XA0201406

FIELD EVALUATION OF UREA FERTILIZER AND WATER USE EFFICIENCY BY TOMATO UNDER TRICKLE FERTIGATION AND FURROW IRRIGATION IN THE ISLAMIC REPUBLIC OF IRAN

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Abstract

Urea fertilizer and water use efficiency by tomato (Early Urbana VF) were studied in a sandy loam soil, comparing trickle fertigation and conventional furrow irrigation — band fertilization systems. During the period of 1995–1998, a conventional treatment, NS, with band application of 50, 150 and 100 kg N as urea, P as diammomium phosphate and K as potassium sulfate respectively was carried out. The average concentration of N in the total irrigation water was 0, 38, 76 and 114 mg/L for the N0, N1, N2 and N3 fertigation treatments, respectively. All fertigation treatments also received equally 24 and 16 mg/L P and K, respectively. An increase of K for the conventional treatment to 1200 kg/ha in 1998 coincided with the increase of the same element to 190 mg/L for the trickle irrigated treatments. To evaluate the urea-N use efficiency, the plants of isotope subplots received 2% ^{15}N a.e. urea. The soil moisture in all treatments was measured by the neutron moisture gauge. During the first 3 years of experimentation there was no significant difference between the yields of the treatments. For the years 1995 through 1997 the average tomato yield was low in comparison to the yield shown in most reports. The yield variance among treatments and years was negligible. The highest fruit yield, 27.3 t/ha for the N1 treatment was observed in 1997. In this experiment, the low yield and urea-N use efficiency can be primarily attributed to unbalanced applied fertilizers in the trickle irrigation system. The highest urea-N use efficiency was 12.3% for the fertigation N1 treatment in 1997. In the 1998, a repetition of the experiment with increasing K rates for all treatments at the same experimental site, led to a considerable increase in yield and urea-N use efficiency as compared to previous years. The tomato fresh fruit yield attained for N0, N1, N2, N3 and NS respectively 84, 76, 69, 36 and 26 t/ha. Based on the 14N/15N ratio analysis of the dry matter the urea-N use efficiency was 42, 25, 11 and 6 for the N1, N2, N3, and NS treatments, respectively. All N treatments under trickle irrigation and conventional furrow irrigation received on average a total amount of 6,536 and 12,286 m3/ha irrigation water (1996–1998). The total water use efficiency for the NS treatment was the lowest (24 kg/ha.cm) of all treatments and was the highest for the fertigation treatment N1 (51 kg/ha.cm) (1996 – 1997). The yield increase of the fertigation treatments enhanced the water use efficiency for 1998 as compared to 1996 and 1997. The overall water use efficiency was the lowest for the NS treatment (33.3 kg/ha.cm) and the highest for urea-N0 treatment (155.4 kg/ha.cm) and urea-N1 treatment (154.1 kg/ha.cm) for 1998. This investigation indicates that application of conventional quantities of fertilizers via trickle irrigation is not suitable. In the second phase (1999–2000) of this project, with the application of proper amounts and proportions of fertilizers plus microelements, it is expected to obtain better results.

1. INTRODUCTION

Sustainable high yield with high yielding crops depends entirely on the sustainable use of the limited sources of water and energy, specifically in developing countries with arid and semi-arid regions. This can only be attained with efficient use of water and fertilizers. Any increase in N use efficiency will increase the importance of N as crop production factor, increase farmers' profit, conserve energy and raw materials required to produce fertilizer N, and minimize any adverse effects on the environment resulting from inefficient N use [1].

Fertigation as an attractive technology in modern irrigated agriculture increases yield and fertilizer use efficiency [2]. It has been reported that with fertigation, N fertilizer use efficiency can be enhanced to 80–90% [2]. Through fertigation, water and nutrients are applied to the root zone of the crop, where they are mostly needed, normally resulting in a better water and fertilizer use efficiency than with conventional irrigation and fertilization methods. Furrow irrigation and broadcast or in-band fertilization is very common by farmers in Iran. Some research has been carried out on the application of fertigation of fruit trees with drip irrigation in Iran. Research need to be done on fertigation including row crops.

Four field experiments were conducted between 1995 and 1998 with the following objectives:

(i) comparison of urea fertilizer use efficiency between conventional in-band N application and fertigation with different concentrations of urea using the 15N methodology;

(ii) comparison of water consumption and water use efficiency by tomato under trickle irrigation and conventional furrow irrigation using the neutron scattering method; and

(iii) study of the response of tomato yield to different concentrations of urea fertigation and conventional in-band application.

