Journal of Agrometeorology

ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 25 (3) : 419-424 (September - 2023)
https://doi.org/10.54386/jam.v25i3.2172
https://journal.agrimetassociation.org/index.php/jam

Research paper

Response of stress irrigation management on chlorophyll content, water potential, PAR and canopy temperature in tomato (*Lycopersicum Esculentum* Mill.)

K.A. CHAVAN[1*] and P.S. BODAKE[2]

[1]*Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India*
[2]*Department of Agronomy, Dr Balasaheb Savant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India*
**Corresponding author email - kac.shirur@gmail.com*

ABSTRACT

This study was conducted to investigate the response of stress irrigation management on chlorophyll content, water potential, photosynthetically active radiation (PAR) and canopy temperature in tomato during summer season. The main plot treatments consist of three drying cycles that is 7, 11 and 15 days and sub treatments include four irrigation levels *viz.,*60, 80, 100, and 120 % ET_C. The control treatments i.e. drip irrigation with 100% ET_C on every two alternate days. The results showed that the 7 days drying cycle showed maximum chlorophyll content, absorbed PAR and leaf water potential followed by 11 days drying cycle. Among the drip irrigation levels, the maximum drip irrigation levels 120 % ET_C exhibited significantly maximum chlorophyll content, absorbed PAR and leaf water potential. However, it was at par with 100 % ET_C and further 80 % ET_C drip irrigation level also showed significant at 90 and 120 DAT. While in the case of difference between canopy and air temperature (Tc-Ta) less negative values were noted by 7 days drying cycle and 120% ET_C drip irrigation level.

Keywords : Partial root zone drying, irrigation, chlorophyll content, leaf water potential, tomato

Tomato (*Lycopersicum esculentum* Mill.) is an important vegetable crop grown in India and also in the world. Tomato is very famous because of its color and juiciness. Drought is a common environmental stress which decreases agricultural production worldwide. Many vegetable crops, including tomato, have high requirement of water and in many countries supplemental irrigation is necessary. Plants adopt various defense mechanisms in response to drought which are accomplished by regulating internal plant water status. Under arid and semi-arid weather conditions, adoption of irrigation management strategy with deficit irrigation may be a possible option to improve production. Many investigations are conducted to realize experiences in irrigation of crops to maximize performance, efficiency and profitability. However, research in water saving irrigation is still continued (Sleper *et al.,* 2007). Water-saving irrigations are used to raise the water productivity during recent period. Summy *et al*., (2015) showed that the under-moisture stress condition, the leaf water potential, osmotic potential and RWC had a significant positive association with the seed yield of chickpea.

Partial root-zone drying irrigation (PRD) is the new irrigation strategy that is mainly adapted to a vast kind of agronomic crops to increase the water productivity (WP). Firstly, the idea of PRD was first adopted by Grimes *et al.,* (1968). It is based on split-root technology which involves alternatively wetting and drying of roots. It is an irrigation technique in which only half part of the roots is irrigated while the another half is left to dry. After some period, the treatment is then altered, allowing the previously irrigated side to dry out while irrigating the preceding dry side i.e drying days as per type of crop (Stoll *et al*., 2000; Topcu *et al.,* 2007). Plant growth is affected badly when the temperature decreases below 5^0C or rises above 32^0C. But in Partial root-zone drying the plant saves its water status by taking up water from the irrigated zone of soil. The practical use of PRD was developed based on the knowledge of physiological regulations of plants grown under dry soil conditions. However, the aperture of stomata can be regulated so that a partial closure of stomata at a certain level of soil water deficit may lead to limit transpiration rate and sustain crop production. (Liu *et al.,* 2005). The PRD induced plant responses decreased inefficient transpiration

Article info - DOI: *https://doi.org/10.54386/jam.v25i3.2172*
Received: 30 March 2023; Accepted: 08 June 2023;

but without significant reduction in photosynthesis, thus increasing the intrinsic water use efficiency (Wei *et al*., 2016). Intercellular concentration of Co_2 which is the main factor in photosynthesis is not affected by conductance of stomata due to water stresses conditions. Both the photosynthesis rate and stomatal conductance have a very low sensitivity to slight water stress conditions but their water productivity increases with low water availability (Liu *et al.,* 2005; Davies *et al.,* 2002).

