Madras Agric. J., **2018**, *105 (7-9)(2)*: 408-411; doi: 10.29321/MAJ.2018.000172

Effect of Elevated Temperature on Physiological Traits andYield Components in Greengram

N. Sritharan[1*], B. Rakavi[1], A. Senthil[1], P. Jeyakumar[1], S. Kokilavani[2], S. Pannerselvam[2]
[1]Department of Crop Physiology, [2]Agro Climate Research Centre,
Tamil Nadu Agricultural University, Coimbatore - 641 003

Pulses are popularly known as poor man's meat and rich man's vegetable. They contribute significantly to the nutritional security of the country. Among the pulses, greengram is one of the most ancient and extensively grown pulse crops of India. Pulses are very sensitive to drought, water logging and high temperature. Due to climate change, elevated temperature seriously affects greengram production worldwide. Global temperatures have increased in the past 100 years by an average of 0.86ºC. Elevated temperature stress during sensitive crop growth stages affects yield in greengram and leads to very low productivity. With this background, the present investigation was carried out in CO 8 greengram under elevated temperature stress by raising the temperature upto 2°C and 4°C from the ambient temperature. The experiment was conducted in the open top chambers located at the Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore. The main objective was to investigate the effect of elevated temperature on physiological aspects and yield attributes of greengram by imposing stress at different growth stages. Observations on various physiological parameters *viz.,* chlorophyll index, chlorophyll fluorescence, relative water content, osmotic potential, and yield traits were studied under heat stress. From the results, it was concluded that CO 8 greengram variety exposed to elevated temperature of 2°C and 4°C from the ambient, showed significant changes in its physiology and yield attributes. Elevated temperature stress during flowering phase was critical when compared to other growth stages. Thus, the experiment created innovative views to study the molecular and physiological mechanism in detail to develop stress tolerant genotypes.

Key words: Chlorophyll index, Chlorophyll fluorescence, Relative water content, Osmotic potential, Yield traits

Pulses are one of the important food crops due to higher protein content. Among the pulses, greengram (*Vigna radiata* L.) is popular and major grain legume used for consumption from ancient days. Greengram is an economically and nutritionally important food cum feed legume crop in Asia, particularly in the Indian sub-continent, which accounts for 45% of the global production. Keeping in view large benefits of pulses for human health, the Food and Agriculture Organization (FAO) of the United Nations declared the year 2016 as the International Year of Pulses. Currently, we are in the mid-way of attaining self-sustainability in pulses production as we are world leader in production, consumption and import (Singh *et al*., 2013). Greengram is a short duration crop that can be grown over a range of environments. It is grown extensively in India under varying soil types and climatic conditions. The productivity of greengram in India is very low and far below the other greengram growing countries. It is an important summer season legume crop in north India. Elevated temperature is an alarming factor due to global warming (Singh and Sing, 2011). The optimum average temperature for potential yield of greengram lies between (28-30) ºC. It is also grown in summer when the temperature and light irradiance fluctuate frequently.When the temperature gets elevated than the optimum, the growth and yield traits are reduced drastically. The rise in temperature mainly due to climate change affects the growth, development and production potential of crops. In spite of the best efforts for improving the greengram varieties, the yield of this crop remains low.

*Corresponding author's email: sritnau@gmail.com

Material and Methods

A pot culture experiment was conducted during 2017 at the open top chambers located in the Department of Crop Physiology, TNAU, Coimbatore. The recent variety in greengram CO 8 was taken for the experiment. The treatments were ambient temperature that exists under open field condition (T_1), Elevated temperature of 2°C from the ambient temperature (T_2), Elevated temperature of 4°C from the ambient temperature (T_3). The treatments were imposed during vegetative (S_1), flowering (S_2) and pod development stages (S_3). The physiological parameters and yield traits were recorded under elevated temperature stress. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with four replications. Chlorophyll index was recorded using a portable chlorophyll meter (Minolta SPAD 502). Five readings were taken from each replication and the average values computed using method described by Minolta (1989) and Monje and Bughree (1992). Chlorophyll fluorescence in light adapted leaves was detected with a portable OS1p, a modulated Fluorometer (Model - OS1p Advanced, Opti-Sciences, USA) (Maxwell and Johnson, 2000). Relative water content was calculated according to the formula given by Barrs and Weatherley (1962) and expressed in per cent.