2. MATERIALS AND METHODS

This study was conducted from 1995 till 1998 at the Nuclear Research Center for Agriculture and Medicine in Rajaie — Shahr, Karaj, about 60 km west of Tehran. The Center is located at an altitude of 1310 m, latitude 36N, longitude 51E, with an average of 250 mm annual rainfall and 13.6°C air temperature. The experimental site was situated at the foot steps of the Alborz mountains. The experimental field was on a sandy loam soil, which had been exposed to heavy soil erosion due to the rainfall of many years. Some physical and chemical characteristics of the experimental field and irrigation water are summarized in Tables I and II.

TABLE I. SELECTED CHARACTERISTICS OF THE SOIL AT THE EXPERIMENTAL SITE

Sand (%)	Silt (%)	Clay (%)	Total N (%)	O.M. (%)	P µg/g	K µg/g	E.C. dS/m	NO_3^--N µg/g
68	15	17	0.04	0.35	5.7	160	0.53	8.7

TABLE II. CHEMICAL CHARACTERISTICS OF IRRIGATED WATER

E.C. dS/m	pH	Ca meq/L	Mg meq/L	HCO3- meq/L	SO4 meq/L	Cl meq/L	Na meq/L	NO3- ppm	NH4 ppm
1.26	7.3	4.9	2.3	4.7	6.5	2.3	6	7	0.7

The following five treatments were replicated four times in a randomized complete block design:

1. Urea-N0= 0 mg N L^{-1} trickle fertigation
2. Urea-N1= 38 mg N L^{-1} trickle fertigation
3. Urea-N2= 76 mg N L^{-1} trickle fertigation (equivalent NS treatment)
4. Urea-N3= 114 mg N L^{-1} trickle fertigation
5. Urea-NS= 500 kg N ha^{-1} conventional fertilization/furrow irrigation.

In the second half of May of each year (1995–1998) tomato (Early Urbana VF) seedlings were planted in plots consisting of five and six rows for trickle and furrow irrigation, respectively. The distance between the rows was 100 cm. The experimental layout is shown in Fig 1.

2. 1. Irrigation schedule and moisture monitoring

In the trickle irrigated plots, drippers (one for each plant) were installed 50 cm apart from each other. The dripper discharge was 4 L/h. The rate of water applied was calculated on the basis of the evaporation rate from class A pan [2]. The amount of water was uniformly applied to all fertigation treatments. The furrow irrigated plots were irrigated according to the amounts that were recommended by the Ministry of Agriculture for this region [3]. Access tubes for neutron probe reading in all treatments were installed in duplicate to a depth of 100 cm below the drippers in the middle of the second row. Readings with the neutron gauge were taken before and after each irrigation at 30, 45, 60, 75 and 90 cm soil depth. Water consumption (ET) was calculated using the water balance approach [4]. Water use efficiency was calculated on the basis of the ratio of fruit — canopy dry matter weight to the amount of water consumed (Table VII and VIII).

