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In the name of Allah

INFLUENCES OF IRRIGATION INTERVAL, NITROGEN FERTILIZATION, AND PLANT SPACING ON TOMATO FRUIT YIELD AND QUALITY[1]

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ABSTRACT

The effects of 7- and 14- day irrigation intervals, three side-dressed N fertilizations, and 30, 40, 50, 60, and 70 cm plant spacings were studied on tomato fruit quantity and quality. Marketable fruit yield was significantly affected by all treatments and maximum yield was produced by a combination of 7-day irrigation interval, 125 kg/ha N side-dressing twice during the growing season, and 50-cm plant spacing.

Neither irrigation interval nor N fertilization significantly affected the number of seeds per fruit. However, palnt spacing was effective, with 50 cm being the optimum. While irrigation did not influence the total number of fruits and titratable acidity, both N fertilization and plant density affected these traits. When tomato plants received less water, soluble solids of fruit juice increased significantly. Highest percentages of soluble solids were found with two N side-dressings on 15300 plants/ha.

تحقیقات کشاورزی ایران
جلد دوم شماره اول ۱۳۶۲

بنام خدا

اثر دور آبیاری، کود ازته و فاصله بوته روی عملکرد و کیفیت میوه گوجه فرنگی

مرتضی خوشخوی و حمید آذرخش
بترتیب دانشیار و دستیار فنی بخش باغبانی دانشگاه شیراز

خلاصه

اثرات دورهای آبیاری ۷ و ۱۴ روز، سه نوع کوددهی ازته و فاصله بوته ۳۰، ۴۰، ۵۰، ۶۰ و ۷۰ سانتیمتر بر روی کمیت و کیفیت میوه گوجه فرنگی مورد مطالعه قرار گرفت. عملکرد میوه های قابل عرضه به بازار بطور معنی داری تحت تاثیر این تیمارها قرار گرفت و بالاترین میزان محصول توسط دور آبیاری ۷ روز همراه با دو بار کوددهی ازته هر بار بمیزان ۱۲۵ کیلو در هکتار و با فاصله بوته ۵۰ سانتیمتر بدست آمد.

دور آبیاری و کوددهی اثری بر روی تعداد بذر در هر میوه نداشت ولی فاصله بوته بر روی این صفت موثر و فاصله مطلوب ۵۰ سانتیمتر بود. در حالیکه دور آبیاری بر روی تعداد کل میوه و میزان اسید تیتره شده اثری نداشت، کود ازته و تراکم بوته بر این عوامل موثر بودند. هنگامیکه بوته های گوجه فرنگی آب کمتری دریافت داشتند، میزان مواد جامد افشره میوه بطور معنی داری بالا رفت. بالاترین درصد مواد جامد با دو بار کود ازته دادن و در ۱۵۳۰۰ بوته در هکتار بدست آمد.

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the promising crops for intensive production practices including an adequate supply of water, a high rate of fertilization, and an increase in plant density. Meeting the nutrient requirements is an urgent matter if large quantities of high quality tomatoes are to be produced effectively and efficiently year after year. Of the nutrient elements applied, N is often added in the largest amount and most often during growing season. As N is prone to leaching and denitrification, it is desirable to apply it gradually when needed.

Irrigation and N fertilization not only affect tomato fruit yield, but may also influence fruit quality and general appearance, factors of prime importance in shelf life and consumer acceptance (2). However, marketable tomato fruit yields are influenced more by applied N than by irrigation (2).

On the other hand, as tomato plant densities increase, yield per plant decreases and there is a trend towards smaller fruits with decreased number of flower cluster, flowers per cluster, and percent fruit set (9).

Several experiments have been conducted with tomatoes in regards to irrigation, fertility, and plant spacing (2, 5, 6, 7). Generally, high fertilization and close spacing increased yield but reduced fruit size. Irrigation partially alleviated the reduced fruit size in close-spaced planting and improved color of the ripe fruits.

To our best knowledge, no published report is available on the effects of irrigation intervals, N fertilization, or plant spacings on tomato fruits under the climatic conditions of Iran. Thus the present investigation was undertaken to determine the effects of these factors.

MATERIALS AND METHODS

The experiment was conducted at the Bajgah Experimental Station of Shiraz University, College of Agriculture, 15 km north of Shiraz, Iran. The soil of this location is classified as Calcixerollic Xerochrept and its texture is silty clay. The soil of the experimental site had a pH of 7.8 (saturated paste) and contained 2.08% organic matter. Prior to planting, 250 kg/ha ammonium diphosphate (18% N and 19.8% P) was uniformly broadcasted over the soil. To control weeds, treflan (48% active ingredient) at the rate of 2 lit/ha was thoroughly sprayed on the soil and both fertilizer and herbicide were then disked into the soil. Further weeding was practiced by hand hoeing during the growing season.

