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Short Communication

WATER STRESS TOLERANCE AT THE REPRODUCTIVE PHASE IN SELECTED LENTIL GENOTYPES

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Abstract

Lentil (*Lens esculenta* Medik.) is an important pulse crop with high protein content, has the potential capacity to combat nutritional deficiencies in developing countries. An experiment was carried out with six mutants *viz*., LMI-3, LMM-4, LMM-5 LMM-6, LMM-7, LMM-9 and a check variety (Binamasur-8) of lentil at the pot-yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh during November 2020-March 2021. Seedling were grown in plastic pot filled with field soil and three water stress treatments *viz.* control, 45 and 30% FC were imposed at flowering stage and continued up to maturity. The experiment was laid out following a completely randomized design with three replications. Data on morpho-physiological attributes *viz*., plant height, number of branches plant-^{1}, total dry matter plant-^{1}, harvest index, yield and yield attributes were recorded. Results revealed that almost all the traits decreased significantly in response to water stress. The mutants LMM-7 and LMM-4 were considered as water stress tolerant as they showed better yield performance under stress.

Key words: Water stress, total dry matter, 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 countries. High temperature and water stress are significant abiotic stresses that limit production worldwide (Sehgal *et al*. 2017; Gaur *et al*. 2015). Lentil is commonly grown under rain fed condition, conserves moisture from preceding monsoon season and usually faces water stress (Islam and Ferdousi, 2006; Helai *et al*. 2002). Water stress is one of the most common environmental factors affecting plant growth and yield. In general, lentil is relatively tolerant to drought, severe drought stress experienced during flowering can cause yield and quality losses. Even though lentils are a moderately drought tolerant crop and can grow in reduced water supply, plant productivity can decrease under a range of drought stress conditions. Water stress affects plants at different growth stages, including vegetative (intermittent drought) and reproductive (terminal drought) stages. Terminal drought can suppress nearly all the processes of lentil growth and metabolism, causing heavy yield losses (Bhandari *et al*. 2016), as it reduces flower production, pod number, and seed number (Shrestha *et al*. 2005). During seed filling, sucrose metabolism is crucial in leaves and seeds, as it plays an important role in the hexose-sucrose balance that regulates essential aspects of seed development (Weschke *et al*. 2000). High temperature affects crops through either:

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(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^{o}C) that causes non-recoverable reduction in grain set and yield potential (Vadez *et al*. 2012). 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^{o}C (Roy *et al*. 2012). Lentil is particularly sensitive to high temperature (>30^{o}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^{o}C day time, 23^{o}C night) (Bhandari *et al*. 2016), 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 (Islam and Haque 2020; Tickoo *et al*. 2005). Identifying the plant species resistant/tolerant to drought stress and understanding the tolerance mechanisms can play an important role in coping with drought conditions. Efforts can be given to increase area as well as yield of lentil crops by the use of water stress tolerant variety. The lentil mutants were previously selected on the basis of yield performance and those might have some tolerance to water stress. The present paper reports our results on variation for morpho-physiological attributes *viz*., plant height, number of branches plant-^{1}, total dry matter plant-^{1}, harvest index and yield and yield attributes in lentil mutants under different water regimes to identify water stress tolerant mutants.

A pot experiment was conducted at the pot yard of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh. The experimental site falls under the AEZ (Agro-Ecological-Zone)-9 (Old Brahmaputra Floodplain) of Bangladesh and situated at latitude 24.75°N and longitude of 90.50°E. The soils of the experiment were collected from the field of BINA Farm. The top soil was non-calcareous Dark Grey Floodplain with loamy texture belonging to the AEZ Old Brahmaputra Floodplain. The collected soil was pulverized, inert materials, visible insect pest and plant propagules were removed. Pots are filled with top soils. The pot was 25 cm deep with 27 cm diameter at the top. The soil moisture stresses were calculated based on field capacity (FC). Gravimetric Method determined FC. FC of the soil was treated as 100% FC and 60% of FC (control), 45 and 30% were used as drought stress. Each pot contained 12 kg soil. All soils pots were fertilized with urea, TSP, MP and gypsum @ 0.41, 0.55, 0.30 and 0.26 g pot^{-1} corresponding @ 32, 77, 32 and 50 kg ha^{-1}, respectively. All fertilizers were applied as basal dose. The experiment was carried out with six mutants *viz*., LMI-3, LMM-4, LMM-5 LMM-6, LMM-7, LMM-9 and a check variety (Binamasur-8) of lentil. Seeds were sown in pots on 24 November 2020. Five seeds were sown in each pot and finally one plant was allowed to grow for treatment imposition and data collection. The experiment was set in a two factorial RCBD with three replications. The first factor was lentil genotypes and the second factor

was irrigations: control (60% FC) and drought (45 and 30% FC) stress treatments. Treatments were imposed at flowering stage and continued up to maturity. Cultural practices were followed as and when required. At maturity, data on plant height, number of branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, seed weight plant^{-1}, straw weight plant^{-1}, total dry matter plant^{-1} and harvest index were recorded. Statistical analysis was done and DMRT test adjusted the means.