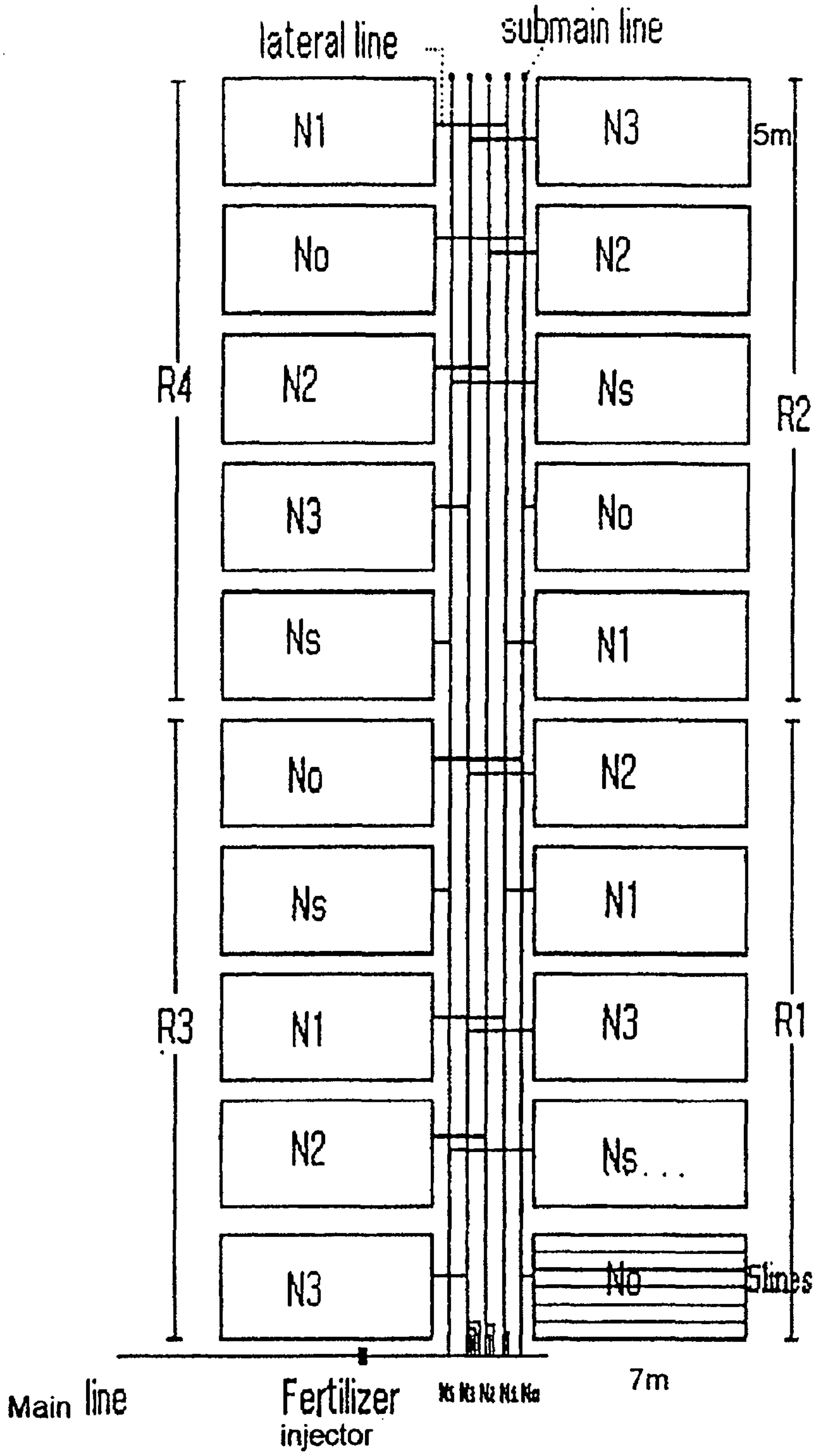

Fig 1. Experimental layout Karaj 1995–1998.

2.2. Fertilizer applications

For the 1995–1997 experiments, the amounts and forms of fertilizers used was in accordance with the recommendations for the region. The conventional NS treatment received 500 kg N/ha as urea in three stages (planting, flowering and fruiting) plus 345 kg/ha P_2O_5 as diammonium phosphate at planting and flowering, and 125 kg/ha K_2O as potassium sulfate at planting in band application. Six plants from the middle of each plot received 2% ^{15}N a.e. urea as isotope subplot.

On the trickle irrigated plots, the above-mentioned fertilizers were applied through the irrigation system by the use of two fertigators: one for the application of urea and the other one for the application of diammonium phosphate and potassium sulfate. Installed microtubes in the system [5] splitted the urea in three concentrations of 38, 76 and 114 mg N/L, respectively. Phosphorus and potassium were applied to all fertigation treatments at the concentration of 24 and 16 mg/L respectively. Six drippers in the middle row of each plot were blocked and the plants received 2% ^{15}N a.e. urea through bottles. The amount of water and fertilizers applied through the bottles was equivalent to the concentrations applied through a single dripper. In the 1998, the experiment was replicated by increasing the potassium level to 1200 kg/ha for the NS treatment and 190 mg/L for all fertigation treatments. All other manipulations were the same as in the previous years.

2.3. Sampling and analysis

During the experiment the mature fruit was harvested five times. Unripe fruit and the canopy were harvested at the end of the experiment. The collected samples from yield and isotope sub-plots were weighted, and the samples from the isotope sub-plot were dried at 70°C for 48 hours. Samples were ground to pass a 0.2 mm sieve. The total N analysis was done by the micro-Kjeldahl method and the ^{15}N abundance was measured by emission spectrometry [6].

3. RESULTS AND DISCUSSION

The effect of the conventional furrow irrigation — band fertilization and trickle fertigation method with different N concentrations of urea on the tomato fresh fruit and canopy yield for three years (1995, 1996 and 1997) is presented in Table III. Statistically significant differences in fresh fruit and canopy yield from the different treatments were not observed. However, in 1997, the fruit and total yield (fruit plus canopy) produced with the N1 and N2 treatments showed a positively significant difference as compared to the other treatments. The tomato fruit yield was equivalent to 27 t/ha for each of the N1 and N2 treatments. For unknown reasons, the fruit yield (15.9 t/ha) and total fresh yield (20.6 t/ha) from the NS treatment was lower as compared to the yield obtained during previous years.

