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Total Chlorophyll Content and Leaf Water Potential of Tomato as Influenced by Fertigation Under Controlled Environment Condition

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Abstract: *A two years of experiment was carried out at Post Graduate Research Farm, Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.) to elucidate the effect of fertigation levels and schedules on Total chlorophyll content, Leaf water potential and yield of tomato (Solanum lyc opersicum L.) under polyhouse condition. The treatments include three fertigation levels viz., F_1- 60% of RDF, F_2- 80% of RDF and F_3- 100% RDF and three fertigation schedules viz., S_1- 6 equal splits of RD of NPK at every 18 days interval up to 120 DAT, S_2- 9 equal splits of RD of NPK at every 12 days interval up to 120 DAT, S_3- 12 equal splits of RD of NPK at every 9 days interval up to 120 DAT. Based on two years of investigation it could be concluded that fertigation of 100% of RDF in 12 equal splits at every 9 days interval up to 120 days after transplanting registered significantly maximum Total chlorophyll content and Leaf water potential of tomato during summer season under polyhouse condition. Similarly, significantly higher fruit yield unit of polyhouse (784 m^2) was recorded with fertigation of 100% of RDF in 12 equal splits at every 9 days interval. However it was at par with 80 % of RDF in 12 equal splits at every 9 days interval during both the years of study and on pooled mean.*

Keywords: *Total Chlorophyll Content, Leaf Water Potential, Fertigation, Tomato, Yield, Polyhouse.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important and widely grown solanaceous vegetable crop around the world and belongs to the family *Solanaceae*. It is considered an important source of vitamin A, C and minerals (Hari, 1997). Apart from this, lycopene is valued for its anti-cancer property (Bose *et al*., 2002). It acts as an antioxidant and scavenger of free radicals, which is often associated with carcinogenesis. Thus, lycopene has got great beneficial effects on human health. It may also interfere with oxidative damage to DNA and lipoproteins and inhibits the oxidation of LDL (low density lipoprotein) cholesterol. Polyhouse is a framed or inflated structure covered with transparent or translucent polythene papers, large enough to grow crops under partial or fully controlled environmental conditions to get optimum growth and productivity. Flowering and fruit setting in polyhouse were advanced by 3 to 4 days as compared to field condition. Similarly, tomato plants grown under polyhouse showed the best performance in terms of vegetative and reproductive development, yield contributing characters and total yield.

Chlorophylls are photosynthetic pigments absorbs light energy for synthesis of carbohydrates and are important factor for plant productivity. The total chlorophyll content has direct influence on fruit production by influencing the photosynthetic production capacity of plant. The plant response to specific environmental parameter is related to the physiological processes. Since the microclimate components inside the polyhouse influences higher leaf water potential might be due to accumulation of polyamines which has association for the better maintenance of turgidity and cell membrane stability.

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In this view polyhouse is the best alternative for accumulation maximum chlorophyll content and leaf water potential for higher production of tomato under polyhouse condition during off season. No much information is available on this issue, hence, the study was focused to study the effect of fertigation scheduling on total chlorophyll content, leaf water potential and yield of tomato under polyhouse condition during summer season.

MATERIALS AND METHODS

The present investigation was carried out during summer season of 2013 and 2014 at Department of Agronomy, M.P.K.V., Rahuri (M.S.). Geographically, the site is situated between 19°47′ and 19°57′ N latitude and between 74°19′ and 74°32′ E longitude. The altitude varies from 495 to 555 m above the mean sea level. The soils of the experimental site was sandy clay in texture having pH-7.70, organic carbon 0.53% with low in available nitrogen (254.7 kg/ha), medium in available phosphorous (19.73 kg/ha) and very high in available potassium (369.5 kg/ha). Similarly, low in iron (4.44 mg/kg) and zinc (0.49 mg/kg) and moderate in manganese (2.35 mg/kg) and copper (1.49 mg/kg). The field capacity, permanent wilting point and bulk density were 22.74%, 11.37% and 1.39 g/cm^3, respectively.

