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Effect of Different Levels of Nitrogen Fertilizer with Two Types of Bio-Fertilizers on Growth and Yield of Two Cultivars of Tomato (*Lycopersicon esculentum* Mill)

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Abstract: An experiment was conducted to study the effect of different rates of nitrogen (N) fertilizer with two types of bio-fertilizers (0, 125, 75, 225, 125 plus Super Nitro and 125 kg N h^{-1} plus Nitroxin bio-fertilizer) and two cultivars (Super Chief and Super Beita) on growth and yield of tomato, at a field Andimeshk, Khuzestan Iran, during 2006. The experiment design was randomized complete block design arranged in split plot, with three replications. During of study, were measured some of vegetative and reproductive characteristics such as seedling emergence time, plant height, leaf number, leaf number below the inflorescence, flowering time in the first inflorescence, flowers and fruits number per the first inflorescence, fruit mean weight, fruit number per plant and fruit yield. Results indicated that there were significant differences between N level and most of characteristics such as plant height, leaf number, fruit number per the inflorescence, fruit number per plant, fruit mean weight and fruit yield and bio-fertilizers affected the growth parameters such as seedling emergence time, plant height, leaf number, fruit mean weight and fruit yield but they have not significant effect on flowering time, flower and fruit number per the first inflorescence and fruit number per plant. Also there was significant differences between the cultivars in seedling emergence time, plant height, flowers and fruits number per the first inflorescence, fruit mean weight and fruit yield. The maximum yield was accomplished when Super Beita cultivar received 225 kg N h^{-1}.

Key words: Nitrogen, yield, tomato, super nitro plus, nitroxin

INTRODUCTION

Tomato is one of the most popular and widely grown vegetable crops in the world. The tomato crop is highly responsive to nitrogen (N) fertilizer application where N availability may be limited and time of the application is critical (Taber, 2001).

Nitrogen is a one of the major elements for plants growth and development that have an important role in plant nutrition and therefore is the yield-limiting factor for plant growth in many areas especially in low organic soils. N fertilizers often are mobility in soils and they can pollution soils and groundwater. Therefore, management N fertilizer such as rate, type of N fertilizer, application time is very important (De Pascale *et al*., 2006).

Akanbi *et al.* (2003) reported that N fertilizer influence leaf number per plant, plant height, fruit number per plant, fruit mean weight and total yield per plant in tomato crops. Ruiz and Romero (1998) studied tomato cultivars and found that cultivars have significant effect on yield and Bufalo cultivar and Nancy cultivar, respectively had a least and greatest yield.

Bio-fertilizers are eco-friendly inputs and are less damaging to the environment chemical fertilizers use (Gentili and Jumpponen, 2006). El- Zeiny *et al.* (2001) indicated that inoculation of tomato seedling with bio-fertilizer containing Azotobacter and Azosperillium, Bacillus, increased plant height, leaf number per plant, fruit mean weight and yield in compare to control (without bio-fertilizer). Khalequzzaman and Hossain (2007) showed bio-fertilizer application increased germination, plant height and yield of bush bean. Subramanian *et al.* (2006) reported that bio-fertilizer increased flower and fruit number per plant and yield of tomato.

Cultivar is another factor that is important for tomato production. The high production acquired with adapted cultivar to environmental condition and suitable seed.

This study aimed to evaluate the effect of different N rates applied as urea and two bio-fertilizers on growth and yield of two cultivars of tomato which may help in predicting the optimal N fertilizer requirement and to improve the practices of tomato production.

MATERIALS AND METHODS

The experiment was conducted in a field of the Environs of Andimeshk city (The climate was semiarid), Khuzestan, Iran, during cropping season of 2006. The

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experimental field was cleared, ploughed, harrowed and divided into plots. The soil texture at the experimental site was loam with approximately 1.69% organic matter, pH 7.6, EC 1.0 dS m^{-1}. The 0-30 soil layers contained, respectively 0.56% total N, 24.8 ppm available phosphorous and 510 ppm available K. The experimental design was a split plot fitted to randomized complete block. The treatments included four N rates and two bio-fertilizers (N_1 = 0, N_2 = 125, N_3 = 175, N_4 = 225, N_5 = 125 plus seed inoculation with Super Nitro Plus bio-fertilizer, N_6 = 125 kg N kg ha^{-1} puls seed inoculation with Nitroxin bio-fertilizer) as the main plot and two tomato cultivars (Super Chief (A_1) and Super Beita (A_2)) as the sub-plot.