Osmotic potential was calculated by using vapour pressure osmometer. The penultimate fully expanded leaf on the main stem was cut, wrapped in a plastic bag and soaked in water in the refrigerator for 24hrs to rehydrate the tissue. The rehydrated leaf placed in aluminium foil, frozen with liquid nitrogen for 30sec to stop the physiological function of its cells and stored in a -80oC freezer. The sap was collected by squeezing the leaf sample with the help of a sterile syringe and the osmolality (mmol kg-1) of the expressed sap was determined using a vapour pressure osmometer (Vapro Model 5520 Wescor Inc., Logan, UT, USA). Osmotic potential (ys) was calculated as,

Ψ_π = - CRT

Where,

C is concentration,

R is the universal gas constant (0.0832) and

T is the temperature in degrees Kelvin (310^o k). Osmotic potential value expressed in 'Mega pascal' (-Mpa).

The number of pods produced in each plant was taken randomly from four plants in each replication from each treatment at the harvest stage. The total pod weight was weighed and expressed in gram plant^{-1}. The weight of hundred seeds picked at random from each replication for every treatment was taken and expressed in gram.

Results and Discussion

Chlorophyll index measured using SPAD meter was drastically reduced under elevated temperature treatments (Table 1.). Plants grown in 4ºC showed the higher reduction per cent of 13.3 at S_1 and 15.8 at S_2. SPAD values were taken at two different stages (S_1, S_2). The SPAD values observed at $S_1$and S_2 in the treatment T_1 were 40.5 and 42.8 respectively. SPAD value was reduced under T_2 (37.5 at S_1, 39.5 at S_2) and T_3 (35.1 at S_1, 36.0 at S_2). High temperature caused gradual reduction in chlorophyll content in greengram (Saha *et al.,* 2010). Similarly, a reduction in chlorophyll content in chickpea was observed under high temperature stress in chickpea, the tolerant genotype showed lesser decline over sensitive genotype (Kumar *et al*., 2012). Chlorophyll fluorescence showed significant difference between treatments. F_v/F_m ratio of T_1 was recorded as 0.711 (S_1) and 0.720 (S_2). During elevated temperature condition, F_v/F_m ratio of T_3 (0.677 at S_1, 0.667 at S_2) was found to be lesser when compared to T_2 (0.701 at S_1, 0.709 at S_2) and T_1. The data are represented in Table.1. Chlorophyll fluorescence (F_v/F_m ratio) which denotes the maximal quantum yield of PSII photochemistry (F_v/F_m ratio) is an important parameter for the PSII activity and any decrease in F_v/F_m ratio indicates the loss of PSII activity. Han *et al.* (2009) reported that F_v/F_m ratio was 0.836 at 26ºC, however, decreased slightly (0.817) at 35ºC, and significantly to 0.782 at 40ºC and to 0.62 at 45ºC, indicating the inhibition of PSII activity under high-temperature stress condition. Similar results were observed in the present investigation where plants subjected to elevated temperature stress (T_3 and T_2) showed reduction in chlorophyll fluorescence ratio.

Table1. Effect of elevated temperature on chlorophyll index and chlorophyll fluorescence

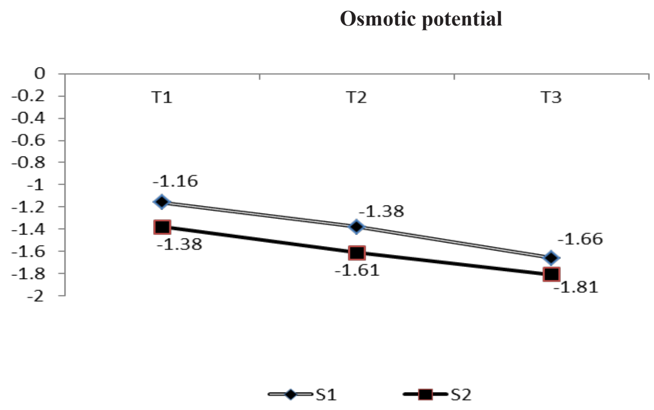
Treatments	Chlorophyll index Crop growth stages			Chlorophyll fluorescence (Fv/Fm ratio) Crop growth stages		
	S_1	S_2	Mean	S_1	S_2	Mean
T_1	40.5	42.8	41.62	0.711	0.720	0.715
T_2	37.5	39.5	38.47	0.701	0.709	0.705
T_3	35.1	36.0	35.56	0.677	0.667	0.672
Mean	37.70	39.40	38.55	0.696	0.699	0.697
	T	S	T×S	T	S	T×S
SEd	0.51	0.51	1.08	0.007	0.007	0.013
CD (P≤0.05)	1.05**	1.05**	1.81*	0.015*	0.015**	0.027$^{(NS)}$

