fruits decreased.
4. The NO_3-N contents in indicative tomato leaves varied, depending on the growth stage from 0.02 to 0.35 percent at the low critical content and from 0.3 to 0.9 percent at the upper critical content respectively.
5. Nitrogen fertilization and irrigation affected the quality of the tomato fruits.

References

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Table 1 - Effect of nitrogen fertilization and irrigation on yield of direct seeded tomatoes

Treatment		Yield $kg.m^{-2}$ Total	Marketable	Early*
Nitrogen fertilization, $kg\ N.ha^{-1}$	37.5	4.9	3.6	0.8
	75	6.1	4.1	0.8
	75+75	6.8	4.5	0.6
	150	7.2	4.5	0.6
	150+75	7.9	4.8	0.6
	225	7.8	4.7	0.6
	150+150	7.6	4.6	0.5
LSD P = 0.05		0.3	0.4	0.2
Irrigated		8.1	5.5	0.7
Nonirrigated		5.3	3.4	0.6
LSD P = 0.05		0.9	1.7	N.S.

* Harvested during first 1/3 part of the harvest period

Table 2 - Effect of nitrogen fertilization and irrigation on some chemical traits of tomato fruits

Treatment		Dry matter %	Sugars % in dry matter	Vitamin C mg/100 g dry matter	Nitrate N mg/kg dry matter
Nitrogen fertilization, kg $N.ha^{-1}$	37.5	6.4	5.40	313.6	57.3
	75	6.7	5.52	272.3	91.1
	75+75	7.0	5.51	249.4	99.4
	150	7.2	5.50	221.8	145.1
	150+75	6.9	5.36	216.9	112.4
	225	6.9	5.28	206.8	113.3
	150+150	6.9	5.24	178.6	115.2
LSD P = 0.05		0.4	0.9	22.9	13.6
Irrigated		6.3	5.34	256.2	99.2
Nonirrigated		7.5	5.46	217.7	102.9
LSD P = 0.05		0.7	N.S.	N.S.	3.9

Table 3 - Effect of nitrogen fertilization and irrigation on color, skin hardness and firmness of tomato fruits

Treatment		Fruit color a/b	Skin hardness N	Fruit firmness N
Nitrogen fertilization kg $N.ha^{-1}$	37.5	2.4	15.5	3.0
	75	2.4	15.9	3.6
	75+75	2.4	16.2	3.6
	150	2.4	15.1	3.6
	150+75	2.4	15.0	3.4
	225	2.4	14.9	3.1
	150+150	2.3	13.9	2.9
LSD P = 0.05		N.S.	1.2	0.3
Irrigated		2.3	14.2	3.6
Nonirrigated		2.4	16.1	3.0
LSD P = 0.05		N.S.	1.7	0.1