Results showed that plant height, number of branches plant^{-1}, number of pods plant^{-1} and yield plant^{-1} decreased with increasing water stress (Table 1). The highest values of those parameters were found in control plants and the lowest was recorded in 30% water stress condition. The results conforms the findings of many authors (Gaur *et al*. 2014; Islam *et al*. 1998; Salam and Islam 1994; Islam *et al*. 1993). Seeds plant^{-1}, 1000-seed wt. and HI were significantly reduced by 30% FC compared to control. Under the treatments, LMM-9 produced the longest plant (38.67 cm) and LMM-6 produced the lowest (31.33 cm) (Table-2). LMM-7, LMM-4, LMM-9 and Binamasur-8 had higher number of branches (3.08-3.22). LMM-6 produced the lowest number of branches (2.61). The highest seed weight plant^{-1} was found in LMM-7 (2.47 g) followed by LMM-4 (2.38 g) and LMM-9 (2.38 g) and the lowest in Binamasur-8 (2.01 g). The higher yields of those mutants are due to their higher number of pods plant^{-1}, seeds pod^{-1} and 1000-seed weight. The highest TDM were recorded in LMM-7 (6.27 g) and the lowest in LMI-3 (5.31 g). LMM-7 produced the highest yield (2.97 g) and TDM (6.87 g) under control (Table 3). On the other hand, the lowest yield (1.56 g) and TDM (4.76 g) were found in Binamasur-8 at 30% FC. Plant height, branches plant^{-1} and pods plant^{-1} were decreased up to 36.48, 26.53 and 38.33%, respectively due to water stress compared to control (Table 1). Water stress decreased seeds pod^{-1} and 1000-seed weight up to 4.16 and 2.66%, respectively and seed weight, straw weight, TDM and HI 37.9, 19.48, 19.93 and 21.95%, respectively. The results agree with the findings of Shrestha *et al*. (2005); Salam and Islam (1994). Water stress decreased seed yield and TDM plant^{-1}of LMM-7 and LMM-4 less compared to other genotypes (Table 3). Reduced cell division under water stress may result in shorter plants and less branch number. High biomass production is almost always associated to higher yield and biomass production may be decreased due to lower photosynthesis under stress (Islam and Haque 2020).

Table 1. Effect of different soil moisture levels on morpho-physiological and yield attributes of lentil genotypes during 2020-21

Mutants /variety	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)	TDM plant^{-1} (g)	HI
Control	41.61 a	3.43 a	77.39 a	1.68 a	21.35 a	2.77 a	3.85 a	6.62 a	0.41 a
45% FC	36.48 b	3.08 b	63.39 b	1.66 ab	21.28 a	2.25 b	3.10 c	5.35 b	0.41 a
	(12.32)	(10.20)	(18.09)	(1.19)	(0.32)	(18.77)	(19.48)	(19.18)	(0)
30% FC	26.77 c	2.52 c	47.72 c	1.61 b	20.78 b	1.72 c	3.58 b	5.30 b	0.32 b
	(35.66)	(26.53)	(38.33)	(4.16)	(2.66)	(37.90)	(7.01)	(19.93)	(21.95)

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT.
Figures within parenthesis indicate % decrease at 45 and 30 % FC compared to control.

Table 2. Morpho-physiological and yield attributes of lentil genotypes under water stress during 2020-21

Mutants /variety	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed wt. (g)	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)	TDM plant^{-1} (g)	HI
LMI-3	34.64 c	2.83 b	63.00 cd	1.59 b	20.14 c	2.11 c	3.21 e	5.31 e	0.39 a
LMM-4	34.07 c	3.20 a	64.67 bc	1.65 ab	21.60 b	2.38 ab	3.75 a	6.13 b	0.38 abc
LMM-6	31.33 d	2.61 c	60.78 d	1.71 a	19.96 c	2.11 c	3.40 c	5.51 d	0.37 bc
LMM-7	34.10 c	3.22 a	67.11 ab	1.72 a	21.80 b	2.47 a	3.81 a	6.27 a	0.39 ab
LMM-9	38.67 a	3.08 a	69.33 a	1.64 b	20.16 c	2.38 b	3.61 b	5.99 c	0.39 a
Binamasur-8	36.91 b	3.09 a	52.11 e	1.59 b	23.16 a	2.01 d	3.31 d	5.32 e	0.37 c

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT.