The results from three years of experimentation indicate that the average fruit yield from the NS treatment (19.3 t/ha) was lower than the average fruit yield of 36.9 t/ha for the Tehran Province and the average fruit yield of 27.3 t/ha for the whole country. This difference might be related to the chemo-physical properties of the experimental site in addition to climatic variations among these sites.

The increased yield with the fertigation method in 1997, as compared to the previous years, could be because of a more uniform water distribution in that year resulting in an improved distribution of the fertilizer. Nonetheless, as Table III shows, the fruit (the highest yield of 27.3 t/ha belonging to the N1 treatment in 1997) and canopy yield in all three years were much lower than what is reported by other investigators [2,8]. The low yield in all fertigation treatments, being the basis of this research can primarily be due to the inappropriate balance between N and K. Anyhow, the considerably low yield with the fertigation method in 1996 and 1997 has an effect on the urea-N water use efficiency hence limiting any possible interpretation.

TABLE III. FRESH FRUIT, CANOPY AND TOTAL YIELD OF TOMATO (t/ha) FOR THE 1995, 1996 AND 1997 EXPERIMENTS

Treatments	1995			1996			1997		
	Fruit	Canopy	Total	Fruit	Canopy	Total	Fruit	Canopy	Total
Urea-N0	17.6a	5.2	22.8	14.9a	5.5	20.5	21.5b	4.2	25.7
Urea-N1	20.8a	5.6	26.4	20.5a	6.0	26.4	27.3a	7.3	34.6
Urea-N2	19.2a	7.3	26.5	20.3a	6.4	26.7	27.1a	6.4	33.5
Urea-N3	22.4a	5.6	28.0	18.1a	5.9	24.0	19.5b	6.9	26.4
Urea-NS	20.8a	5.2	26.0	22.3a	5.1	27.4	15.9c	4.7	20.6

Values in columns followed by the same letter are not significantly different at the 5% probability level.

TABLE IV. FRUIT, CANOPY, AND TOTAL DRY MATTER YIELD AND UREA-N UTILIZATION OF TOMATO IN 1996

Treatment	D.M. yield t/ha	Total N %	N yield kg/ha	Nddf %	F.N.Y. kg/ha	N.U.E. %
			Fruit			
N0	0.9a	3.14	28.3	-	-	-
N1	1.2a	3.69	44.3	34.9	15.5	6.2a
N2	1.2a	3.74	44.9	35.9	16.1	3.2ab
N3	1.3a	3.86	50.2	39.2	19.7	2.6b
NS	1.4a	3.22	45.1	25.5	11.5	2.3b
			Canopy			
N0	1.3a	2.27	29.5	-	-	-
N1	1.4a	2.44	34.2	30.1	10.3	4.1a
N2	1.5a	2.41	36.2	35.9	13.0	2.6b
N3	1.2a	2.70	32.4	48.9	15.8	2.1b
NS	1.3a	2.38	30.9	32.9	10.2	2.0b
			Total			
N0	2.2a	2.71	57.8	-	-	-
N1	2.6a	3.07	78.5	32.5	25.8	10.3a
N2	2.7a	3.08	81.1	35.9	29.1	5.8b
N3	2.5a	3.28	82.6	44.1	35.5	4.7b
NS	2.7a	2.80	76.0	29.2	21.7	4.3b

Values in columns followed by the same letter are not significantly different at the 5% probability level.

The tomato fruit and canopy dry matter yields (D.M.Y.) and urea-N utilization for 1996 and 1997 (data for 1995 are not shown) are given in Tables IV and V, respectively. Based on the 1996 and 1997 results, neither the fresh nor dry matter yield showed a significant difference. The fertigation N3 treatment with 3.86% for the fruit and 2.7% for the canopy in 1996 and the fertigation N2 treatment with 3.33% for the fruit dry matter in 1997 showed the highest total N as compared to the other treatments. The N percentages for total fruit and canopy dry matter were the highest for the N3 treatment with values equivalent to 3.28 and 3.04 for 1996 and 1997, respectively. The N0 treatment produced the lowest total N percentage (fruit and canopy) in all treatments.

The highest N uptake values (N yield kg/ha) were found with the N3 and N2 treatments. They were 50.2 kg N/ha and 53.3 kg N/ha for 1996 and 1997, respectively. The lowest N uptake was found with the N0 treatment being 28.3 and 32.2 kg-N/ha for 1996 and 1997, respectively. In 1996, the N uptake by the fruit for the NS and N2 treatments, which received an equal amount of N, was not statistically different. In 1997, for unknown reasons, the NS treatment gave the lowest N yield in comparison to other treatments. This low yield was statistically significant.