Variables were arranged in four replications of a split-split-plot design with soil water regimes as the main plots, N fertilization treatments as the sub-plots, and plant spacings as the sub-sub plots. Each plot consisted of three 6-m rows each with 80-cm width and separated by a 50 cm furrow. Tomatoes were planted in one side of the row with the appropriate plant spacing of each density treatment. Data obtained from the central row of each plot after discarding 1 m from each end, were used for statistical analyses.

The seeds of tomato (*Lycopersicon esculentum* Mill. cv. Red Cloud) were sown in a cold frame. Seedlings were transplanted on May 15, 1982 to the field. Tomato plants were not either stalked or pruned. After keeping the soil wet for about 2 weeks, by furrow irrigation, to allow the young plants to get established, the irrigation treatments, 7- and 14- day intervals, were applied. The amount of water was measured by means of a Parshal Flume. The depths of applied water during the growing season were 89.0 and 45.5 cm for 7- day and 14- day irrigation

intervals, respectively.

The N fertilization treatments consisted of side-dressing the following amounts of N fertilizers beyond that provided by ammonium diphosphate prior to planting: a) None (no further N fertilizer was applied), b) 250 kg/ha urea (46% N) applied as soon as the transplants were established, and c) 125 kg/ha urea applied as soon as the transplants were established, and again the same amount side-dressed just before flowering. The soil was irrigated immediately after N fertilizer applications.

Plant density treatments involved plant spacings of 30, 40, 50, 60, and 70 cm on the rows which were roughly equivalent to densities of 25600, 19200, 15300, 12800, and 11000 plants/ha.

Marketable red fruits were harvested from August 7, 1982. Notes were taken for number of days to flowering, total number of fruits harvested, total fruit weight, average fruit weight, number of seeds per fruit, pH, titratable acidity, and soluble solids of the fruit juice. To obtain the juice, four randomly selected fruits of each treatment were used to prepare the slurry. The pH of each sample slurry was measured by an electronic pH meter. Acidity was determined by diluting 10 ml of the slurry to 50 ml of distilled water and titrating with 0.1 N NaOH. Phenolphthalein was used as an indicator. The results were expressed as grams of citric acid per ml of the slurry. A hand refractometer was used to measure percent soluble solids.

Data were subjected to variance and regression analyses and mean comparisons were performed using Duncan's new multiple range test (3).

RESULTS

Number of Days to Flowering

Number of days to flowering was not significantly affected by irrigation intervals, N fertilizer treatments, plant densities, or either of their interactions.

Total Furit Number

Irrigation interval had no influence on the total fruit number harvested from each treatment plot. However, both N fertilizer and plant spacing greatly affected total fruit number (Fig. 1). Highest number of fruits were

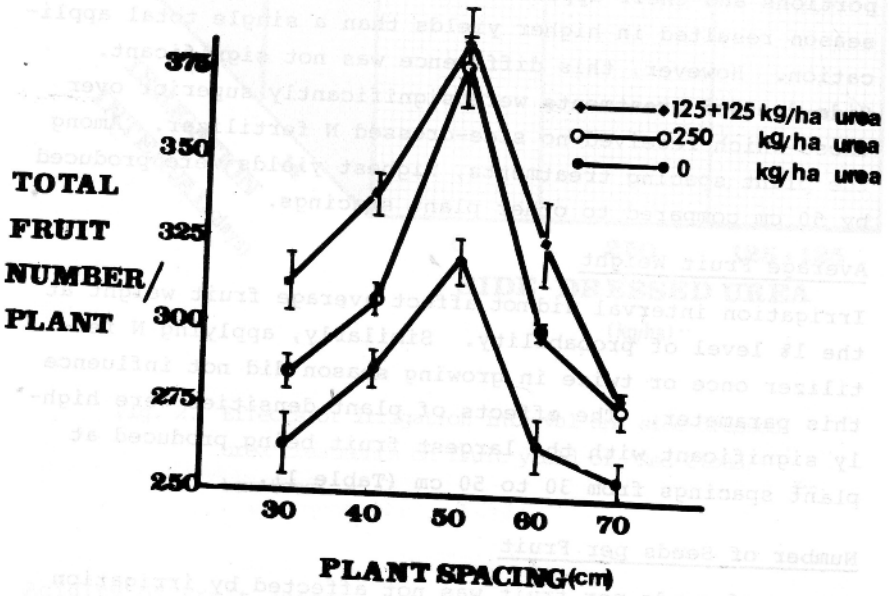

Fig. 1. Effects of plant spacing and side dressed urea treatments on total number of fruits per plant of 'Red Cloud' tomatoes.

obtained by side-dressing N fertilizer twice and at the 50-cm plant spacing (15300 plants/ha). All interactions, excluding irrigation x fertilizer x density, were significant.