Partial root-zone drying has many advantages in relation to deficit irrigation. Its main benefit is the irrigated side provides water to the plant and, in this way, the water potential remains at such a level that there is no stress to the crop plants. Hence, this study was undertaken to study response of stress irrigation management on chlorophyll content, water potential, PAR and canopy temperature in tomato.

MATERIALS AND METHODS

Experimental details

The field experiment was conducted at farm of AICRP on IWM, Mahatma Phule Krishi Vidyapeeth, Rahuri- 413 722 during summer season of 2018 and 2019. The physicochemical properties of the soil indicated clay loam texture, alkaline in soil reaction (pH 8.32), medium in organic carbon (0.53) and normal electrical conductivity (0.30 dSm^{-1}). Available primary plant nutrients analyzed were to have low in available nitrogen, medium in phosphorus and very high in potassium. The experiment was laid out in strip plot design. The three main treatments comprised of three drying cycles that is 7, 11 and 15 days and sub plot treatments consist of four irrigation levels *viz.,*60, 80, 100, and 120 % ET_C. The control treatment i.e. drip irrigation with 100 % ET_C on every two alternate days was considered only for comparison and not included in statistical analysis. Irrigation was given on alternate day basis over the whole crop period of tomato by drip irrigation method. The depth of irrigation was applied to tomato as per drip irrigation levels of I_1- 60 % ET_C, I_2- 80 % ET_C, I_3- 100 % ET_C, I_4-120 % ET_C. In case of Partial rootzone drying (PRD), half of the root zone is irrigated while the other half is exposed continuously to dry conditions. To adapt the PRD treatments, the irrigation under PRD treatment shifted from one side of the plants to the other, according to the drying cycles.

Meteorological data viz. daily maximum and minimum temperature, daily maximum and minimum relative humidy, wind speed, actual sunshine hours, rainfall etc. collected from the meteorological observatory of AICRP on IWM, Mahatma Phule Krishi Vidyapeeth, Rahuri were used to calculate reference crop evapotranspiration (ETr) by using FAO Penman-Monteinth method (Allen *et al*., 1998) and ETc was determined using formula :

$$ETc = Kc \times ETr$$

Where,

ETc = Crop evapotranspiration.

ETr = Potential evapotranspiration, mm

Kc = Crop coefficient. It is crop specific and dependent upon crop growth stage.

Observations

Total chlorophyll content in tomato leaflets was recorded by Spadometer (SPAD 502) at 30, 60, 90, 120 and at harvest and expressed in per cent. Leaf water potential in tomato leaflet was computed in bars and recorded with Plant Water Console (Pressure Bomb Apparatus) from transplanting at an interval of 30 days. The photosynthetically active radiation (PAR) was recorded between 11.00 am to 1.00 pm on clear sky with the U 19ISA Line Quantum sensor (Li-Cor make) at an interval of 30 days. The Incident PAR (PARo) was measured 1 feet above the canopy facing towards sky by line quantum sensor. The transmitted PAR (TPAR) was taken by placing the line quantum sensor at ground level facing upwards. Reflected PAR by soil (RPARs) was measured at ½ to 1 ft. above the ground by facing line quantum sensor towards soil. The reflected PAR by canopy + soil (RPARc) was taken by holding line quantum sensor 1 ft. above the canopy facing towards canopy. The absorbed photosynthetically active radiation (APAR) was calculated using the following formula given by Gallo and Daughtry (1986).

$$APAR = (PARo + RPARs) - (TPAR + RPAR_C)$$

The treatment wise canopy temperature in tomato leaf was recorded with Infrared thermometer at an interval 30 days from transplanting.

The total fruit yield was obtained by summation of all the pickings for both the study years.

Statistical analysis

The data recorded were statistically analyzed by using technique of analysis of variance (Fisher, 1950) and significance was determined for strip plot design (Panse and Sukhatme, 1967). The standard error of mean (SE$\pm$) was worked out. Whenever, the results were significant, the critical difference (CD) at 5 per cent level of significance was worked out and presented.

RESULTS AND DISCUSSION

Total chlorophyll content

The total chlorophyll content has direct influence on fruit production. The 7 days drying cycle reported significantly maximum chlorophyll content and also at par with 11 days of drying cycle. Whereas, minimum and significantly lower chlorophyll was observed at 15 days drying cycle. Among drip irrigation levels, the non- stress soil moisture situation that is 120 % ET_C indicated significantly highest total chlorophyll content. However, it was at par with 100 % ET_C Further 80 % ET_C also obtained significant chlorophyll content at 90 and 120 DAT. Alternate irrigation of root system causes continuous Abscisic acid (ABA) based chemical signal which regulate shoot physiology which regulate chlorophyll content. Similar findings found by Abdelraouf *et al.* (2016) (Table 1).