TABLE V. FRUIT, CANOPY, AND TOTAL DRY MATTER YIELD AND UREA-N UTILIZATION OF TOMATO IN 1997

Treatment	D.M. yield t/ha	Total N %	N yield kg/ha	Nddf %	F.N.Y. kg/ha	N.U.E. %
			Fruit			
N0	1.3a	2.48	32.2	-	-	-
N1	1.6a	2.93	46.9	37.3	17.5	7.0a
N2	1.6a	3.33	53.3	39.4	21.0	4.2b
N3	1.4a	3.29	46.1	44.1	20.3	2.7b
NS	1.0a	3.29	32.9	27.2	8.9	1.8c
			Canopy			
N0	1.0b	1.68	16.8	-	-	-
N1	1.7a	2.29	38.9	34.2	13.3	5.3a
N2	1.5a	2.43	36.5	38.8	14.2	2.8b
N3	1.4a	2.79	39.1	51.7	20.2	2.7b
NS	1.2b	2.46	29.5	33.2	9.8	2.0c
			Total			
N0	2.3b	2.08	49.0	-	-	-
N1	3.3a	2.61	85.8	35.7	30.8	12.3a
N2	3.1a	2.88	89.8	39.1	35.2	7.0b
N3	2.8a	3.04	85.2	47.9	40.5	5.4b
NS	2.2b	2.88	62.4	30.2	18.7	3.8c

. Values in columns followed by the same letter are not significantly different the 5% probability level.

The results obtained on the basis of the $^{15}N/^{14}N$ ratio analysis of the dry matter of the plant samples indicate that the %Ndff in fruit and canopy increased with increasing urea-N concentration (Tables IV and V). A higher N contribution was found from urea in all 1997 treatments as compared to the 1996 treatments. In 1997, the fertigation N3 treatment led to an uptake of 44.1 and 51.7% respectively in the fruit and canopy. Comparison between the N2 and NS treatments shows a slightly higher N uptake from urea in the N2 treatment than in the NS treatment, in both 1996 and 1997. However, this difference was not statistically significant.

The fertilizer N yield (F.N.Y. kg/ha) followed the same pattern as the %Ndff (Tables IV and V). An increase in N concentration caused an enhancement of the N taken up from the fertigation treatments. These values were higher for all treatments in 1997 than in 1996. Comparing the N uptake for the N2 and NS treatments, it was found that the fruit and canopy had a higher uptake for the N2 treatment than for the NS treatment. It was respectively 21 and 14.2 kg/ha for fruit and canopy for the N2 treatment while it was 8.9 and 9.8 kg N/ha for the NS treatment. These data refer to 1997.

The urea-N use efficiency (%N.U.E) for fruit, canopy and total are shown for 1996 and 1997 in Tables IV and V. A decrease in % N.U.E. for fruit and canopy were observed with increasing amounts of urea-N. The values showed a slight increase in 1997 relative to 1996, for all treatments. The N1 treatment produced the highest %N.U.E. for fruit and canopy in 1997 with values of 7 and 5.3%. This was statistically different from the other treatments. The urea-N use efficiency for total fruit and canopy was 12.3, 7.0, 5.4, 3.8% for respectively the N1, N2, N3 and NS treatments. The lowest N.U.E. was found for the NS treatment as compared with the N2 and the other fertigation treatments. This was statistically different. Papadopoulos [2] reports 80–90% N.U.E. in case of appropriate fertigation.

The low yield and N.U.E. for the 3-year experiment can be primarily attributed to low amounts of N and K fertilizers with an improper ratio between N and K. This inadequacy can be related to the proportions of nutrients in fertilizers used in conventional tomato cultivation. The theoretical basis for low application of K for conventional tomato cultivation has been based on the existence of a high reserve of K in Iranian soils [7]. However, this K is most likely not available to the crop when it is required. More over, the use of secondary nutrients and micronutrients is not at all popular in the conventional cultivation procedure. As a result, it is impossible to reach an optimum yield as compared with the fertigation method.

Bar-Yosef and Sagev [8] applied 1,090 kg N/ha with a ratio of 10(N): 0.9(P): 14(K) along with micronutrients and without microelements for which they found a production of 112 t/ha and 76 t/ha tomato fruit, respectively. Papadopoulos [2] reported an appropriate concentration (150–180, 30–50, 200–250 g m^{-3} of N-P-K) in the irrigation water for tomato fertigation. In another report [9] he points out that K absorption by tomato is equivalent to 1600 kg/ha. Burt et. al [10] reports that the required range of K varies from 700–1,100 kg/ha. The same authors report that, for healthy plants, the ratio of N/P is approximately 10 and N/K is approximately 1. Considering the results of the 3-year experiment and other reports indicating the requirement of more N and K for tomato fertigation in the experimental field, we feel determined to perform an investigation based on previous investigations in 1998.