Marketable Yields

Marketable tomato yields were highest with a 7-day irrigation interval, application of N fertilizer twice in the growing season, and plant spacing of 50 cm (Fig. 2). Weekly irrigation of tomato plants resulted in the production of approximately 40 tons/ha and this was significantly different ($P < 0.01$) from biweekly irrigation which produced about 33 tons/ha. Dividing 250 kg/ha urea in equal portions and their application twice during the growing season resulted in higher yields than a single total application. However, this difference was not significant. Side-dressed treatments were significantly superior over those which received no side-dressed N fertilizer. Among the plant spacing treatments, highest yields were produced by 50 cm compared to other plant spacings.

Average Fruit Weight

Irrigation interval did not affect average fruit weight at the 1% level of probability. Similarly, applying N fertilizer once or twice in growing season did not influence this parameter. The effects of plant densities were highly significant with the largest fruit being produced at plant spacings from 30 to 50 cm (Table 1).

Number of Seeds per Fruit

Number of seeds per fruit was not affected by irrigation interval or N fertilization but the effects of plant spacings and all interactions, excluding N fertilizer x density, were significant. Average number of seeds per fruit for 30, 40, 50, 60, and 70 cm plant spacings was 76.3, 74.0, 87.7, 72.9, and 64.8, respectively.

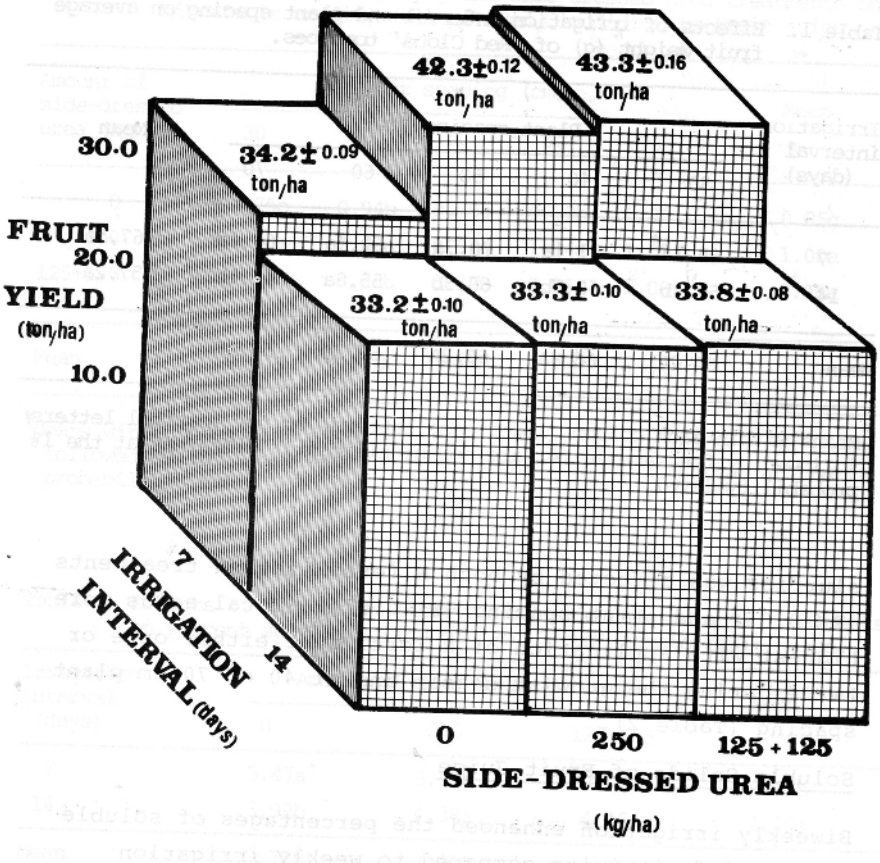

Fig. 2. Effects of irrigation interval and side-dressed urea treatments on fruit yield of 'Red Cloud' tomatoes.

Acidity of Fruit Juice

While no significant differences were found among the means of different treatments for pH, total acidity of the

Table 1. Effects of irrigation interval and plant spacing on average fruit weight (g) of 'Red Cloud' tomatoes.