Before sowing, phosphorous (P_2O_5) and poultry manure were applied at a rate of 100 kg ha^{-1}, 20 t ha^{-1}, respectively. On the 20th January 2006, tomato seeds were sown in main field under plastic tunnels for chilling protection (at first of cropping season). All recommended cultural practices such as irrigation, removal of weeds and plant protection were adopted uniformly according to standard crop requirements. Weeds were manually controlled. N fertilizer was applied and split into three applications (7, 11 and 15 weeks after seeds sowing). The form of N fertilizer used was urea (46% N) and two liquid bio-fertilizers Super Nitro Plus (containing mixture of bacteria of the genus Pseudomonas fluorescens, *Azospirillium* sp. and *Basillus subtilis*) and Nitroxin (containing mixture of bacteria of the genus *Azotobacter* sp. and *Azospirilium* sp.). At first seeds inoculated with this bio-fertilizer in 15 min and then dried in shade condition, then sown as other seeds (without inoculation). Tomato fruit were hand-harvested at the color breaker stage and at 4 times with 10 days intervals. Statistical analysis of experimental data were conducted using the SPSS software package and the means were separated following ANOVA by Duncan's multiple range test at $p<0.05$.

RESULTS

Seedling emergence time: Result showed that there is an effect of the two bio-fertilizers on seedling emergence time was significant. Comparison of mean value indicated all treatments without bio-fertilizer (containing N_1, N_2, N_3 and N_4 in sowing time) was higher in respect to N_5 and N_6 treatments (Table 1). N_5 treatment had shortest time for emerging. Khalequzzaman and Hossain (2007) reported similar result in bush bean. The effect of cultivar on seedling emergence time was significant. Super Beita cultivar (11.3 day) required a more time seedling emergence than Super Chief cultivar (9.6 day). Seed germination rates are sensitive to genetic, environmental and physiological factors. Dahal and Bradford (1990) indicated that the germination of tomato seeds of cultivar T5 to those of rapidly germinating genotypes PI 341988 and PI 120256.

Leaf number below the first inflorescence: The effect of fertilizer N levels (urea with two bio-fertilizer)on leaves number below the first inflorescence was significant and comparison of mean value (Table 1) indicated N_5, N_1 and N_2 rates had the least value, while N_2, N_3 and N_4 rates had the greatest leaf number. But low leaf number was shown in control and bio-fertilizers treatments. Also, among cultivars and interaction between cultivars and N fertilizer levels did not show any significant differences (Table 1). However leaf number below the first inflorescence is related to genetic control more than environmental factors (Wien, 1997).

Plant height (84 days after emergence): N fertilizer application at all levels increased plant height by 30.7-56.1 cm. The highest level of N fertilizer (225 kg N ha^{-1}) produced the tallest plants, while the shortest plants formed by the control (without N) treatment. However, no significant difference was found between two treatments: 175, 225 kg N ha^{-1}. But bio-fertilizer treatments (N_5 and N_6) produced higher plant height compare to non treated (N_2) (Table 1). These results coincide with that obtained by Akanbi *et al.* (2003) and Bhaskara Rao and Charyulu (2005). The two cultivars were differed significantly in plant height (Table 1). Super Beita cultivar was taller than Super Chief cultivar. Similar results have been reported in investigations conducted by Babu *et al.* (2000).