The experiment was laid out in split plot design and replicated thrice with nine treatment combinations. The gross and net size of experimental plot was 8 m × 3 m. The treatments includes 3 fertigation levels *viz*., F_1-60% of RDF (180-90-90 kg N-P-K/ha), F_2-80% of RDF (240-120-120 kg N-P-K/ha) and F_3-100% RDF (300-150-150 kg N-P-K/ha) and 3 fertigation schedules *viz*., (S_1-6 equal splits of RD of NPK at every 18 days interval, S_2-9 equal splits of RD of NPK at every 12 days interval, S_3-12 equal splits of RD of NPK at every 9 days interval). The naturally ventilated polyhouse (784 m^2) was oriented in north-south direction and covered with UV stabilized LDPE film of 200 micron thickness as cladding material. The four week old healthy and uniform tomato seedlings were transplanted at the spacing of 60 cm × 50 cm on the raised beds. Fertigation was started 12 days after transplanting through Automatic Fertigation Unit as per treatment. The fertigation was done by using water soluble fertilizer (19:19:19 NPK grade) and urea (46.6% N). All the agronomic practices and plant protection measures were adopted as per recommendation. Observations on different growth and yield parameters were recorded from five randomly sampled plants from each treatment. The chlorophyll content in tomato leaves was measured with the help of Spadometer and Leaf water potential was measured by Leaf water console instrument.

RESULTS AND DISCUSSION

Effect of Fertigation Levels

The total chlorophyll content and leaf water potential were influenced significantly due to the different fertigation levels (Table 1). The maximum total chlorophyll content in tomato leaves (53.94 and 54.14%) was noticed where higher level of fertigation was applied at 135 DAT during both the years. This might be due to adequate application of NPK nutrients through drip in the vicinity of root zone leads to more availability and uptake of nitrogen enhanced the turgidity of mesophyll cells and chloroplast and thereby resulted in increased chlorophyll content in leaves. These results are in line of El-nemr (2012) and Mozafariyan *et al*. (2013).

The higher level of fertigation *i.e*. 100 per cent RDF recorded significantly higher leaf water potential *i.e.* higher leaf water content throughout the crop growth stages of tomato during both years under study. Significantly minimum leaf water potential was noticed under fertigation of 60 per cent RDF at all the crop growth stages during the period of investigation. This was due to adequate amount of nutrients were applied in the rhizosphere of the root zone leads to maximum moisture and nutrients uptake that meets the nutrition demand of the crop resulted in increased cell turgidity and higher leaf water potential throughout crop growth period. The results were in corroborated with Topcu *et al*. (2007) and Kanai *et al*. (2011).

Fertigation of NPK with different levels significantly influenced the yield attributing parameters of polyhouse tomato. A perusal of pooled data (Table 1) indicated that fertigation of 100% RDF recorded significantly higher number of

Table 1
Total chlorophyll content, Leaf water potential and yield of tomato as influenced by different treatments

