Bangladesh J. Nuclear Agric. 33 & 34: 147-150 (December, 2020) ISSN 0258-7130

Short Communication

PHOTOSYNTHESIS, DRY MATTER PRODUCTION AND YIELD PERFORMANCE OF LENTIL VARIETIES UNDER HIGH TEMPERATURE

M. T. Islam* and M. A. Haque

Abstract

Climate is changing and air temperature is rising due to increasing concentration of CO_2 and other atmospheric greenhouse gases. The rise in atmospheric temperature causes detrimental effects on growth, yield, and quality of the crop varieties by affecting their phenology, physiology, and yield components. A pot experiment was carried out with ten high yielding lentil varieties to assess the effects of high temperature (34°C) on physiological parameters yield attributes and yield and to find out temperature stress tolerant varieties. Temperature treatments *viz*. (i) Ambient, (ii) 34°C at flower initiation stage and (iii) 34°C at pod filling stage of the 10 lentil varieties *viz*. Binamasur-2, Binamasur-3, Binamasur-4, Binamasur-5, Binamasur-6, Binamasur-7, Binamasur-8, Binamasur-9, Binamasur-10 and BARI masur-5 were imposed separately for 7 days in plant growth chamber. Photosynthesis, chlorophyll content in leaves, total dry matter and yield attributes decreased under high temperature. Temperature imposed at pod growth stage had greater negative effect. The higher yield reduction was recorded in Binamasur-2 and Binamasur-3. But the yield loss under high temperature was less in two varieties *viz*. Binamasur-6 and Binamasur-8.

Key words: Dry matter, high temperature, photosynthesis, yield, lentil

Lentil (*Lens esculenta* Medik.) is an important pulse crop with high protein content, has the potential capacity to combat nutritional deficiencies in developing regions and countries. High temperature and water stress are significant abiotic stresses that limit production worldwide (Sehgal*et al*. 2017; Gaur *et al*. 2015). High temperature affects crops through either: (i) above-optimum temperatures for an extended period, which increases supply of assimilates but reduces grain filling period and yield; or (ii) heat wave responses, which is a short period of high temperature (>32°C) that causes non-recoverable reduction in grain set and yield potential (Vadez*et al*. 2012). Together these abiotic stresses, estimated to cause up to 50% yield loss per annum in pulse crops globally (Gaur *et al*. 2014). Lentil requires low temperatures during vegetative growth, while at maturity, warm temperatures required; the optimum temperature for its best growth has been reported to be 18-30°C (Roy *et al*. 2012). Lentil is particularly sensitive to high temperature (>30°C) during the reproductive phase, causing pod and flower abortion and significant reduction in grain yield and quality ((Sita*et al*. 2017). Yield was reduced by 87% for lentils grown in pots under field conditions with high temperature during the reproductive phase (38°C day time, 23°C night) (Bhandari*et al*. 2016),

Crop Physiology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh
*Corresponding author: islamtariqul05@yahoo.com

and grain set was observed to be the most sensitive yield component (Bhandari*et al*. 2016; Gaur *et al*. 2015). In Bangladesh, lentil sowings occasionally get postponed because of the delayed harvest of the preceding crop, mostly T. Aman rice. The lentil crop is then adversely affected by the high approaching summer temperatures, leading to low grain yields and poor grain quality (Tickoo*et al*. 2005). Efforts can be made to increase area as well as yield of lentil crops by the use of temperature stress tolerant varieties. So the experiment was conducted to evaluate ten high yielding lentil varieties to observe the effect of high temperature and to find out temperature tolerant varieties.

A pot experiment was carried out with ten high yielding lentil varieties cultivating by the farmers to assess the effects of high temperature (34ºC) on photosynthesis, chlorophyll content (SPAD reading) in leaves, dry mass production, yield attributes and yield and to find out temperature stress tolerant varieties. The experiment was conducted during November 2017 to March 2018 at BINA, Mymensingh, Bangladesh. Seeds were sown in pots on 21 November 2017. Each pot contained 8 Kg of soils (Silty loam, organic matter 1.05%, total N 0.07%, available P 14.3 ppm, exchangeable K 0.25 meq.per 100g soil, available S 13.2 and soil pH 6.67). The experiment was laid out in a Complete Randomized Design with three replications. Recommended dose of fertilizers was applied and other cultural practices were followed as and when required. Temperature treatments *viz*. (i) Ambient, (ii) 34ºC at flower initiation stage and (iii) 34ºC at pod filling stage of the lentil varieties *viz*. Binamasur-2, Binamasur-3, Binamasur-4, Binamasur-5, Binamasur-6, Binamasur-7, Binamasur-8, Binamasur-9, Binamasur-10 and BARI Masur-5 were imposed separately for 7 days in controlled plant growth chamber (RH 80%, CO_2 330 ppm). The nitrate reductase activity, chlorophyll content and photosynthetic rate of leaves were determined during temperature imposed. At harvest, total dry matter, seed yield and yield related parameters were recorded. Photosynthetic rate was recorded using *Portable Photosynthesis System LI-6400XT, LI-COR Inc.,* Lincoln, NE, USA. Statistical analysis was done as per design used with the help of MSTAT computer packages.

