

Effect of elevated temperature and moisture stress on gas exchange parameters of *Trianthema portulacastrum* L.

Govindaraj T.^{1*} and P. Murali Arthanari^{2*}

¹Agro Climate Research Centre, ²Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

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ABSTRACT

Rising carbon dioxide (CO₂) concentrations, increasing ambient temperature and associated precipitation are major concerns for future weed management and crop production. Weeds with C₃ and C₄ photosynthetic pathways may exhibit differential responses to higher CO₂ levels and temperatures, which can affect the dynamics of crop-weed competition. Since photosynthetic biochemistry depends on climatic factors, the photosynthetic pathway of weeds C₃ and C₄ had shown varied responses to elevated concentrations of CO₂ and elevated temperature, the main source of carbon for plants, directly impacts gas exchange parameters at increased concentration of temperature and CO₂. This study evaluated the performance of *Trianthema portulacastrum* gas exchange parameter viz., photosynthetic rate, stomatal conductance, transpiration rate had positively interacted with increased temperature, excess moisture and also under drought condition. Hence, under this climatic condition, the *Trianthema portulacastrum* very well survives with adverse environmental conditions also by reduced transpiration rate and photosynthetic rate.

Key words: *Trianthema portulacastrum* weed, Temperature, Moisture regimes, Gas exchange parameters

Introduction

Climate change is occurring across the globe at a rapid rate that greatly impacts plant growth and dynamics of the ecosystems. An IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways. (IPCC, special report 2018). Weed growth and development is directly related to atmospheric CO₂, ambient temperature, moisture availability. A weed impose a significant change in recourses and is likely to adapt and grow in different habitat types because of their greater genetics, physiological variability compared to crops. As with crops, weeds with C₃ or C₄ photosynthetic pathways

exhibit differences in their response to changing climate (Varanasi *et al.*, 2016).

Weeds with photosynthetic pathway C₃ and C₄ differ in their responses to CO₂ levels ambient temperature and different moisture level, CO₂ concentration, temperature have a direct effect on physiological processes such as photosynthesis and stomatal conductance. Temperature and moisture has significantly influenced the seed production in *Trianthema portulacastrum*. Though the vegetative phase responded positively towards stress but the reproductive phase was severely affected when weed subjected to the combination of elevated temperature and moisture stress (Ugalechumi *et al.*, 2018). In addition, increased temperatures result in

in higher respirations rates, shorterseed formation periods, and lesser biomass production, hence lower yields (Stone and Nicolas, 1995; Adams *et al.*, 1998). Impact of different elevated temperature (2 °C or +4 °C) and moisture stress combinations on *Trianthema portulacastrum* growth parameters were increased with increase in temperatures (+2 °C or + 4 °C) and the growth was significantly more if the plant had no moisture stress (M₁₀₀) (Mandal *et al.*, 2017). This study aimed to investigate the aspects of the gas exchange parameters (Photosynthetic rate, transpiration rate and stomatal conductance) of *Trianthema portulacastrum* weed when grown under a range of temperature regimes and moisture regimes to measure gas exchange parameters.

Materials and Methods

The pot culture experiments were conducted at Agro Climate Research Centre of Tamil Nadu Agricultural University, Coimbatore during November 2018 to January 2019. Coimbatore is located at western zone of Tamil Nadu with latitude 11°N and longitude 77 °E. The mean elevation is 426.7 m above the MSL. Coimbatore's normal climatic conditions (mean of past 50 years) are shown in Figure 3.1 and the result of mean annual rainfall of 674.2 mm were received in 47 rainy days. The maximum and minimum annual mean temperatures are 31.5 °C and 21 °C, respectively. The mean relative humidity ranges from 49.1% (14:22 hours) to 84.9% (07:22 hours). The mean bright sunshine hour is 7.3 hours per day with a mean solar radiation of 429.2 cal/cm.

Table 1. Treatment details

The experiment comprised of 9 treatments with two factors viz., elevated temperature and moisture stress. Each treatment was combination of one temperature, one moisture stress.