Absorbed photosynthetically active radiation (APAR)

Absorbed photosynthetically active radiation significantly influenced by different treatments. The drying cycle of 7 days recorded significantly highest APAR at all growth stages and also

Table 1: Total chlorophyll content of tomato as influenced periodically by different drying cycles and drip irrigation levels

Treatments	Total Chlorophyll content (%)				
	Pooled				
	30	60	90	120	At harvest
Main plot					
Drying cycles (D)					
D_1 - 7 days	42.89	51.57	54.35	52.39	50.67
D_2 - 11 days	41.96	50.12	50.74	48.89	48.16
D_3 - 15 days	39.28	44.09	47.49	37.79	35.04
S.E.m.±	1.18	0.74	1.12	1.15	0.86
C.D. at 5 %	NS	2.40	3.64	3.74	2.82
Subplot					
Drip irrigation levels (I)					
I_1 – 60 % ET_C	39.60	44.72	47.26	42.71	41.02
I_2 – 80 % ET_C	40.78	46.84	49.19	44.61	42.90
I_3 – 100 % ET_C	42.01	50.86	52.88	48.31	46.64
I_4 – 120 % ET_C	43.12	51.95	54.11	49.81	47.96
S.E.m.±	1.20	1.34	1.74	1.68	1.38
C.D. at 5 %	NS	4.09	5.31	5.34	4.21
Interactions (D X I)					
Between two sub plots means at same level of main plots means					
S.E.m.±	2.65	2.78	3.12	2.80	2.6
C.D. at 5 %	NS	NS	NS	NS	NS
Between two main plots means at same level of sub plot means					
S.E.m.±	2.68	3.08	3.46	3.18	2.94
C.D. at 5 %	NS	NS	NS	NS	NS
General mean	41.37	48.59	50.86	46.36	44.62
Control: Drip irrigation with 100 % ET_C	40.71	46.89	47.68	44.97	43.09

Table 2: Absorbed photosynthetically active radiation of tomato as influenced periodically by different drying cycles and drip irrigation levels

Treatments	Absorbed photosynthetically active radiation				
	Pooled				
	30	60	90	120	At harvest
Main plot					
Drying cycles (D)					
D_1 - 7 days	602.88	1323.96	1510.57	1126.32	1025.30
D_2 - 11 days	577.40	1297.58	1465.50	1111.11	1015.09
D_3 - 15 days	547.14	1262.42	1405.21	1093.88	983.55
S.E.m.±	12.23	10.64	22.75	6.69	8.67
C.D. at 5 %	39.87	34.71	74.20	21.83	28.29
Subplot					
Drip irrigation levels (I)					
I_1 – 60 % ET_C	478.10	1201.47	1335.73	1032.04	960.06
I_2 – 80 % ET_C	574.78	1275.12	1475.73	1111.75	985.56
I_3 – 100 % ET_C	614.44	1345.39	1504.11	1137.98	1036.78
I_4 – 120 % ET_C	635.91	1356.64	1525.80	1159.98	1049.50
S.E.m.±	16.80	20.88	22.46	18.40	16.37
C.D. at 5 %	51.78	64.34	69.20	56.70	50.43
Interactions (D X I)					
Between two sub plots means at same level of main plots means					
S.E.m.±	35.263	39.32	60.59	28.90	32.26
C.D. at 5 %	NS	NS	NS	NS	NS
Between two main plots means at same level of sub plot means					
S.E.m.±	37.47	45.22	57.90	36.60	36.43
C.D. at 5 %	NS	NS	NS	NS	NS
General mean	575.80	1294.65	1460.34	1110.45	1007.97
Control: Drip irrigation with 100 % ET_C	569.44	1262.67	1452.30	1100.46	972.00

Table 3: Leaf water potential of tomato as influenced periodically by different drying cycles and drip irrigation levels