Results indicated that high temperature imposed either at flower initiation stage or pod growth stage had high significant negative influence on plant parameters (Table 1). But temperature imposed at pod development stage had greater negative influence on morpho-physiological parameters as well as seed yield than temperature imposed at flowering stage. The results agreewith Bhandary*et al*. (2016), Kumar *et al*. (2016) and Delahunty*et al*. (2018) who stated that morpho-physiological parameters of lentil decreased under high temperature. Binamasur-6, Binamasur-8 and Binamasur-10 showed taller plants, Binamasur-7 showed higher photosynthetic rate, and BARI Masur-5 and Binamasur-9 had higher seed yield and harvest index under high temperature (Table-2). But seed yield drastically reduced under high temperature in all varieties at any growth stage (Fig. 1). Higher yield reduction was recorded in Binamasur-2 and Binamasur-5 (Fig. 1). Yield loss under high temperature was less in two varieties *viz*. Binamasur-6 and Binamasur-8 and showed tolerance to high temperature.

Table 1. Growth stages on morpho-physiological parameters and yield traits of lentil varieties as affected by high temperature

34°C imposed at	Plant height (cm)	Photo-synthesis rate (µmolCO_2 m^{-2} S^{-1})	Chloro-phyll content ($mgg^{-1}fw$)	Nitrate reductase (µ mol NO_2/ gfw/h)	Total dry mass plant^{-1} (g)	Pods plant^{-1} (no.)	Seeds plant^{-1} (no.)	Seed weight plant^{-1} (g)	Harvest index (%)
Control *Stages:*	29.5a	32.36 a	2.85 a	2.84a	8.53 a	230 a	249.1 a	6.49 a	40.33 a
Flowering	27.0c	27.66 b	2.29 b	0.78b	3.16 c	197 b	84.21 b	1.81 b	36.41 b
Pod filling	28.2 b	25.05 b	2.14 b	1.52c	3.13 b	181 c	15.91 c	0.74 c	19.12 c
F-test	**	**	**	**	**	**	**	**	**

In a column, figure (s) with same letter do not differ significantly at P#0.05 by DMRT; ** indicates significant at 1 % level of probability

Table 2. Variation in morpho-physiological parameters, seed yield and yield attributes of 10 lentil varieties under high temperature

Varieties	Plant height (cm)	Photo-synthesis rate (µmolCO_2 $m^{-2}S^{-1}$)	Chloro-phyll content ($mgg^{-1}fw$)	Nitrate reductase (µ mol NO_2/ gfw/h)	Total dry mass plant^{-1} (g)	Pods plant^{-1} (no.)	Seeds plant^{-1} (no.)	Seed weight plant^{-1} (g)	Harvest index (%)
Binamasur-2	27.6 b	32.66 bc	2.42bcd	1.62 cd	3.75 cd	88.2 b	133.8 b	3.18 bc	38.12 bc
Binamasur-3	28.1 b	26.94 f	1.96e	1.96 a	3.84 bc	75.9 e	116.7 c	3.21 bc	37.05 c
Binamasur-4	25.0 c	30.07 d	2.26cde	1.61 cd	3.45 e	71.0 f	111.1 d	3.04 bc	38.72 b
Binamasur-5	27.4 b	28.56 e	2.81ab	1.87 ab	4.00 ab	78.9 d	119.8 c	3.21 bc	37.21 c
Binamasur-6	30.7 a	32.06 c	2.53bc	1.44 d	3.59 de	69.7 g	103.1 e	2.28 de	33.88 d
Binamasur-7	26.5 bc	36.65 a	2.39cd	1.79abc	3.64 d	75.1 e	110.5 d	2.87 c	37.24 c
Binamasur-8	30.8 a	30.16 d	2.50bc	1.42 d	3.66 d	53.9 h	76.44 f	1.89 e	26.21 f
Binamasur-9	27.6 b	29.61 de	2.07de	1.76abc	4.05 ab	85.8 c	132.4 b	3.59 ab	39.19 ab
Binamasur-10	32.3 a	33.35 b	3.00a	1.71 bc	4.15 a	71.4 f	109.4 d	2.57 cd	31.18 e
BARI Masur-5	26.3 bc	26.81 f	2.34cde	1.98 a	4.17 a	98.2 a	150.9 a	3.94 a	41.92 a
F-test	**	**	**	**	**	**	**	**	**

In a column, figure(s) with same letter do not differ significantly at P#0.05 by DMRT; ** indicates significant at 1 % level of probability