RWC was found to be increased up to S_2 and then slowly decreased in pod development stage in all the treatments (T_1, T_2 and T_3). Plants which were grown in ambient temperature condition (T_1) recorded the higher relative water content (77.2 at S_1, 85.1 at S_2, 82.7 at S_3). Whereas in the treatments T_2 (73.6 at S_1, 80.6 at S_2, 75.9 at S_3) and T_3 (66.2 at S_1, 72.5 at S_2, 68.1 at S_3), the RWC was reduced than T_1. Relative water content (RWC) is an important physiological parameter that indicates the stress level. Elevated temperature stress is one of the major abiotic stresses that has adverse effects on plant water status. RWC was very much reduced in all the elevated temperature treatments. T_2 and T_3 plants showed highest per cent reduction of RWC at pod development stage (T_2:8.2 and T_3:17.6) when compared to vegetative and flowering stage (Fig.2). Elevated temperature disturbs the water relations and hydraulic conductivity of roots (Morales *et al*., 2003). Our observations were in agreement with the earlier reports indicating reduction in RWC due to high temperature stress in greengram (Sanjeev *et al.,* 2012). The Osmotic potential (OP) of leaves was measured in terms of 'Mega Pascal'. Osmotic adjustment (OA)

Table 2. Effect of elevated temperature on yield traits

Treatments	Total Pod weight (g plant^{-1}) Crop growth stages				Hundred seed weight (g) Crop growth stages			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T1		4.24				3.75		
T2	3.82	2.83	3.24	3.29	3.59	3.45	3.43	3.48
T3	3.27	2.11	2.31	2.56	3.26	2.93	3.20	3.12
Mean	3.77	3.05	3.26	3.36	3.53	3.37	3.45	3.45
		T	S	T×S	T	S	T×S	T
SEd		0.18	0.18	0.32	0.06	0.06	0.11	0.06
CD ($P \leq 0.05$)		0.38**	0.38*	0.66(NS)	0.13**	0.13(NS)	0.22(NS)	0.13**

was also observed in the leaves of control (T_1) and stressed (T_2 and T_3) plants. Osmotic potential was measured in vegetative stage (S_1) and flowering stage (S_2).Osmotic potential increases with more negative value indicating that plants under stress condition. The osmotic potential of leaves became more negative in T_3 (-1.66 at S_1, -1.81 at S_2) then T_2 (-1.38 at S_1, -1.61 at S_2) followed by T_1 (-1.16 at S_1, -1.38



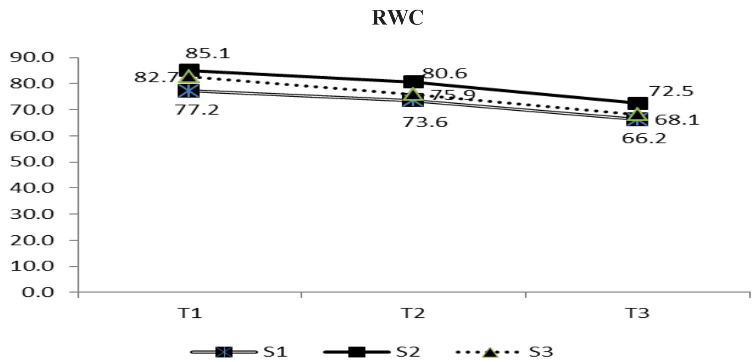


Fig.1 and 2 Effect of elevated temperature on osmotic potential and RWC

at S_2). The more negative Among the treatments, T_1 (4.24) recorded maximum pod weight showing its better performance under ambient temperature condition (Table 2). Number of pods was decreased when temperature elevated (T_2 and T_3) from the ambient condition. Irrespective of the stages, plants imposed with elevated temperature have recorded the lowest number of pod weight with a mean value of 2.83 (T_2) and 2.11 (T_3). Elevated temperature stress given during pod development stage also exhibited reduction in seed yield. In control plants (T_1), higher hundred seed weight (3.75) was recorded. In T_2 where elevated temperature was raised up to 2ºC from ambient condition showed lower (3.59 at S_1, 3.45 at S_1, 3.43 at S_1) 100 seed weight than T_1. In T_3 (4ºC raise from ambient), plants recorded least 100 seed weight (3.26 at S_1, 2.93 at S_1, 3.20 at S_3) over control (T_1). It was clearly evident that elevated temperature subjected during flowering stage (S_2) recorded lower hundred seed weight than other stages (Table 2.).