Table 1: The simple effect of N fertilizer levels and cultivars on mean of characters some of tomato vegetative growth

Treatments	Time of seedling emergence (days)	Leaf No. below the first inflorescence	Plant height 84D (cm)	Leaf No. 84D
Fertilizer				
N_1	10.6a*	7.0b	36.7d	17.4d
N_2	10.5a	7.6a	42.3c	18.8c
N_3	10.9a	7.5a	55.4a	26.0a
N_4	10.5a	7.5a	56.1a	26.9a
N_5	9.8c	6.9b	45.1bc	21.9b
N_6	10.2b	7.1b	47.4b	21.2b
Cultivar				
A_1	9.6b	7.3a	45.9b	22.2a
A_2	11.3a	7.2a	48.5a	21.2a

Different letter(s) within a column indicates a significant difference by Duncan's multiple range test, p = 0.05. 84D- 84 day after emergence

Table 2: Simple effect of fertilizer and cultivar on characteristics related with yield

Treatments	Emergence time of of first inflorescence	Flower No. per first inflorescence	Fruit No. per first inflorescence	Fruit No. per plant	Fruit mean weight	Plant yield
Fertilizer						
N_1	57.3a*	4.6a	3.2c	16.3d	104.1d	1714e
N_2	58.7a	4.8a	4.0b	29.0c	106.9cd	3109d
N_3	58.7a	4.8a	4.7b	35.0b	114.7ab	4009b
N_4	57.3a	5.0a	4.2a	41.4a	115.5a	4796a
N_5	58.1a	4.6a	3.9b	30.1c	112.0ab	3365c
N_6	58.3a	4.4a	3.8b	28.7c	110.6bc	3186cd
Cultivar						
A_1	57.5a	5.0a	3.7b	29.9a	102.9b	3115b
A_2	58.3a	4.4b	4.3a	30.2a	118.4a	3611a

*Different letter(s) within a column indicates a significant difference by Duncan's multiple range test, p = 0.05

Leaf number per plant (84 days after emergence): Fertilizer N levels (urea with two bio-fertilizers) significantly affected on leaf number. The highest leaf number was related to the fourth treatment (225 kg N ha^{-1}) while the lowest was related to the control treatment. However, no significant differences were found between three levels, namely 175 and 225 kg N ha^{-1} (Table 1). Gulser (2005) also reported that increments in the nitrogen rate of the fertilizers increased the number of leaves in spinach, but these increases were not statistically significant. Karic *et al.* (2005) applied four nitrogen levels (0, 50, 100 and 200 kg N ha^{-1}) to leek culture and reported that the application of 200 kg N ha^{-1} resulted in a maximum number of leaves per plant (14.4).

Result also indicated effect of cultivar on leaf number was not significant whether more leaf number was observed in Super Chief cultivar.

Emergence time of the first inflorescence: Fertilizer N levels (urea with two bio-fertilizers) and cultivars did not significant affect on emergence time of the first inflorescence (Table 2). But comparison of mean value showed Super Chief cultivar requires a shorter emergence time of inflorescence. Dielen *et al.* (1998) showed that the flowering time of the mutant was always delayed as compared to normal cultivar.

Flowers number per the first inflorescence: The effect of fertilizer N levels (urea with two bio-fertilizers) on the flowers number per the first inflorescence did not show any. Among the tomato cultivars in this experiment about flowers number per the first inflorescence was significant and Super Chief cultivar had higher flowers per the first inflorescence compared Super Beita cultivar. Quinet *et al.* (2006) shown that the reproductive structure of tomato is a raceme-like inflorescence and genes regulating its morphogenesis.

Fruits number per first inflorescence: The effect of fertilizer N levels (urea with two bio-fertilizer) and cultivars on fruits number in first inflorescence was significant. And mean value showed that minimum and maximum fruits number in first inflorescence in control (3.29) and 225 kg N ha^{-1} (4.42), respectively was observed. Also, Super Beita cultivar (4.36) had higher fruits number in first inflorescence than Super Chief cultivar (3.76). Odanaka *et al.* (2002) shown that fruits number is controlled by plant genetics.

Fruits number per plant: The effect of fertilizer N levels (urea with two bio-fertilizers) on fruits number in plant was significant. Comparison mean was shown that minimum and maximum fruits number in plant in control (16.3) and 225 kg N ha^{-1} (41.4), respectively was observed. But between treatments N_2, N_5, N_6 were not significant. It is mean, bio-fertilizers did not effect on fruits number in plant, Aujla *et al.* (2007) reported that with increasing the rate of N fertilizer increased the fruits number in plant. Also effect of cultivar on fruit number in plant was not significant.