Table 3. Combined effect of genotype and water stress (45 and 30% FC) with control on morpho-physiological and yield attributes in six lentil genotypes during 2020-21

Mutants /variety	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed wt. (g)	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)	TDM plant^{-1} (g)	HI
V_1 x T_0	42.43 ab	3.34 abcd	79.66 b	1.64 a	20.40 d	2.66 b	3.68 d	6.35 c	0.41 ab
V_1 x T_1	36.03 d	2.83 ef	63.66 de	1.62 ab	20.34 de	2.05 d	2.76 h	4.81 gh	0.42 a
	(15.08)	(15.26)	(20.08)	(1.21)	(0.29)	(22.93)	(25.00)	(24.25)	(-2.43)
V_1 x T_2	25.46 hi	2.32 gh	45.66 h	1.50 b	19.67 de	1.60 f	3.17 f	4.78 h	0.33 e
	(39.99)	(30.53)	(42.68)	(8.53)	(3.57)	(39.84)	(13.85)	(24.72)	(19.51)
V_2 x T_0	39.19 c	3.59 a	79.33 b	1.65 a	21.74 bc	2.86 a	3.95 b	6.81 ab	0.41 abc
V_2 x T_1	35.98 d	3.23 cd	67.00 d	1.65 a	21.7 bc	2.46 c	3.40 e	5.87 de	0.41 abc
	(8.19)	(10.02)	(15.54)	(0)	(0.18)	(13.98)	(13.92)	(13.80)	(0)
V_2 x T_2	27.04 h	2.77 f	47.66 gh	1.65 a	21.36 c	1.81 e	3.88 bc	5.69 ef	0.31 ef
	(31.00)	(22.84)	(39.92)	(0)	(1.74)	(36.71)	(1.77)	(16.44)	(24.39)
V_3 x T_0	38.37 cd	3.06 de	76.33 bc	1.73 a	20.24 de	2.68 b	3.95 b	6.63 b	0.40 bcd
V_3 x T_1	32.61 ef	2.60 fg	60.66 ef	1.71 a	20.14 de	2.03 d	2.96 g	5.00 g	0.40 bcd
	(14.98)	(15.03)	(20.52)	(1.15)	(0.49)	(24.25)	(25.06)	(24.58)	(0)
V_3 x T_2	22.99 i	2.17 h	45.33 h	1.67 a	19.48 e	1.61 f	3.29 ef	4.90 gh	0.32 ef
	(29.50)	(29.08)	(40.61)	(3.46)	(3.75)	(39.92)	(16.70)	(26.09)	(20.00)
V_4 x T_0	39.06 c	3.53 ab	78.66 b	1.73 a	21.80 bc	2.97 a	3.88 bc	6.86 a	0.42 a
V_4 x T_1	35.45 de	3.30 bcd	65.00 de	1.73 a	21.79 bc	2.55 bc	3.42 e	5.98 d	0.42 a
	(9.24)	(6.51)	(17.36)	(0)	(0.04)	(14.14)	(11.85)	(12.82)	(0)
V_4 x T_2	27.79 gh	2.84 ef	57.66 f	1.70 a	21.79 bc	1.87 e	4.11 a	5.98 d	0.30 f
	(28.85)	(19.54)	(26.69)	(1.73)	(0.04)	(37.03)	(-5.92)	(12.82)	(28.57)
V_5 x T_0	45.42 a	3.46 abc	85.00 a	1.65 a	20.29 de	2.86 a	3.80 cd	6.66 ab	0.42 a
V_5 x T_1	40.40 bc	3.11 de	72.00 c	1.63 a	20.26 de	2.45 c	3.19 f	5.64 f	0.43 a
	(11.05)	(10.11)	(15.29)	(1.21)	(0.14)	(14.33)	(16.05)	(15.31)	(-2.38)
V_5 x T_2	30.19 fg	2.65 f	51.00 g	1.62 ab	19.92 de	1.82 e	3.82 bc	5.65 f	0.32 ef
	(33.53)	(23)	(40.00)	(1.81)	(1.82)	(36.36)	(-0.52)	(15.16)	(23.80)
V_6 x T_0	45.19 a	3.55 ab	65.33 d	1.64 a	23.61 a	2.55 bc	3.84 bc	6.39 c	0.39 cd
V_6 x T_1	38.41 cd	3.35 a-d	52.00 g	1.61 ab	23.43 a	1.91 de	2.87 gh	4.79 h	0.39 d
	(15.00)	(5.63)	(20.40)	(1.82)	(0.76)	(25.09)	(25.26)	(25.03)	(0)
V_6 x T_2	27.12 h	2.35 gh	39.00 i	1.51 b	22.43 b	1.56 f	3.20 f	4.76 h	0.32 ef
	(39.98)	(33.80)	(40.30)	(7.92)	(4.99)	(38.82)	(16.66)	(25.50)	(17.94)

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT.

Where, V_1: LMI-3, V_2: LMM-4, V_3: LMM-6, V_4: LMM-7, V_5: LMM-9, V_6: BINA-8 and T_0: Control, T_1: 45% FC, T_2: 30% FC. Figures within parenthesis indicate % decrease at 45 and 30 % FC compared to control.

Plant height, number of branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, seed weight plant^{-1}, straw weight plant^{-1}, total dry matter plant^{-1} and harvest index of the lentil genotypes decreased significantly in response to water stress. Plant height, branches plant^{-1} and pods plant^{-1} were decreased up to 36.48, 26.53 and 38.33%, respectively due to water stress compared to control. Water stress decreased seeds pod^{-1} and 1000-seed weight up to 4.16 and 2.66%, respectively and seed weight, straw weight, TDM and HI 37.9, 19.48, 19.93 and 21.95%, respectively. The mutants LMM-7 and LMM-4 were considered as water stress tolerant as they showed better yield performance under water stress.

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