The comparative results obtained from four years (1995–1998) are presented in the Figs. 2, 3, 4, 5, 6 and 7. As it is shown in Fig. 2, a fresh fruit yield of 84, 77, 69, 36 and 26 t/ha and a total fresh yield of 95, 98, 89, 50 and 35 t/ha were obtained for the N0, N1, N2, N3 and NS treatments respectively, in 1998. The fresh fruit yield of the N2 treatment was 2.5 times more than that of NS treatment. The total dry matter yield shows the same pattern, being equivalent to 9, 9, 8, 5 and 3 t/ha for the respective treatments (Fig. 3).

The total N percentage of the dry matter for the respective treatments was 2.5, 2.7, 2.8 and 2.6. However, it was not statistically different between the N2 and NS treatment. The N percentage of the fruit dry matter was higher than of the canopy. The N taken up (N-yield kg/ha) by the total dry matter for the respective treatments was 224, 243, 223, 138 and 86 kg/ha. The value for N2 was 2.5 times higher than for NS.

The % N derived from the urea fertilizer (Ndff), based on the $^{14}N/^{15}N$ ratio in the dry matter, indicates a slightly higher N uptake from urea in the fruit than in the canopy, (Fig. 4, 5). The Ndff was 43, 54, 63, and 37 for N1, N2 N3 and NS, respectively. This share of urea-N is 1.5 times more for N2 than for NS. There is an indication of increasing %Ndff in the fertigation treatments along with the increasing N input.

The N use efficiencies (%N.U.E) were 42, 25, 11 and 6 for the N1, N2, N3 and NS treatments, respectively (Fig. 7). The N.U.E in the N2 treatment was more than four times higher than in the NS treatment. This indicates that the increasing amount of K not only caused an increase in yield but also enhanced the N.U.E. for the fertigation treatments in 1998 as compared to the previous years. As already pointed out, appropriate fertigation regimes, adjusted to the soil fertility, can enhance the fertilizer use efficiency, particularly that of N, up to 80–90%. Evidently the amount of water allocation should be based on the actual crop water requirements [2].

All N treatments under trickle irrigation received a total amount of 6,879 and 6,450 m^3/ha of irrigation water for respectively 1996 and 1997 (Table VI). Otherwise, under conventional furrow irrigation the amount of irrigation water applied was 10,928 and 12,250 m^3/ha for 1996 and 1997, respectively. As it is shown in Table VII the highest water consumption (ET) was 1,041 mm and 994mm with the conventional furrow irrigation treatment (NS) for 1996 and 1997, respectively. Comparing the N2 and NS treatments (both received the same amount of urea-N), N2 consumed on average 621 mm while NS consumed 1,017 mm of water (Table VI).