Treatments	*Total chlorophyll content (%)*		*Leaf water potential(–Ψ)*		*Number of fruits plant^{-1}*			*Avg. fruit weight (g)*			*Fruit weight plant^{-1} (kg)*			*Fruit yield unit^{-1} of polyhouse (784 m^2) (t)*		
	2013	*2014*	*2013*	*2014*	*2013*	*2014*	*Pooled*	*2013*	*2014*	*Pooled*	*2013*	*2014*	*Pooled*	*2013*	*2014*	*Pooled*
A. Fertigation levels																
F_1 – 60% of RDF	53.57	53.78	-13.38	-13.90	56.85	52.20	54.51	62.02	60.13	61.07	3.43	3.00	3.21	11.24	9.51	10.37
F_2 – 80% of RDF	53.75	53.97	-12.93	-13.61	71.96	65.40	68.68	65.85	65.93	65.89	4.61	4.24	4.43	14.96	13.42	14.19
F_3 – 100% of RDF	53.94	54.14	-12.64	-13.28	74.13	67.50	70.82	67.02	66.98	67.00	4.85	4.43	4.64	15.72	14.07	14.90
S.Em ±	0.02	0.03	0.01	0.03	0.77	0.74	0.54	0.32	0.27	0.28	0.07	0.05	0.04	0.22	0.17	0.18
C.D. (p=0.05)	0.10	0.11	0.06	0.09	3.04	2.91	2.16	1.25	1.06	1.14	0.27	0.21	0.16	0.85	0.67	0.74
B. Fertigation schedules																
S_1 – 6 equal splits (18 days interval)	53.63	53.84	-13.11	-13.81	62.16	56.90	59.55	62.83	63.20	63.02	3.81	3.53	3.67	12.44	11.20	11.82
S_2 – 9 equal splits (12 days interval)	53.76	53.98	-12.98	-13.61	68.24	61.80	65.03	64.42	64.49	64.44	4.28	3.91	4.09	13.92	12.38	13.15
S_3 – 12 equal splits (9 days interval)	53.87	54.07	-12.87	-13.37	72.54	66.30	69.44	67.63	65.34	66.50	4.80	4.24	4.52	15.56	13.42	14.49
S.Em ±	0.02	0.02	0.01	0.02	0.34	0.53	0.39	0.19	0.12	0.17	0.02	0.03	0.03	0.10	0.11	0.10
C.D. (p=0.05)	0.07	0.07	0.05	0.08	1.06	1.62	1.21	0.60	0.38	0.69	0.08	0.11	0.09	0.33	0.35	0.30
Interaction (A × B)																
C.D. (p=0.05)	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

fruits/plant (74.13, 67.50 and 70.82), average fruit weight (67.02, 66.98 and 67.00 g) and fruit weight/ plant (4.85, 4.43 and 4.64 kg) as compared to rest of the fertigation levels during both the years and on pooled mean, respectively, however it was at par with fertigation of 80% RDF.

This might be because of enhanced supply of nitrogen, phosphorous and potassium in the root rhizosphere increases the uptake of nutrients and favourable microclimatic conditions was optimized inside polyhouse with maintaining optimum temperature, CO_2 concentration, high relative humidity that enhanced luxurious growth of crop with increasing total chlorophyll content in leaves and there by maximum leaf water potential which helps to absorbed more PAR accompanied with increased enzyme actions aids in higher rate of photosynthesis and dry matter accumulation reflected in efficient translocation of sugar and starches towards reproductive parts reflected in increase in yield attributes. These results are in the line of Hasan *et al*. (2014), Singh *et al*. (2015).

Significant effect of fertigation was observed on fruit yield of tomato inside polyhouse (Table 1). Pooled data averaged over the two years revealed that the fruit yield of tomato increased significantly with increasing level of fertigation. The maximum fruit yield/unit of polyhouse (15.72, 14.07 and 14.90 t) was recorded with fertigation of 100% RDF during both the years and on pooled mean, respectively. However it was at par with 80% RDF indicating 20% saving of fertilizers. While, fertigation of 60% RDF produced significantly minimum fruit yield/unit of polyhouse (11.24, 9.51 and 10.37 t) during both the years and on pooled mean, respectively. The 100% RDF applied through fertigation directly in the active root zone of the plant increases the nutrient use efficiency indicated through enhanced nutrient uptake by crop. The microclimate in the polyhouse was more favourable to increase the growth and yield attributes of tomato crop. The higher rate of photosynthate translocation from vegetative part (source) to reproductive organs (sink) might be increased the fruit size and weight which resulted in higher fruit yield of tomato. Similar findings were reported by Nagre *et al*. (2013), Patel *et al*. (2013) and Kuscu *et al*. (2014).