Treatment	Treatment combination	Treatment details
T ₁	T ₁ M ₁	Ambient temperature+ M ₁₀₀ per cent of E _p
T ₂	T ₁ M ₂	Ambient temperature+ M ₁₄₀ per cent of E _p
T ₃	T ₁ M ₃	Ambient temperature+ M ₆₀ per cent of E _p
T ₄	T ₂ M ₁	Elevated temperature + 2 °C + M ₁₀₀ per cent of E _p
T ₅	T ₂ M ₂	Elevated temperature + 2 °C+M ₁₄₀ per cent of E _p
T ₆	T ₂ M ₃	Elevated temperature + 2 °C+M ₆₀ per cent of E _p
T ₇	T ₃ M ₁	Elevated temperature + 4 °C+M ₁₀₀ per cent of E _p
T ₈	T ₃ M ₂	Elevated temperature + 4 °C+M ₁₄₀ per cent of E _p
T ₉	T ₃ M ₃	Elevated temperature +4 °C+ M ₆₀ per cent of E _p
T ₁ - Ambient temperature,		M ₁ -M ₁₀₀ % (Normal condition)
T ₂ -+2°C elevated temperature,		M ₂ -M ₁₄₀ % (Excess moisture)
T ₃ -+4°C elevated temperature		M ₃ -M ₆₀ % (Dry condition)

The potculture experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three.

Physiological leaf gas exchange parameters

Leaf gas exchange parameters was measured using Portable Photosynthetic System (PPS – ADC inc., Lincoln, Nebraska, USA) positioned on the cuvette. Narrow leaves were inserted in a 3.0 cm leaf chamber. Using the above PPS system, the following gas exchange parameters (Stomatal conductance, Photosynthetic rate and Transpiration rate) were recorded at 20, 40, and 60 DAS.

Results and Discussion

Impact of elevated temperature and moisture stress

Photosynthetic rate

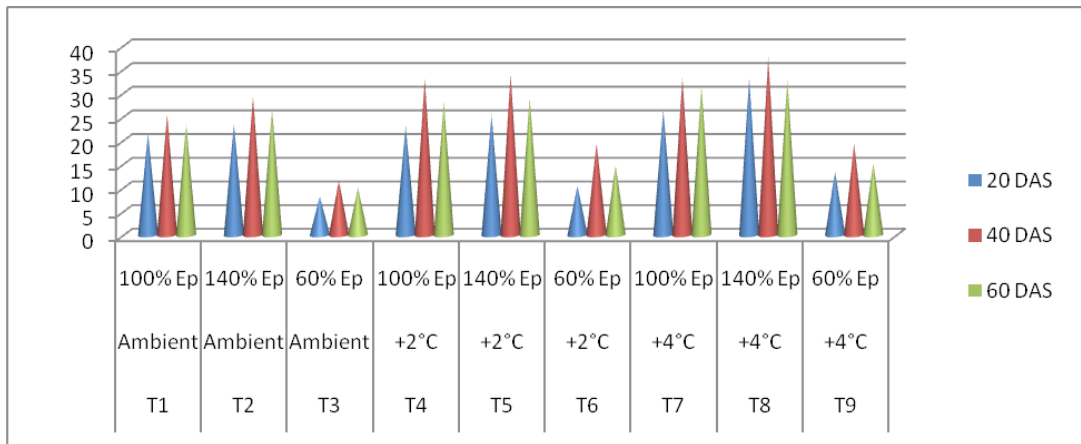
At 20 DAS, the horse purslane recorded significantly higher ($P < 0.05$) photosynthetic rate of 33.15 $\mu\text{mol CO}_2 \text{ m}^2/\text{s}$ with the treatment of Elevated temperature + 4 °C+M₁₄₀ per cent of E_p. It was observed that horse purslane photosynthetic rate imposed with treatment Ambient temperature + M₆₀ per cent of E_p at 20 DAS recorded the lowest photosynthetic rate of 8.07 $\mu\text{mol CO}_2 \text{ m}^2/\text{s}$. The horse purslane recorded significantly higher ($P < 0.05$) photosynthetic rate of 37.56 $\mu\text{mol CO}_2 \text{ m}^2/\text{s}$ with the treatment Elevated temperature + 4 °C+M₁₄₀ per cent of E_p of 40 DAS. It was observed that horse purslane photosynthetic rate with treatment Ambient temperature + M₆₀ per cent of E_p at 40 DAS recorded the lowest pho-