In greengram, the chlorophyll index values were drastically reduced when the temperature was elevated to 4°C from the ambient condition. Chlorophyll fluorescence (Fv/Fm) showed reduced values when plants were exposed to 4°C raise than the ambient temperature thus relating the efficiency of PS II. Relative Water Content was greatly reduced under the influence of elevated temperature conditions with the values being minimal at Pod development stage (S_3) for both the treatments. Osmotic potential was increased under stress condition. Elevated temperature mainly affected the pod and seed yield. From the present study, it was concluded that, when greengram crop exposed to an elevated temperature of 4°C from the ambient, showed significant changes in its physiology and yield attributes than 2°C elevated temperature.

References

Barrs, H.D. and Weatherley, P.E. 1962. A re-examination of relative turgidity for estimating water deficits in leaves. *Aus. J. Biol. Sci.,* **15:** 413-428.

Chand, G. 2015. Physiological and reproductive behaviour of summer Mung bean [*Vigna radiata* (L.) Wilczek] under terminal heat stress. Doctoral dissertation, CCSH.

Han, F., Chen, H., Hi, X.J., Yang, M.F., Liu G.S. and Shen, S.H. 2009. A comparative proteomic analysis of rice seedlings under various high temperature stresses. Biochem. *Biophys. Acta.,* **1794**: 1625-1634.

Kaushal, N., Gupta, K., Bhandhari, K., Kumar, S., Thakur, P. and Nayyar, H. 2011. Proline induces heat tolerance in chickpea (*Cicer arietinum* L.) plants by protecting vital enzymes of carbon and antioxidative metabolism. *Physiol. Mol. Biol. Plants,* **17:** 203-213.

Kumar, N., Nandwal, A.S., Yadav, R., Bhasker, P., Kumar, S., Devi, S., Singh, S., and Lather, V.S. 2012. Assessment of chickpea genotypes for high temperature tolerance. *Ind. J. Plant Physiol.* **17 (3&4)**: 224-232.

Maxwell, K. and Johnson, G.M. 2000. Chlorophyll *fluore scence* - A practical guide. *J. Exp. Bot.,* **51**: 659-668.

Minolta, C. 1989. Manual for Chlorophyll meter SPAD-502. Minolta Cameraco., Osaka, Japan

Monje, O.A. and Bughree. 1992. Inherent limitation of non-destructive chlorophyll meters. A comparison of two types of meters. *Hort. Sci.,* **27**: 71-89.

Morales, D., Rodriguez, D., Dell-Amico, J., Nicolas, E., Torrecillas, A. and Sanchez Blanco, M.J. 2003. High temperature preconditioning and thermal shock imposition affects water relations gas exchange and root hydraulic conductivity in tomato. *Biol. Plant.*, **47:** 203-208.

Saha, P., Chatterjee, P. and Biswas, A.K. 2010. NaCl pretreatment alleviate salt stress by enhancement of antioxidant defence system and osmolyte accumulation in mungbean (*Vigna radiata* L. Wilczek). *Ind. J. Expt. Biol.,* **48**: 593-600.

Sanjeev, K., Neeru, K., Harsh, H., Nayyar and Gaur. P. 2012. Abscisic acid induces heat tolerance in chickpea (*Cicer arietinum* L.) seedlings by facilitated accumulation of osmoprotectants. *Acta. Physiol. Plant.,* **34**: 1651–1658.

Singh, D.P. and Singh, B.B. 2011. Breeding for tolerance to abiotic stresses in mungbean. *J. Food Legumes,* **24**: 83–90.

Singh., Manibhushan, A.K., Bhatt, B.P., Singh, K.M. and Upadhyaya, A. 2013. An Analysis of Oilseeds and Pulses Scenario in Eastern India during 2050-51. *Journal of Agrl. Sci.,* **5 (1)**: 241- 9.