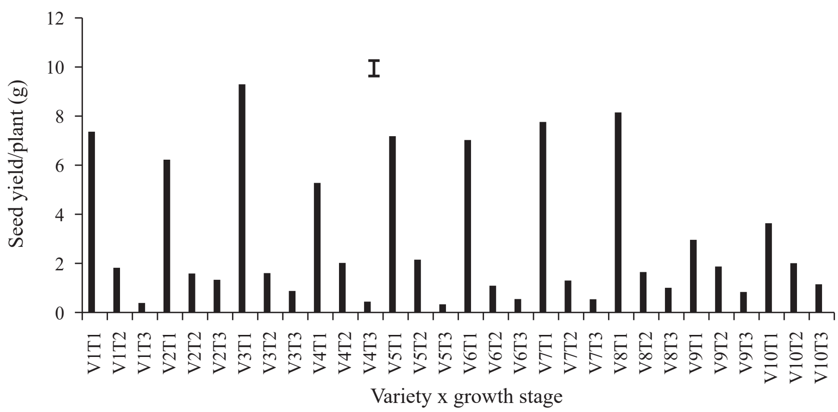

Fig. 1. Interaction effect of high temperature between variety and growth stage on seed yield in lentil

Vertical bar represents Lsd0.05. V_1 = Binamasur-2, V_2 = Binamasur-4, V_3 = BARI Masur-5, V_4 = Binamasur-10, V_5 = Binamasur-5, V_6 = Binamasur-7, V_7 = Binamasur-3, V_8 = Binamasur-9, V_9 = Binamasur-8, V_{10} = Binamasur-6; T_1 = Control, T_2 = 34ºC temperature imposed at flowering stage, T_3 = 34ºC temperature imposed at pod growth stage

High temperature at flowering or grain filling stage severely affected yield and attributes of the lentil varieties. But temperature imposed at grain filling stage had greater negative influence. Among ten lentil varieties, Binamasur-6 and Binamasur-8 had some tolerance to high temperature.

References

Bhandari, K., Siddique, K. H. M., Turner, N. C., Kaur, J., Singh, S., Agrawal, S. K. and Nayyar, H. 2016. Heat stress at reproductive stage disrupts leaf carbohydrate metabolism, impairs reproductive function and severely reduces seed yield in lentil. J. Crop Improv. 30: 118-151.

Delahunty, A., Nuttall, J., Nicolas, M. and Brand, J. 2018.Response of lentil to high temperature under variable water supply and carbon dioxide enrichment. Crop Pasture Sci. 69(11): 1103-1112.

Gaur, P. M., Samineni, S., Krishnamurthy, L., Kumar, S., Ghanem, M. E., Beebe S., Rao I., Chaturvedi, S. K., Basu, P. S., Nayyar, H., Jayalakshmi, V., Babbar, A., Varshney and R. K. 2015. High temperaturetolerance in grain legumes.Legume Perspectives. 7: 23-24.

Gaur, P. M., Srinivasan, S. and Varshney, R. K. 2014.Drought and heat tolerance in chickpea.Legume Perspectives. 3: 15-17.

Kumar, J., Kant, R., Kummar, S., Basu, P., Sarker, A. and Singh, N. 2016.Heat tolerance in lentil under field conditions.Legume Genomics and Genetics. 7: 1-11.

Roy, C. D., Tarafdar, S., Das, M.and S.,Kundagrami. 2012. Screening lentils (*Lens culinaris*Medik.) germplasms for heat tolerance. Trends Biosci. 5: 143-146.

Sehgal, A., Sita., K., Kumar, J., Kumar, S., Singh, S., Siddique, K. H. M. and Nayyar, H. 2017. Effect of drought, heat and their interaction on the growth, yield and photosynthetic function of lentil (Lens culinarisMedikus) genotypes varying in heat and drought sensitivity. Front. Plant Sci. 8: 1776.

Sita, K., Sehgal, A., Kumar, J., Singh, S., Siddique, K. H. M. and Nayyar, H. 2017.Identification of high temperature tolerant (*Lens culinaris*Medik.) genotypes through leaf and pollen traits. Front. Plant Sci. 8: 744.

Tickoo, J. L., Sharma, B., Mishra, S. K. and Dikshit, H. K. 2005. Lentil (*Lens culinaris*) in India: present status and future perspectives. Indian J. Agric Sci. 75: 539-562.

Vadez, V., Berger, J. D., Warkentin, T., Asseng, S., Ratnakumar, P., Rao, K. P. C., Gaur, P. M., Munier-Jolain, N., Larmure, A., Voisin, A.S., Sharma, H. C., Pande, S., Sharma, M., Krishnamurthy, L. and Zaman, M. A. 2012. Adaptation of grain legumes to climate change: a review. Agron. Sustain. Dev. 32: 31-34.