tosynthetic rate of 11.50 $\mu\text{mol CO}_2 \text{ m}^2/\text{s}$. At 60 DAS, the horse purslane recorded significantly higher photosynthetic rate of 32.79 $\mu\text{mol CO}_2 \text{ m}^2/\text{s}$ with the treatment of Elevated temperature + 4°C + M₁₄₀ per cent of E_p. It was observed that horse purslane photosynthetic rate imposed with treatment of Ambient temperature + M₆₀ per cent of E_p at 60 DAS recorded the lowest photosynthetic rate of 9.92 $\mu\text{mol CO}_2 \text{ m}^2/\text{s}$. Increased concentration of ambient CO₂ increased net photosynthesis and transpiration compared to concentration of ambient CO₂. The net photosynthesis was at 35 °C maximum and at 7 and 25 °C minimum. At 47 °C, the transpiration rate was more than three times higher than 35 °C. The total number of seed 16000 per plant for (32/24 °C) and

19,000 seeds per plant for cooler temperature regime (25/16 °C)(Nguyen *et al.*, 2017). C₄ plant, with sufficient moisture the *Trianthema portulacastrum* will adopt easily and produce more growth under elevated temperature as supported by the earlier studies of (Carter and Peterson, 1983); (Ziska and Bunce, 1983).

Stomatal conductance

At 20 DAS, the horse purslane recorded significantly higher stomatal conductance of 0.35 molH₂O m²/s with the treatment of Elevated temperature + 4°C + M₁₄₀ per cent of E_p. It was observed that horse purslane stomatal conductance imposed with treatment of Ambient temperature + M₆₀ per cent of E_p



Pict. 1. Effect of elevated temperature and moisture stress on *Trianthema portulacastrum* photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^2/\text{s}$)

Table 2. Effect of elevated temperature and moisture stress on *Trianthema portulacastrum* photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^2/\text{s}$)

Treatment	Temperature	Moisture	20 DAS	40 DAS	60 DAS			
	T	M						
T ₁	Ambient	100% E _p	21.56	25.50	23.38			
T ₂	Ambient	140% E _p	23.50	29.32	26.61			
T ₃	Ambient	60% E _p	8.07	11.50	9.92			
T ₄	+2°C	100% E _p	23.06	33.04	28.08			
T ₅	+2°C	140% E _p	25.36	34.02	28.96			
T ₆	+2°C	60% E _p	10.41	19.30	14.72			
T ₇	+4°C	100% E _p	26.41	33.20	31.45			
T ₈	+4°C	140% E _p	33.15	37.56	32.79			
T ₉	+4°C	60% E _p	13.33	19.30	15.10			
Mean			20.5	27	23.4			
			SED	CD(0.05)	SED	CD(0.05)		
T			0.20919	0.47323	0.2	0.46	0.18	0.41
M			0.20919	0.47323	0.2	0.46	0.18	0.41
T*M			0.36233	0.81967	0.35	0.79	0.31	1.02

at 20 DAS recorded the lowest stomatal conductance of 0.12 mol H₂O m²/s. At 40 DAS, the horse purslane recorded significantly higher stomatal conductance of 0.37 molH₂O m²/s with the treatment of Elevated temperature + 4 °C + M₁₄₀ per cent of E_p. It was observed that horse purslane stomatal conductance imposed with treatment of Ambient temperature+ M₆₀ per cent of E_p at 40 DAS recorded the lowest stomatal conductance of 0.16 molH₂O m²/s. The horse purslane significantly recorded the higher stomatalconductance of 0.35 molH₂O m²/s with the treatment) at 60 DAS.It was observed that horse purslane stomatal conductance imposed with treat-

ment of Ambient temperature + M₆₀ per cent of E_p at 60 DAS recorded the lowest stomatal conductance of 0.10 molH₂O m²/s. The Maximum photosynthesis, stomatal conductance and internal CO₂ concentration had been observed growing at 75 percent water holding capacity, when minimum values had been observed for plants growing at 50 percent water holding capacity (Bajwa *et al.*, 2017).

