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Effect of Drought Stress on the Yield, Glutamine Synthetase Activity and Protein Contents in Four Varieties of Tomato

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Abstract: The effect of drought stress was studied to determine the effect of different moisture stress levels on the yield, protein contents and the activity of glutamine synthetase, a key enzyme of ammonia assimilation in four tomato varieties i.e., Roma, Bunhong, Lyp-1 and Eva. Among four moisture stress levels (M_1, M_2, M_3 and M_4 at 40, 50, 60 and 70% depletion of available moisture). M_1 (40% depletion of available moisture) proved the best level for attaining the maximum yield of all the tested varieties. Among varieties, Lyp-1 gave the best yield at all moisture stress levels followed by Eva, Roma And Bunhong. Glutamine synthetse activity at flowering stage in the tested varieties was low at M_1 and $_{M2}$ but increased after irrigation application. It was high at M_3 and M_4 but decreased on rewatering. Protein contents of leaves at the flowering stage were low at the tested moisture stress levels before irrigation but increased after application of water.

Key words: Drought stress, yield, glutamine synthetise,yrotein, tomato

Introduction

Tomato *Lycopersicon esculentum* Mill. is cultivated world wide vegetable and condiment. It is a better source of nutrition as well as minerals and vitamins (Villareal, 1980).

Soil water is the most crucial factor in arid and semi-arid regions and yield potential is directly a function of water available for plant growth. Water plays a pivotal role in determining the yield of tomato (Rudich and Luchinsky, 1987) and under precise nutrient controlled condition, average yield is 200 tonnes/hectare (Van de Vooren *et al*., 1987).

Rudich and Luchinsky (1987) demonstrated that water requirement of tomato is affected by cultivation and precise irrigation scheduling is important to avoid stress (Phene *et al*., 1982).

Erdtmann (1986), reported that certain enzymes especially Glutamine synthase are affected by drought. Protein content usually falls under drought stress (Denial, 1976). Total fruit yield under water deficit (40% and 70% water deficit of full capacity) fell by 60-65% in less resistant varieties as against 40-50% more resistant varieties of tomato (Natarajan, 1990). The present study was undertaken to determine the effect of drought stress on the yield, Glutamine synthetase activity and protein contents of four varieties.

Materials and Methods

The experiment was laid out in glasshouse under complete randomized block design with three replicates. Four moisture stress levels were developed ranging from 40 to 70% depletion of available moisture. Plot size was 4x1.8 m and in each plot four tomato varieties viz, Roma, Bunhong, Lyp-1 and Eva were transplanted on ridges. Each ridge of plot contained 8 plants of the same variety and the distance from plant to plant was 45 cm. Before transplanting the tomato plants, Farm yard manure, N, P, K were applied at 5 tonnes, 200, 100 and 100 kg ha^{-1} respectively. Nursery of four tomato varieties were raised on July, 26, 1993 in separate plastic trays, containing 1:1 ratio of soil and FYM.

Herbicide "Stomp" was sprayed on wet soil on August 29, 1993 for proper transplantation. After transplantation, first two flat irrigations were applied to ensure proper establishment of tomato plants. Four moisture stress levels (M_1, $_{M2}$, $_{M3}$ and $_{M4}$ with 40, 50, 60 and 70% depletion of available moisture) were developed for respective plots under three replications.

Moisture depletion percentage was determined by taking soil samples, 0-15 and 15-30 cm from 4 different points of each plot and was determined by gravitational method (Atkinson *et al*., 1958). Moisture determination and water requirements were calculated by using the following equation and method proposed by Ahmed (1982).

$$Pm = \frac{Sw-sd}{sd} \times 10$$

Where, Pm = Percent moisture on dry wt bases
Sw = Weight of wet soil
sd = Weight of oven dried soil

The moisture percentage of water was converted into centimeters of water by using equation.

$$d = \frac{Pm \times As \times D}{100}$$

Where, d = centimeters of water
As = Apparent specific gravity or bulk density
D = Depth of soil column in centimeters

Water depth in centimeters was converted into cubic meters of water and then into liters by using the formula.