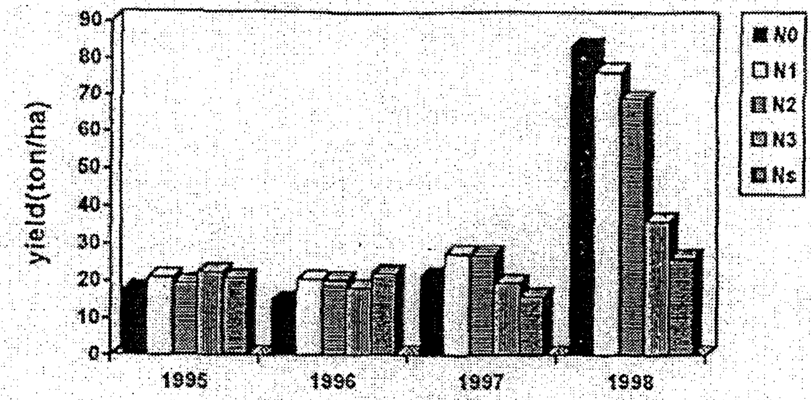

Fig.2. tomato fresh fruit weight

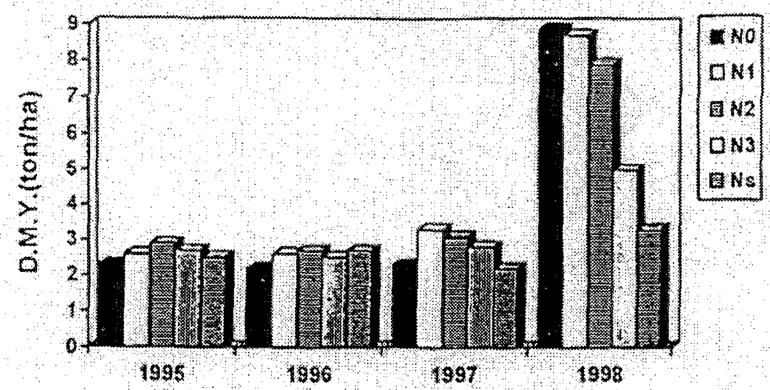

Fig.3. tomato total dry matter yield

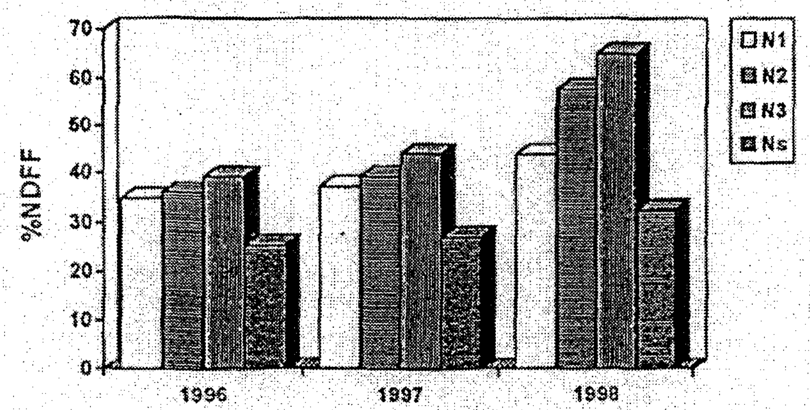

Fig.4. %NDFF for tomato fruit

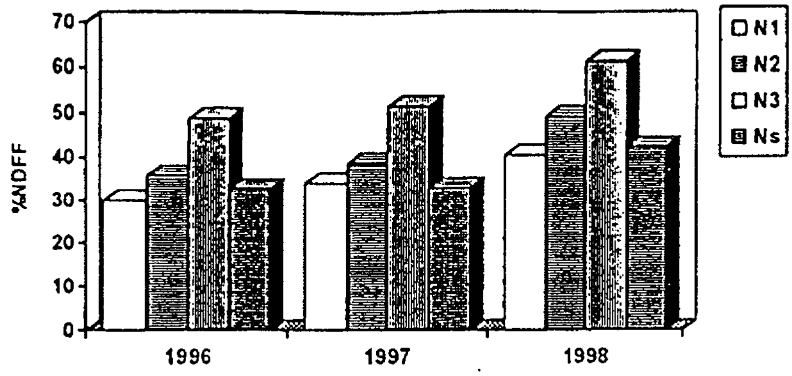

Fig.5. %NDFF for tomato canopy

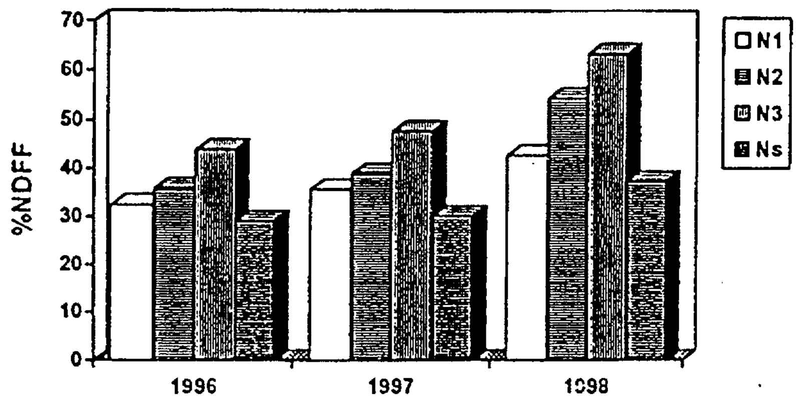

Fig.6. %NDFF for tomato total yeild

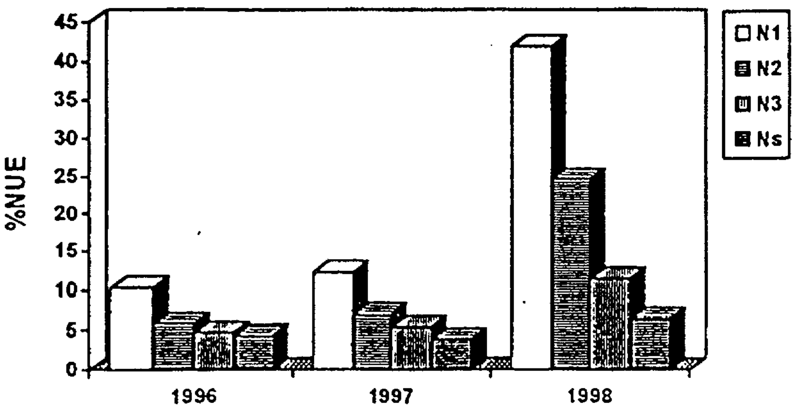

Fig.7. %NUE for tomato total yield

As it is shown in Table VII the mean total water use efficiency (1996–1997) was the lowest for the conventional furrow irrigation (24 kg/ha. cm). It was the highest for the N1 treatment (51 kg/ha.cm). In these two years the water use efficiency was low due to a general drop of yield in all treatments. Comparing N2 and NS the former, with 47 kg/ha. cm mean total water use efficiency proved to be superior to the latter treatment, with a mean total water use efficiency of 24 kg/ha.cm (Table VII).

The 1998 trickle irrigation treatments received 6281 m^3/ha water (Table VI), while the furrow irrigation treatment received 13,680 m^3/ha. From Table VIII it is clear that the fertigation led to an increased yield, indicating an enhanced water use efficiency. The total water use efficiency in the NS treatment was the lowest (33.3 kg/ha.cm), while the highest was found for the N0 and N1 treatments, respectively 155.4 kg/ha.cm and 154.1 kg/ha.cm. Comparing the N2 and NS treatments, the former with a total water use efficiency of 137.8 kg/ha.cm was superior to the latter with 33.3 kg/ha.cm (Table VIII).

TABLE VI. IRRIGATION WATER APPLIED ACCORDING TO CLASS A PAN AND RAINFALL FOR 1996–1997

Month	1996		1997		1998	
	Irrigation water (mm)	Rainfall (mm)	Irrigation water (mm)	Rainfall (mm)	Irrigation water (mm)	Rainfall (mm)
May	19.7	4	23.2	6	32.1	25.1
June	150.9	4	142	6.6	129.5	0
July	239.6	0.5	220	0.2	212.9	0.2