Transpiration rate

At 20 DAS, the horse purslane recorded significantly higher transpiration rate of 8.52 mmolH₂O m²/s with the treatment of Elevated temperature +

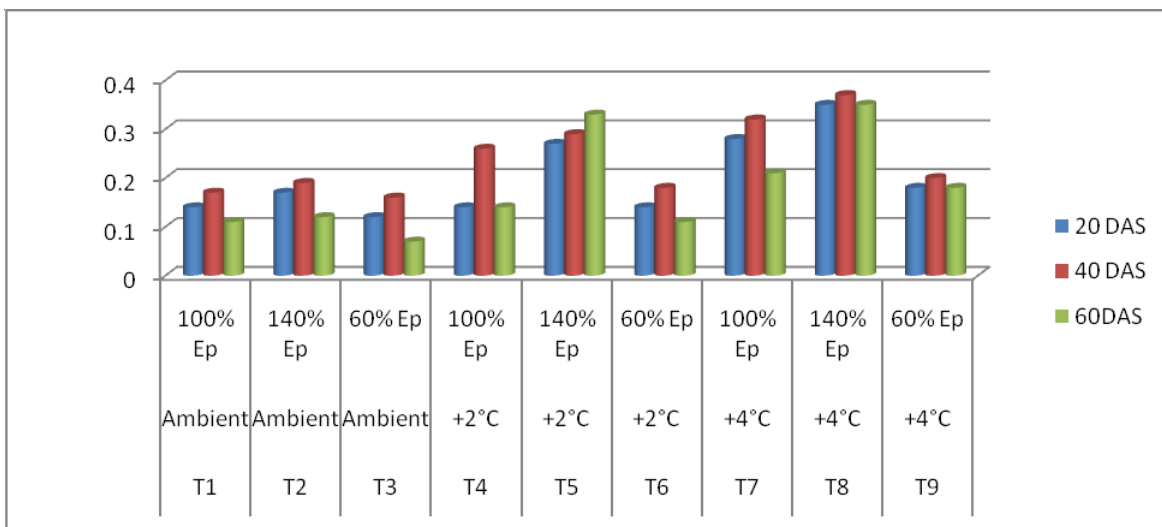


Fig. 2. Effect of elevated temperature and moisture stress on *Trianthema portulacastrum* stomatal conductance (mol H₂O m²/s)

Table 3. Effect of elevated temperature and moisture stress on *Trianthema portulacastrum* stomatal conductance (mol H₂O m²/s)

Treatment	Temperature T	Moisture M	20 DAS		40 DAS		60DAS	
T ₁	Ambient	100% E _p	0.14		0.17		0.11	
T ₂	Ambient	140% E _p	0.17		0.19		0.12	
T ₃	Ambient	60% E _p	0.12		0.16		0.07	
T ₄	+2°C	100% E _p	0.14		0.26		0.14	
T ₅	+2°C	140% E _p	0.27		0.29		0.33	
T ₆	+2°C	60% E _p	0.14		0.18		0.11	
T ₇	+4°C	100% E _p	0.28		0.32		0.21	
T ₈	+4°C	140% E _p	0.35		0.37		0.35	
T ₉	+4°C	60% E _p	0.18		0.2		0.18	
Mean			0.16		0.24		0.18	
			SED	CD(0.05)	SED	CD(0.05)	SED	CD(0.05)
T			0.003	0.007	0.004	0.009	0.003	0.006
M			0.003	0.007	0.004	0.009	0.003	0.006
T*M			0.005	0.012	0.007	0.015	0.005	0.011

4°C+M₁₄₀ per cent of E_p. It was observed that horse purslane transpiration rate imposed with treatment of Ambient temperature + M₆₀ per cent of E_p at 20 DAS recorded the lowest transpiration rate of 4.30 mmolH₂O m²/s. At 40 DAS, the horse purslane significantly recorded the higher transpiration rate of 9.24 mmolH₂O m²/s with the treatment elevated temperature + 4°C+M₁₄₀ per cent of E_p. It was observed that horse purslane transpiration rate imposed with treatment ambient temperature with 60 per cent pan evaporation at 40 DAS recorded the lowest transpiration rate of 3.27 mmolH₂O m²/s. At 60 DAS, the horse purslane recorded significantly higher transpiration rate of 8.40 mmolH₂O m²/s