Treatments	Leaf water potential				
	Pooled				
	30	60	90	120	At harvest
Main plot Drying cycles (D)					
D_1 - 7 days	-11.32	-11.44	-12.89	-13.64	-14.15
D_2 - 11 days	-11.38	-11.53	-12.97	-13.73	-14.23
D_3 - 15 days	-11.58	-11.69	-13.14	-13.85	-14.38
S.E.m.±	0.07	0.06	0.07	0.05	0.06
C.D. at 5 %	0.23	0.19	0.23	0.16	0.20
Subplot Drip irrigation levels (I)					
I_1 – 60 % ET_C	-12.68	-12.82	-13.77	-15.00	-15.53
I_2 – 80 % ET_C	-11.31	-11.46	-13.11	-13.75	-14.17
I_3 – 100 % ET_C	-11.03	-11.11	-12.71	-13.19	-13.77
I_4 – 120 % ET_C	-10.68	-10.86	-12.41	-13.02	-13.53
S.E.m.±	0.19	0.18	0.25	0.24	0.20
C.D. at 5 %	0.58	0.55	0.76	0.74	0.61
Interactions (D X I)	NS	NS	NS	NS	NS
General mean	-11.43	-11.56	-13.00	-13.74	-14.25
Control: Drip irrigation with 100 % ET_C	-11.47	-11.59	-13.14	-13.81	-14.33

Table 4: Canopy temperature of tomato as influenced periodically by different drying cycles and drip irrigation levels

Treatments	Canopy temperature				
	Pooled				
	30	60	90	120	At harvest
Main plot Drying cycles (D)					
D_1 - 7 days	-2.05	-2.00	-1.96	-2.04	-2.06
D_2 - 11 days	-1.94	-1.89	-1.83	-1.93	-1.96
D_3 - 15 days	1.69	1.65	1.57	1.66	1.69
S.E.m.±	0.06	0.08	0.07	0.06	0.07
C.D. at 5 %	0.19	0.27	0.23	0.20	0.23
Subplot Drip irrigation levels (I)					
I_1 – 60 % ET_C	1.70	1.64	1.61	1.52	1.40
I_2 – 80 % ET_C	-1.85	-1.80	-1.73	-1.93	-1.97
I_3 – 100 % ET_C	-1.97	-1.93	-1.86	-1.99	-2.10
I_4 – 120 % ET_C	-2.04	-2.01	-1.94	-2.06	-2.14
S.E.m.±	0.05	0.07	0.07	0.04	0.05
C.D. at 5 %	0.15	0.21	0.22	0.13	0.15
Interactions (D X I)	NS	NS	NS	NS	NS
General mean	-0.92	-0.91	-0.88	-0.97	-0.46
Control: Drip irrigation with 100 % ET_C	-1.79	-1.73	-1.67	-1.785	-1.84

at par with11 days of drying cycle. Tomato crop irrigated at 120 % ET_C showed significantly higher APAR and also at par with 100 % ET_C and further 80 % ET_C showed significant APAR at 90 and 120 DAT. This is because of higher irrigation level at one side of root system facilities more absorption of moisture and nutrients and hence cell becomes turgid and stomata remains open for more exit of H_2O and entry of CO_2. Due to absorption of water and nutrients increased which improve crop canopy and hence more interception of PAR which increases photosynthesis and results in higher yield. The results are in close agreement with the Topcu *et al*. (2007), Xu *et al.,* (2009) and Saha *et al.,* (2022). The irrigation level 60 % ET_C that is water stress situation showed significantly minimum APAR at crop developmental stages. Water stress reduces stomatal conductance and inhibit photosynthesis (Table 2).

Leaf water potential (LWP)

Leaf water potential (LWP) showed different trend in response to different treatment. This clearly suggested that LWP is strongly affected by the amount of water applied. The drying cycle of 7 days showed significantly maximum water potential throughout all stages of tomato and followed by 11 days of drying cycle. The 15 days drying cycle recorded minimum leaf water potential due to excess drying of the rhizosphere which limited the plants ability to meet the transpiration demand due to lowering of root hydraulic conductivity. Greater the soil water stress level observed in 15 days drying, the lower the LWP. The 7 days drying cycle showed maximum leaf water potential because the PRD roots could explore and absorbed water from deeper layers of soil profile and maintained leaf water status. Similar results were recorded by Ali *et al.,* (2004) and Zegbe *et al.,* (2004). The 120 % ET_C drip

Table 5: Fruit Yield of Tomato as influenced by drying cycle and drip irrigation level