August	216.1	0	205.3	0	202.7	15
September	63.4	0	54.5	0	50.9	4.9
Total	687.9	8.5	645	12.8	628.1	45.2

TABLE VII. EFFECT OF IRRIGATION METHOD AND N RATES ON EVAPOTRANSPIRATION (ET) AND WATER USE EFFICIENCY (WUE) ACCORDING TO NEUTRON PROBE CALCULATION FOR TOMATO IN 1996–1997

Treatments	ET (cm)		WUE (kg/ha.cm)					
	1996	1997	1996			1997		
			Fruit	Canopy	Total	Fruit	Canopy	Total
Urea N0	65.4	52.9	13.8	19.9	33.6	24.6	18.9	43.5
Urea N1	64.1	54.0	18.7	21.8	40.6	29.6	31.5	61.1
Urea N2	64.8	59.4	18.5	23.1	41.7	26.9	25.2	52.1
Urea N3	65.7	61.8	19.8	18.3	38.1	22.6	22.6	45.2
Urea NS	104.1	99.4	13.4	12.5	25.9	10.0	12.1	22.1

TABLE VIII. EFFECT OF IRRIGATION METHOD AND N RATES ON EVAPOTRANSPIRATION (ET) AND WATER USE EFFICIENCY (WUE) ACCORDING TO NEUTRON PROBE CALCULATION FOR TOMATO IN 1998

Treatments	ET (cm)	WUE (kg/ha.cm)		
		Fruit	Canopy	Total
Urea-N0	57	90.3	65.1	155.4
Urea-N1	56.2	87.2	66.9	154.1
Urea-N2	57.3	75.0	62.8	137.8
Urea-N3	58.4	42.5	42.8	85.3
Urea-NS	98.5	16.7	16.6	33.3

4. CONCLUSION

An increased nutrient use efficiency and quality and quantity of crop production depends on the adequate and appropriate amount of macro and microelements with fertigation. Obviously, if this principal is not precisely followed, it will lead to a lower efficiency (trickle irrigation), lower quality and quantity of harvested product, lower fertilizer use efficiency and risk for environmental contamination. However, more technical assistance and local research is needed to obtain better results at the farm level.

ACKNOWLEDGEMENT

The authors would like to thank all those who contributed to this research, especially Mr. A-Khorasani, Mr. A. Mousavi Shalmani and Mr. H. Abassalian for technical assistance and analysis of the samples, and Mrs. L. Moharami Nejad for printing the report.

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