Volume of water to be applied = A (d/100) x 100
Where, A = Area in square meters (^{M2})
1000 = conversion factor

Irrigations were applied to the respective plot as soon as the desired stress was reached in the top 30 cm of soil.

The calculated quantity of water according to the specific moisture deficit level of soil was provided which restored the moisture level down 30 cm depth of field capacity schedule and delta of irrigation is reported in Table 1.

Saturation percentage and bulk density of soil were measured according to the method suggested by U.S. Salinity Laboratory Staff (1954), while field capacity and permanent willing point were determined by method proposed by Brown (1988).

Table 1: Schedule and delta of irrigation (L) for tomato (1993)

Moisture Depletion Level							
M_1		M_2		M_3		M_4	
Date	Delta	Date	Delta	Date	Delta	Date	Delta
26-9-93	98.49	26-9-93	98.40	26-9-93	98.49	26-9-93	98.49
13-10-93	98.49	3-10-93	98.49	3-10-93	98.49	3-10-93	98.49
13-10-93	99.70	15-10-93	123.40	19-10-93	150.97	24-10-93	172.91
21-10-93	103.33	24-10-93	123.30	31-10-93	151.20	6-11-93	173.66
28-10-93	112.08	1-11-93	122.60	1 1-1 1-93	147.75	23-11-93	173.75
6-11-93	1 1 8.01	10.11-93	124.20	21-11-93	148.40		
13-11-93	101.27	22-11-93	125.59				
20-11-93	97.92						
Total	829.29	816.07			795.30		717.30
Water applied	1152.0 mm	1135.0 mm			1105.0 mm		997.0 mm
No. of irrigations	8	7			6.0		5.0

M_1 = 40% depletion of available moisture, M_2 = 50% depletion of available moisture
M_3 = 60% depletion of available moisture, M_4 =70% depletion of available moisture

Table 2: Effect of moisture stress on yield (tonnes/ha.) of four tomato varieties

Varieties	M_1	M_2	M_3	M_4	Varietal mean
	Moisture Depletion Level				
Roma	13.73 CDE	11.53 EFG	8.88HIJ	7.54 J	10.42 C
Bunliong	10.43 FGHT	10.51 FGH	9.15 GHIJ	8.03 IJ	9.53 C
Lyp-1	23.65 A	22.90 A	14.90 DEF	13.84 CDE	18.82 A
Eva	16.48 B	14.57 B	12.31 C	11.45 EFG	13.70 B
Moisture mean	16.07 A	14.87 B	11.31 C	10.22 C	

LSD value = 2.246 at alpha = 0.01
Mean with the same letter do not differ significantly.
M_1 = 40% depletion of available moisture, M_2= 50% depletion of available moisture
M_3 = 60% depletion of available moisture, M_4 =70% depletion of available moisture

Table 3: Glutamine synthetase activity moles L-glutamic acid monohydroxarnate produced g^{-1} fresh wt. Leaves hr.) in 4 varieties of tomato at flowering and fruiting stages under different moisture depletion levels

Flower stage	Moisture Depletion Level			
irrigation Status	M_1	M_2	M_3	M_4
Before irrigation	1.23	0.79 C	1.38 AB	1:89.A
After irrigation	1.44 AB	1.03 BC	0.08 C	1.37 AB
LSD value = 0.3912 at alpha 0.01				
Moisture mean	1.34 AB	0.91 C	1.01 BC	1.53A
LSD value = 0.2766 at alpha 0.01				
Varieties				
	Roma	**BunHong.**	**Lyp-1**	**Eva.**
Irrigating stage	1.08 AB	1.04 AB	0.97 B	1.21A
LSD value = 0.1797 at alpha = 0.05				

Mean with the same letter do not differ significantly.
M_1 = 40% depletion of available moisture, M_2 = 50% depletion of available moisture
M_3 = 60% depletion of available moisture, M_4 =70% depletion of available moisture