Effect of Fertigation Schedules

The total chlorophyll content and leaf water potential were influenced significantly due to the different fertigation schedules (Table 1). Fertigation of 12 equal splits of RD of NPK at every 9 days interval up to 120 DAT registered significantly maximum total chlorophyll content in tomato leaves compared to rest of the fertigation schedule at all the crop growth stages during both the years. This might be because of increase in split application of nitrogen, phosphorous and potassium through drip up to 120 days after transplanting increased the nitrogen content in plant which leads to increase the total chlorophyll content in tomato leaves. The fertigation of 6 equal splits of RD of NPK at every 18 days interval up to 120 days after transplanting registered significantly lowest total chlorophyll content in tomato leaves at all crop growth stages during both the years under study. The interrupted supply of nutrients during grand growth period and at fruiting stage inhibits physiological activities thereby reduction in chlorophyll content. The results are in accordance with those reported by Hebber *et al*. (2004), Salam *et al.* (2010).

The microclimatic conditions provided inside the polyhouse increases the transpiration rate that enhances the mobility of water throughout the plant cell and creates the higher internal water conditions of tissues and thereby higher movement of leaf water took place.

The fertigation of 12 equal splits of RD of NPK at every 9 days interval up to 120 days after transplanting noticed significantly highest leaf water potential in tomato leaves during both years under study (Table 1). This might be due to frequent and continuous application of N, P and K up to 120 days after transplanting meets the nutritional requirement of crop and increase vegetative growth in respect of number of leaflets and leaf area $plant^{-1}$ resulted in higher evapotranspiration which create potential gradient between atmosphere and soil water for maximum uptake of moisture because of that plants cells becomes fully turgid which increases the leaf water potential throughout the crop growth period. Significantly minimum leaf

water potential was observed with fertigation of 6 equal splits of RD of NPK at every 18 days interval. Similar findings were reported by Ramchandrappa *et al*. (2010).

Different fertigation schedules significantly influenced the yield contributing characters (Table 1). Among the fertigation schedules, fertigation of 12 equal splits of NPK at every 9 days interval up to 120 DAT exhibited significantly maximum number of fruits/plant (72.54, 66.30 and 69.44), average fruit weight (67.63, 65.34 and 66.50 g) and fruit weight/ plant (4.80, 4.24 and 4.52 kg) during both the years and on pooled mean, respectively. This might be due to continuous split application of nutrients throughout the crop growth period enhanced growth attributes accompanied with more physiological activities and absorbed PAR reflected in higher photosynthetic rate and translocation of assimilates towards reproductive parts resulted an increase in yield attributes. Similar results were reported by Tumbare and Nikam (2004), Bahadur *et al*. (2006).

The fruit yield of tomato (Table 1) was significantly influenced by different fertigation schedules and found that fertigation of 12 equal splits of NPK at every 9 days interval up to 120 DAT recorded significantly higher fruit yield/unit of polyhouse (15.56, 13.42 and 14.49 t) as compared to rest of the treatments during both the years and on pooled mean. While, fertigation of 6 equal splits of NPK at every 18 days interval up to 120 DAT produced significantly minimum fruit yield/unit of polyhouse (12.44, 11.20 and 11.82 t). This might be due to frequent application of required quantity of nutrients directly in vicinity of the root zone throughout crop growth period increased the nutrient use efficiency which enhanced total chlorophyll content and leaf water potential and improved tomato fruit yield.

Similarly the favourable microclimatic conditions maintained inside polyhouse helps to change the phase of plant from juvenile to reproductive phase and significantly contributed to higher fruit yield of tomato. These results are in the line of Tumbare *et al*. (2004), Singh *et al.* (2013).

Based on two years of experimentation it is further concluded that fertigation of 100% RDF in 12 equal splits at every 9 days interval up to 120 days after transplanting found most suitable for enhancing maximum total chlorophyll content and leaf water potential and further achieving higher tomato fruit yield unit^{-1} of polyhouse during summer season. However it was at par with 80% of RDF in 12 equal splits at every 9 days interval during both the years of study.

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