Irrigation interval (days)	Plant spacing (cm)					Mean
	30	40	50	60	70	
7	69.1a*	71.1a	70.3a	61.0a	66.1a	67.5a
14	59.4b	62.7b	60.3b	55.8a	48.1b	57.2a
Mean	64.2A	66.8A	65.2A	58.3B	57.1B	

*Means within each column (lower case letters) or row (capital letters) followed by the same letter are not significantly different at the 1% probability level.

slurries was affected by both N fertilization treatments ($P < 0.05$) and plant spacing ($P < 0.01$). Total acids were highest with application of N fertilizer either once or twice during the growing season and at 40 or 70 cm plant spacing (Table 2).

Soluble Solids of Fruit Juice

Biweekly irrigation enhanced the percentages of soluble solids of fruit juice compared to weekly irrigation (Table 3). Similarly, applying N fertilizer twice in the growing season resulted in higher percentages of soluble solids than side-dressing N fertilizer once in the growing season. Differences among plant density treatments were not significant.

DISCUSSION

Under the conditions of this experiment, it was shown that marketable fruit yield of 'Red Cloud' tomatoes was significantly increased proportionately with a higher level of

Table 2. Effects of plant spacing and side-dressed urea treatments on titratable acidity (ml) of 'Red Cloud' tomato fruit juice.

Amount of side-dressed urea (kg/ha)	Plant spacing (cm)					Mean
	30	40	50	60	70	
0	0.75c*	0.94b	0.79c	0.92b	0.83	0.85c
250	0.93a	1.03a	0.95a	1.04a	1.05	1.00a
125+125	0.85b	0.93b	0.87b	0.86c	1.00	0.90a
Mean	0.84D	0.97A	0.87C	0.94B	0.96A	

*Means within each column (lower case letters) or row (capital letters) followed by the same letter are not significantly different at the 1% probability level.

Table 3. Effects of irrigation interval and side dressed urea treatments on percent soluble solids of 'Red Cloud' tomato fruit juice.

Irrigation interval (days)	Amount of side-dressed urea			Mean
	0	250	125+125	
7	3.47a*	3.53b	3.57b	3.52b
14	3.92b	4.38a	4.45a	4.29a
Mean	3.72B	3.96A	4.01A	

*Means within each column (lower case letters) or row (capital letters) followed by the same letter are not significantly different at the 1% probability level.

water. This is in agreement with data presented in previous reports (1, 2). Bower *et al.* (1), working with 'Tropic' tomatoes showed that when soil water tension in the root zone was maintained below 0.2 bar, the yield of marketable fruit was 17% higher than when tension was maintained below

0.4 or 0.6 bar. Similarly, Doss *et al.* (2), reported that even at the locations where tomatoes were not irrigated, irrigation when 70% of available soil water was removed, increased total marketable tomato yields.

In the present experiment, the increase in tomato yield was associated with lower percentages of soluble solids in fruit juice. This may have been due to reductions in C/N ratio in plants and as a result, higher irrigation did not affect fruit number but larger fruits with diluted juice were produced, while in lower irrigation, smaller size fruits with high percentages of soluble solids were obtained. Production of larger fruits by irrigation was previously reported (2).

One of the major problems in N management is that of N losses by leaching and denitrification. The beneficial effect of applying the same amount of fertilizer twice during the growing season was clearly shown in the present experiment. Gomes-Lepe and Ulrich (4) showed that fresh and dry weights of tomato roots and shoots increased progressively with nitrate nitrogen supply. Another study revealed that yields were influenced more by applied N than by irrigation (2). Since in our experiment the interaction of irrigation by N fertilization was highly significant, it seems advisable to adjust the rate of N fertilization with the amount of available water for higher yields. On the basis of recorded data, it may be recommended that for 'Red Cloud' and possibly other tomato cultivars, N fertilizer should be applied twice rather than once during the growing season if other growth requirements are met.

Maximum marketable 'Red Cloud' tomato yield was obtained with plant spacing of 50 cm. On the other hand, Wilcox (8) showed that on a single harvest of 'C-17' tomatoes, plant spacings of 15 to 30 cm in the single rows and from 15 to 50 cm in the twin rows produced maximum total fruit weights

(ripe and green fruits). Cultivar differences and harvest method may be responsible for this discrepancy.

It was notable that while irrigation and N fertilization affected fruit yields, they were not effective in increasing seed number per fruit. It seems that this trait is little affected by environment and is a characteristic of each specific cultivar. However, other seed characteristics, such as seed vigor or vaiability may be highly influenced by environmental conditions.

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