Table 4: Protein content (mg/g fresh wt. Leaves) in tomato at flowering stage under different moisture depletion levels

Irrigation status	M_1	M_2	M_3	M_4	Varietal mean
	Moisture Depletion Level				
Before irrigation	1.68 A	0.30 B	1.35 A	1.40 B	1.43
After irrigation	1.83 A	1.85 A	1.7 A	1.44 B	1.70 A
LSD value = 0.2543 at alpha = 0.01					
Moisture mean	1.75 B	1.57 C	1.53 C	1.42	
LSD value = 0.1515 at alpha = 0.01					

Mean with the same letter do not differ significantly.
M_1 = 40% depletion of available moisture, M_2 = 50% depletion of available moisture
M_3 = 60% depletion of available moisture, M_4 =70% depletion of available moisture

For biochemical analysis of plant first two leaves of randomized plants from each plot were taken just before irrigation and then next two leaves, from the same plants after 48 hours of irrigation on flowering and fruiting stage. Glutamine synthetase activity in the leaf was measured according to Rowe *et al*. (1970) and protein by the method of Lowry *et al*. (1951).

Data collected were subjected to statistical analysis using the method given by Duncan (1955) Multiple Range and multiple F Test.

Results and Discussion

Effect of water stress on the yield of four tomato varieties: Yield data (Table 2) showed that decrease in yield was obtained with the increase in moisture stress.

Optimum yield of tomato varieties Lyp-1 and Eva of 23.65 and 16.48 tonnes/ha was recorded respectively when crop was subjected at M_1 (40% depletion of available moisture). Similar results were reported for potato tuber by Ahmed and Bhatti (1983).

But the yield of remaining two varieties i.e. Bunhong and

Roma was significantly low at same moisture level. Lyp-1 performed better in comparison with the remaining varieties at all moisture stress levels, ranging from 40-70% depletion of available moisture. These findings agree with that of Petresco and Frier (1983) who found that some tomato varieties were relatively drought resistant at various soil moisture percentage during green house and field trials. There are possibilities for control of plant water status to optimize yield quantity and quality of tomato (De Koning and Hurd, 1983). Effect of water stress on the glutamine synthetase activity. Results (Table 3) indicate that GS activity is affected by moisture stress levels and sampling time i.e before and after irrigation application. In all the tested varieties GS activity at the flowering stage, before irrigation application under M_1 and M_2 (40 and 50% depletion of available moisture) was low as was found for with-holding irrigation in mungbean by Kaur *et al*. (1985) and it increased after irrigation application. At M_3 and M_4 (60 and 70% depletion of available moisture) before irrigation GS activity at this stage, was high but decreased on rewatering. Similar findings were reported by Erdtman (1986) at fruiting stage, the interaction among moisture depletion levels and sampling time was insignificant but varieties showed different GS activity. It was highest in Eva and the lowest in Lyp-1. This observation is in agreement with the findings of Reddy and Veeranjaneyulu (1990) that may be attributed to the assimilation of ammonia. While the decrease may be related to decrease in the glutamine content in the stress treatments (Reddy *et al*., 1990) for horsegram.

Effect of water stress on the protein content: At flowering stage, the protein content (Table. 4) (mg/g fresh wt. Leaves) reveals that there is no significant correlation between varieties and moisture stress levels and among the varieties. Protein contents are low before irrigation but increased on rewatering. Similar results heave been reported in Pera Quibor and Reo Grande by Castrillo and Calcagno (1989). The increase in protein content on rewatering is related to the findings of Tymms (1979) in *Xerophyte villosa* that may be due to increase in protein synthesis in parallel with increasing RNA synthesis on rehydration. The results (Not given) show that at fruiting. stage, there were non-significant difference among moisture stress levels, varieties and sampling time and the interaction between these factors regarding protein content. This may be due to comparatively less decline in dry matter accumulation (Wadleigh and Richards, 1951).

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