Treatments	Fruit yield (t ha^{-1})		
	2018	2019	Pooled
Main plot Drying cycles (D)			
D_1 - 7 days	52.15	44.57	48.36
D_2 - 11 days	49.81	42.55	46.18
D_3 - 15 days	45.46	37.36	41.41
S.E.m.±	1.18	1.16	1.43
C.D. at 5 %	4.60	4.52	4.67
Subplot Drip irrigation levels (I)			
I_1 – 60 % ET_C	39.51	32.23	35.87
I_2 – 80 % ET_C	48.73	41.45	45.09
I_3 – 100 % ET_C	52.54	44.59	48.56
I_4 – 120 % ET_C	55.79	47.71	51.75
S.E.m.±	2.44	1.98	2.73
C.D. at 5 %	8.40	6.82	8.40
Interactions (D X I)	NS	NS	NS
General mean	49.14	41.49	45.32
Control: Drip irrigation with 100 % ET_C	42.26	33.56	37.91

irrigation level showed significantly maximum leaf water potential throughout all development phases and also followed by 100 % ET_C drip irrigation level .The 80 % ET_C also found at par at 90 and 120 DAT. The possible reason was the soil moisture available in the root zone was equal to evaporative need of the crop (ET_C) which resulted in maximum water content throughout the development period of plant. Generally, LWP decreased towards the end of season in comparison to the beginning of the season due to leaf senescence. Similar results were obtained by Zegbe *et al.,* (2003) and Xu *et al.,* (2009) (Table 3).

*Canopy temperature (*Tc-Ta)

The difference between canopy and air temperature was influenced significantly due to drying cycle and drip irrigation levels. Less negative values recorded by drying cycle 7 days and at par with 11 days drying cycle indicating that canopy was cooler than air as crop maintain the evaporative cooling of the canopy. The plants of 15 days drying cycle could not transpire sufficient water to cool the leaf surface below air temperature which consequently increases the heat load and causes stress. But regularly irrigated plants did not heated over air temperature owing to enough soil water content. Similar result found by Ninanya *et al.,* (2021). Among irrigation levels, the 120 % ET_C showed significantly least negative values of Tc-Ta and also found at par with 100 % ET_C drip irrigation level. The 80 % ET_C was also found at par at 90 and 120 DAT. The positive values indicated that leaf temperature was higher because of less relative water content in leaf which decreased transpiration rate. Similar results were found by Singandhupe *et al.,* (2003) and Choudhary *et al.,* (2012) (Table 4). The Fruit Yield of Tomato were significantly influenced by different treatments as shown in Table 5.

CONCLUSION

From the results of the investigation, it clearly concluded that 7 days drying cycle and 120 % ET_C drip irrigation level registered maximum physiological parameters and which eventually increase total yield. But the PRD treatments of 80 % ETc drip irrigation level stress at 11 days also found on par with 120 % ETc showing the positive effect of Partial root zone drying (PRD) on sustainable use of water without compromising any of physiological parameters of tomato. Hence, Partial root zone drying (PRD) is a useful approach in dry land regions where water shortage dominates.

ACKNOWLEDGEMENT

The authors are grateful to the AICRP on IWM, MPKV, Rahuri and Department of Agronomy, MPKV, Rahuri for extending help, guidance and support in carrying out this study.

***Sources of funding*:** This research received no specific funding from any agency.

***Conflict of interest*:** The author(s) declare (s) that there is no conflict of interest.

***Data Availability*:** The data of this study can't be shared.

***Author contributions*:** **KA Chavan:** Conducting experiment, Writing review-editing, Analysis; **PS Bodake:** Conceptualization, Methodology, Guidance, Reviewing

REFERENCES

Abdelraouf, R.E., Okasha, E.M. and Tarabye, H.H.H. (2016). Modified design for drip irrigation system to improve the productivity of irrigation water and fertilizers distribution. *Inter. J. Chem. Tech. Res.,* 9(9): 40-52.

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998). Crop

Evapotranspiration, Guideline for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper 56. FAO Rome, Italy, 300 pp.

Ali, H.I., Ismail, M.R., Saud, H.M. and Manan, M.M. (2004). Effect of partial root zone drying (PRD) on growth, water use efficiency (WUE) and yield of tomatoes grown in soil less culture. *Pertanika J. Trop. Agric.,* 27(2): 143 -149.