with the treatment elevated temperature + 4 °C + M₁₄₀ per cent of E_p. It was observed that horse purslane transpiration rate imposed with treatment ambient temperature with 60 per cent pan evaporation at 60 DAS recorded the lowest transpiration rate of 3.78 mmolH₂O m²/s. With respect to moisture stress the plants when exposed 40% stress the vegetative growth of weed affected by reduction height due to reduced transpiration as a result of thickening leaf cuticles, it also affects the reproductive stage of the weed (Singh *et al.*, 2018). The transpiration rate increased at 7 °C to 25 °C and increased temperature 35 °C transpiration rate double and also increases temperature 47°C the transpiration rate increased

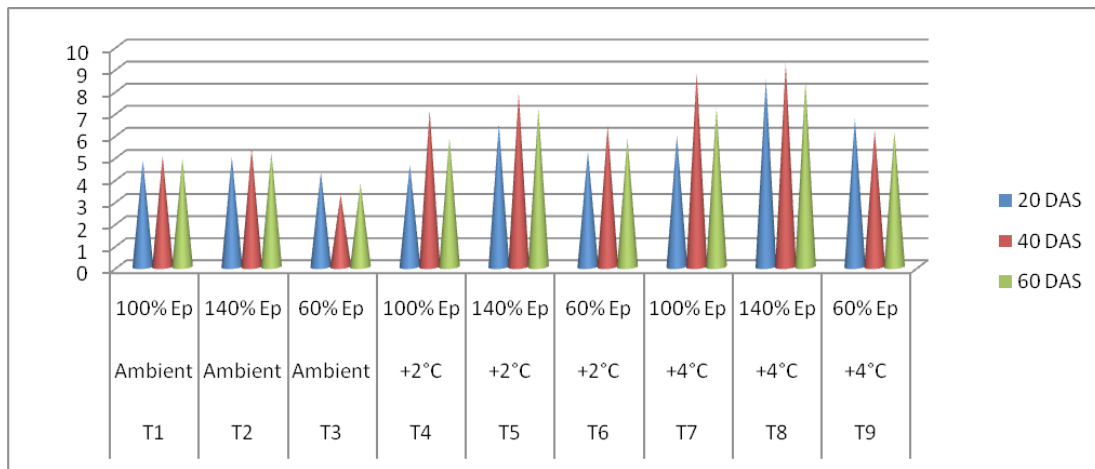


Fig. 3. Effect of elevated temperature and moisture stress on *Trianthema portulacastrum* transpiration rate (mmol H₂O m²/s)

Table 4. Effect of elevated temperature and moisture stress on *Trianthema portulacastrum* transpiration rate (mmol H₂O m²/s)

Treatment	Temperature T	Moisture M	20 DAS	40 DAS	60 DAS			
T ₁	Ambient	100% E _p	4.84	5.02	4.93			
T ₂	Ambient	140% E _p	4.98	5.37	5.17			
T ₃	Ambient	60% E _p	4.30	3.27	3.78			
T ₄	+2°C	100% E _p	4.63	7.07	5.85			
T ₅	+2°C	140% E _p	6.46	7.87	7.17			
T ₆	+2°C	60% E _p	5.22	6.42	5.82			
T ₇	+4°C	100% E _p	5.95	8.81	7.21			
T ₈	+4°C	140% E _p	8.52	9.24	8.4			
T ₉	+4°C	60% E _p	6.72	6.2	6.13			
Mean			5.74	6.58	6.1			
			SED	CD(0.05)	SED	CD(0.05)	SED	CD(0.05)
T			0.08	0.19	0.07	0.16	0.08	0.18
M			0.08	0.19	0.07	0.16	0.08	0.18
T*M			0.14	0.32	0.12	0.28	0.13	0.34

three times of 35°C (Bajwa *et al.*, 2019).

Conclusion

The *Trianthema portulacastrum* weed gas exchange parameters such as photosynthetic rate, transpiration rate and stomatal conductance positively interact with increase temperature and excess moisture and also under drought condition to reduce the transpiration rate and photosynthetic rate.

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