Fruit mean weight: Effect of fertilizer N levels (urea with two bio-fertilizers), cultivars and interaction between them on fruit mean weight was significant. Comparison of means showed that minimum and maximum fruit mean weight in control (104.1) and 225 kg N ha^{-1} (115.5), respectively was observed. And comparison of fruit means weight of cultivars was shown Super Beita (118.4 g) had higher fruit mean weight respect to Super Chief (102.9 g). Also minimum and maximum fruit mean weight was in Super Chief cultivar with control and Super Beita cultivar with 175 kg N ha^{-1}.

Plant yield: Application levels of N fertilizer increased plant yield, so that the effect of fertilizer N levels (urea with two bio-fertilizer), cultivars and interaction between them on plant yield was significant. And mean value comparison was shown that minimum and maximum plant yield were in control (1714 g) and 225 kg N ha^{-1} (4746 g), respectively. In general, the maximum plant yield obtained by maximum N fertilizer of application rates. Many researchers confirmed that commercial yield depends to

the N fertilizer of application rate. They were shown that fertilizer N levels affected not only quantity but also on quality of tomato fruit (De Pascale *et al.*, 2006; Parisi *et al.*, 2006). Super Beita cultivar with 3.611 kg had higher yield compare to Super Chief cultivar with 3.11 kg. The similar results obtained by Taber (2001). Sahoo *et al.* (2002) observed that cultivars with a fewer vegetative growth had fewer yield respect to cultivar with most vegetative growth. Maximum and minimum plant yield, respectively by 5068 and 1418 g in Super Beita cultivar with 175 kg N ha^{-1} and Super Chief cultivar with control was observed, this finding was coincide with Taber (2001) results.

DISCUSSION

Result of this study showed whereas application of 20 tons ha^{-1} poultry manure, N fertilizer is necessary for tomato growth, development and yield commercial. Severe N stress reduced tomato leaf area index, biomass and fruit yield by 60 to 70% (Scholberg *et al.*, 2000). With increased application N fertilizer rate from 0 to 225 kg N ha^{-1} resulted in tomato yield increase. The greatest yield of tomato obtained by application of 225 kg N ha^{-1}. With adequate N supply, 50 to 70% of the total N by the end of the season had accumulated in the fruit (Scholberg *et al.*, 2000). Shahlaei *et al.*, 2007 indicated that nitrate amount of overdose in some of fruiting bear vegetable observed. Application highest of N fertilizer levels may cause to increase nitrate accumulation in vegetable consumption organs (Sánchez *et al.*, 2004). Ram Rao *et al.* (2007) showed that the influence of VAM fungi and Bacterial Bio-Fertilizer (BBF) with 50% reduction in the recommended dose of (N and P) chemical fertilizers on leaf quality traits of mulberry variety (S-13). Dashti *et al.* (2007) indicated that application bio-fertilizer in plants compared to untreated plants, increased 48 and 40% of plant yield in a greenhouse and field experiment, respectively. For decreasing N fertilizer may be used bio-fertilizers. Application of bio-fertilizers such as Super Nitro Plus and Nitroxin influenced growth and yield, Super Nitro Plus (N_5) and Nitroxin (N_6) had 8.2%, 2.4% more yield than N_2 (without bio-fertilizer). So, result indicated this bio-fertilizer could reduce application of chemical nitrogen fertilizer, but this value increase at commercial yield was not considerable. Perhaps reason the high temperature during the fruit set and fruit development period exceeded 40°C, resulted confusion in the bacterial action.

CONCLUSIONS

- The best commercial yield obtained by application maximum N fertilizer
- Bio-fertilizers affected growth and yield of tomato. Overall, the plant growth and yield increased by bio-fertilizers inoculation in comparison to non inoculation treatments. But this value increase at commercial yield was not considerable
- The effect of cultivar on more parameters of growth, development and yield was significant and greatest yield obtained by Super Beita cultivar and 225 kg N ha^{-1}

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