Choudhary, V.K., Bhambri, M.C., Pandey, N. and Sharma, H.G. (2012). Effect of drip irrigation and mulches on physiological parameters, soil temperature, picking patterns and yield in capsicum (*Capsicum annuum* L.), *Arch. Agron. Soil Sci.,* 58(3): 277-292.

Davies WJ, Wilkinson S, Loveys BR (2002). Stomatal control by chemical signaling and the exploitation of this mechanism to increase water use efficiency in agriculture. *New Phytol.,* 153:449-460.

Fisher, R.A. (1950). Statistical methods for research workers. 11th edition. Oliver and Boyd, London. pp-85.

Grimes, D.W., Walhood, V.T. and Dickens, W.L. (1968). Alternate-furrow irrigation for San Joaquin valley cotton. *Calif. Agric.,* 22: 4-6.

Liu F, Jensen CR, Shahnazari A, Andersen MN and Jacobsen SE (2005). ABA regulated stomatal control and photosynthetic water use efficiency of potato (*Solanum tuberosum* L.) during progressive soil drying. *Plant Sci.,* 168:831-836.

Ninanya Joan, Ramirez, D.A., Rinza, J., Silva-Diaz, C., Cervantes, M., Garcia, J. and Quiroz, R. (2021). Canopy temperature as a key physiological trait to improve yield prediction under water restrictions in potato. *Agron*., 11(7): 1436.

Panse, M.A. and Sukhatme, P.V. (1967). Statistical methods for agricultural workers. IInd End. ICAR, New Delhi. Pp. 135-136.

Saha, Sarathi, Saon Banerjee, Soumen Mondal, Asis Mukherjee, Rajib Nath and Shibani Chowdhury (2022). Evaluating radiation interception pattern and RUE of green gram grown in Lower Gangetic Plains and assessing future yield based on RUE. *J. Agrometeorol., 24*(1): 3-9. https://doi.org/10.54386/jam.v24i1.830

Singandhupe, R.B., Rao, G.G.S.N., Patil, N.G. and Brahmanand, P.S. (2003). Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (*Lycopersicon esculentum* L.). *Eur. J. Agron.,* 19: 327-340.

Sleper, D.A., Fales, S.L. and Collins, M.E. (2007). Foreword In: Irrigation of agricultural crops (R.J. Lascano and R.E. Sojka, eds.), 2nd edition, Agronomy Monograph no. 30. ASA-CSSA-SSSA publishing, 664.

Stoll Manfred, Loveys Brian and Dry Peter. (2000). Hormonal changes induced by partial root zone drying of irrigated grapevine. *J. Exp. Bot.,* 51(350): 1627-34.

Summy, K.D. Sharma, K.S. Boora and Neeraj Kumar (2015). Plant water status, canopy temperature and chlorophyll fluorescence in relation to yield improvement in chickpea (Cicer arietinum L.) under soil moisture stress environments. *J. Agrometeorol.,* 17(1): 11-16. https://doi.org/10.54386/jam.v17i1.969

Topcu Sevilay, Kirda, C., Dasgan, Y., Kaman Harun, Cetin Mahmut, Yazici, A. and Bacon, M.A. (2007). Yield response and N-fertiliser recovery of tomato grown under deficit irrigation. *Eur. J. Agron.,* 26: 64-70.

Wei, Z., Du, T., Zhang, J., Shujun, X., Paul, J. C. and Davies, W. J. (2016). Carbon isotope discrimination shows a higher water use efficiency under alternate partial root-zone irrigation of field-grown tomato. *Agric. Water Manage.,* 165: 33-43.

Xu, H.L., Qin, F.F., Du, F.L., Xu, Q.C., Wang, R., Shah, R.P., Zhao, A.H. and Li, F.M. (2009). Applications of xerophytophysiology in plant production - Partial root drying improves tomato crops. *J. Sci. Food Agric.,* 7:981-988.

Zegbe, J.A., Behboudian, M.H., Lang, A. and Clothier, B.E. (2003). Deficit irrigation and partial root zone drying maintain fruit dry mass and enhance fruit quality in 'PetoPride' processing tomato (*Lycopersicon escuelnutm,* Mill.). *Sci. Hortic.,* 98: 505-510

Zegbe, J.A., Behboudian, M.H. and Clothier, B.E. (2004). Partial root zone drying is a feasible option for irrigating processing tomatoes. *Agric. Water Manag.,* 68: 195-206.