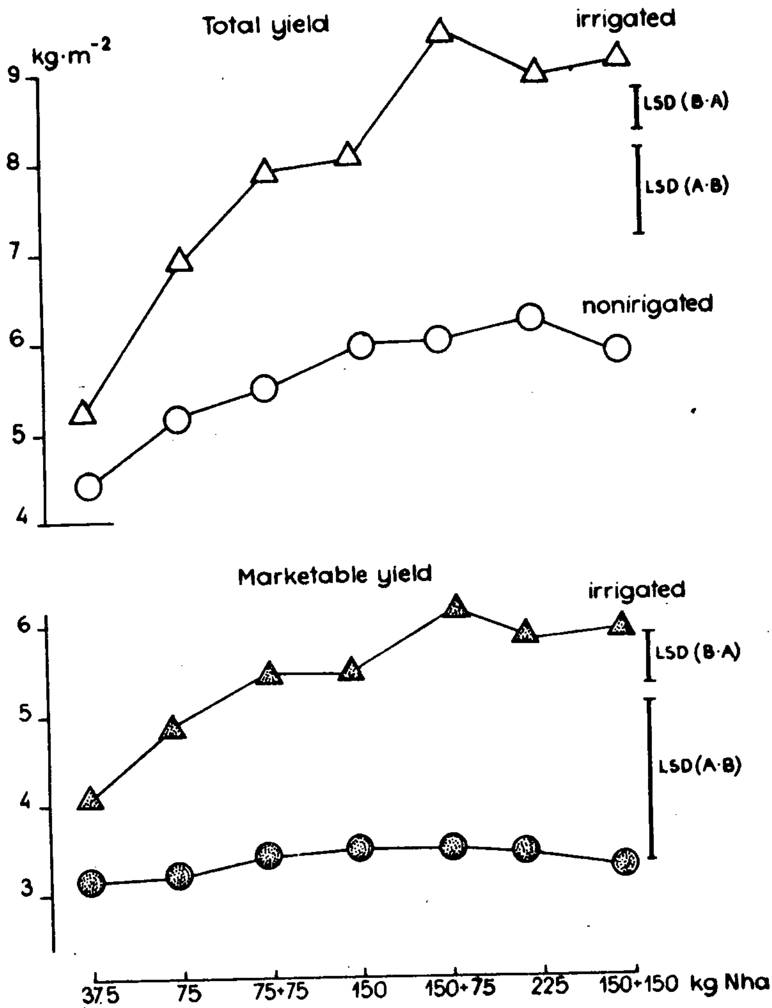

Figure 1 - Interaction of irrigation /A/ and nitrogen fertilization /B/

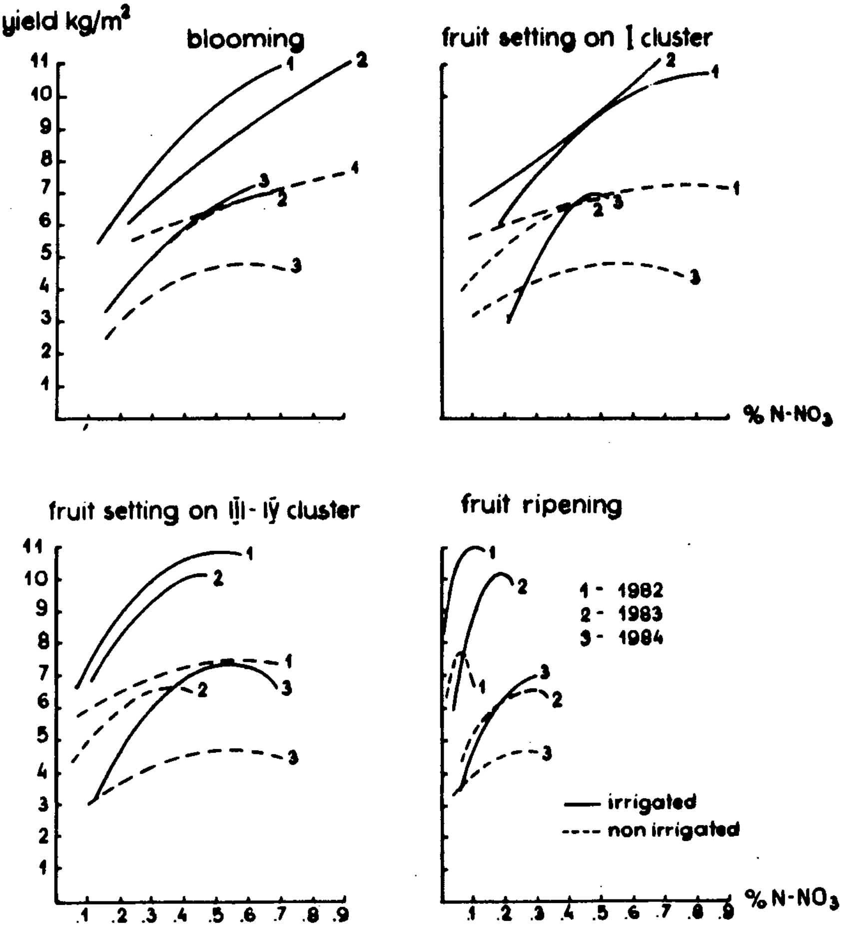

Figure 2 - Relationship between yield and leaf NO_3N content of tomatoes at different growth stages

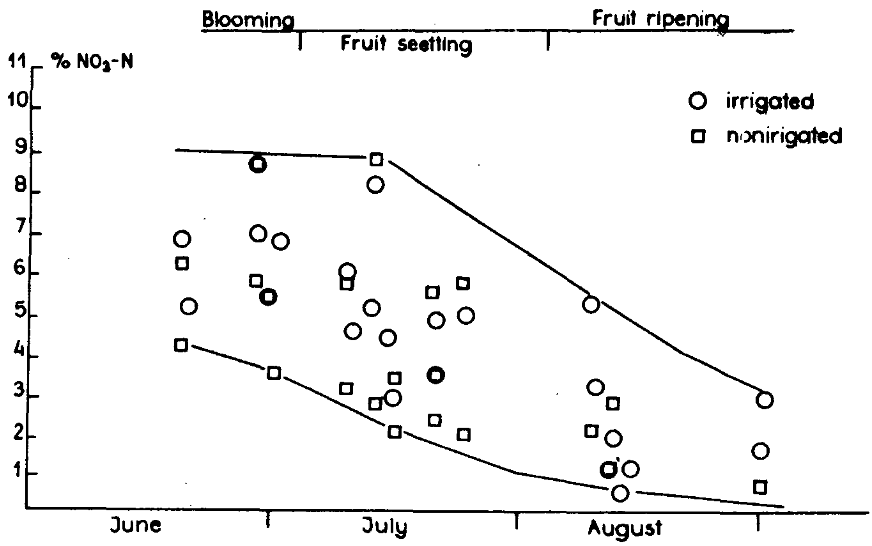

Figure 3 - Range of optimal NO_3-N contents in indicative parts of tomato plants /5-th leaf from plant top/