Research in
AGRICULTURE, LIVESTOCK and FISHERIES
ISSN : P-2409-0603, E-2409-9325
An Open Access Peer-Reviewed International Journal

Article Code: 0234/2019/RALF **Res. Agric. Livest. Fish.**
Article Type: Original Research **Vol. 6, No. 2, August 2019 : 253-262.**

BINAMASUR-10, THE FIRST DROUGHT TOLERANT LENTIL VARIETY REGISTERED IN BANGLADESH

Snigdha Roy[1], Dinesh Chandra Roy[1*], Md. Mahmud Al Noor[1], Shampa Rani Ghosh[2], Farid Ahmed[3] and Deboprio Roy Sushmoy[4]

[1]Plant Breeding division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh; [2]Magura Substation, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh; [3]Department of Horticulture, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh; [4]Department of Crop Botany, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

***Corresponding author:** Dinesh Chandra Roy; E-mail: dinesh.rk.bau@gmail.com

ARTICLE INFO

Received
05 July, 2019

Revised
23 August, 2019

Accepted
24 August, 2019

Online
31 August, 2019

Key words
Lentil
Drought
PEG
Germplasm

A B S T R A C T

A study was initiated to identify high yielding, drought-tolerant lentil genotype from 150 local and exotic lentil germplasm collected from International Centre for Agricultural Research in the Dry Areas (ICARDA) including some advanced lines from Bangladesh Institute of Nuclear Agriculture in 2006. During Preliminary Yield Trial, the genotype LG-208 produced 18.62% and 29.47% higher seed yield than the check variety BARI Masur-5 at Ishurdi and Magura respectively. Through advanced yield trials, regional yield trials, on-station and on-farm trials from 2010-11 to 2015-16, it was found that exotic germplasm LG-208 showed better performance than check (BARI Masur-5). Genotype LG-208 had significantly highest seed setting and harvest index under 20% polyethylene glycol **(**PEG) induced drought and considered as the drought tolerant which showed similar performance with field trials in drought-prone areas (Chapainawabganj and Rajshahi). Based on the superior performance of exotic germplasm LG-208 line, BINA has decided with the National Seed Board (NSB) of Bangladesh to register this line as a high yielding drought tolerant lentil variety, named as Binamasur-10 in 2016.

To cite this article: Roy S, DC Roy, MMA Noor, SR Ghosh, F Ahmed and DR Sushmoy, 2019. Binamasur-10, the first drought tolerant lentil variety registered in Bangladesh. Res. Agric. Livest. Fish. 6 (2): 253-262.

INTRODUCTION

Lentil (*Lens culinaris* Medik) 2n =14, of the family Leguminosae, is one of the ancient food crops originated in the Fertile Crescent of the Middle East (Renfrew, 1969). It was first domesticated in Southern Turkey; from there it moved to Europe and Asia (Ladizinsky, 1979; Cubero, 1984). Lentil is one of the oldest annual food crops that have been grown over 8,000 years (Oplinger *et a*l. 1990; Dhuppar *et al*. 2012). It is an annually sown, cool-season food legume crop. Lentil placed the second position according to area and production but stand first in terms of usage among the pulse crops in Bangladesh (Afzal *et al*. 1999). As a food, its grain contains high amount of protein (19-35.5 %), 59% carbohydrate, 0.7% fat, minerals (K, P, Fe, Zn) and vitamins (β-carotene) for human nutrition (Bhatty, 1988; Afzal *et al*. 1999). Due to its high protein content and quality, it is called 'poor man's meat' (Bhatty, 1988). Malnutrition has become a threatening issue in Bangladesh. Pulses can play an important role in this aspect. Moreover, its straw is a valued animal feed (Erskine *et al*. 1990) and its cultivation also helps to improve soil nutrient status by adding nitrogen, carbon and organic matter to soil (Sarker and Kumar, 2011). The priority of agriculture today has been shifted towards nutritional security and climate-smart agriculture. Drought stress is an extremely universal and disadvantageous cause for crop yield loss in several areas of the world where lentils are grown by forming a community (McWilliams, 1986; Shrestha *et al.,* 2006). Lentil crop when sown during autumn or winter in South Asian countries as well as Mediterranean environments, are to face, occurrence of intermittent drought during the vegetative growth and terminal drought throughout their reproductive period when temperatures are ever-increasing and rainfall is declining (Yusuf *et al.,* 1979; Siddique *et al.,* 1999; Shrestha *et al.,* 2006). Lentil responses to drought are quite disagreeing; some workers reported that lentil is most sensitive to drought at seedling and flowering stages (Yusuf *et al.,* 1979), while others reported that it is sensitive to drought at flowering and pod formation stages (Shrestha *et al.,* 2006; Mishra *et al.,* 2014, 2016). Drought stress is responsible for reductions in plant growth, root functioning, leaf area development, cell membrane stability, alterations in biomass and nitrogen allocation in different plant parts (Hamidi and Erskine, 1996; Kurdali *et al.,* 1997; Sio-SeMardeh *et al.,* 2006; Shrestha *et al.,* 2006; Gunes *et al.,* 2008; Singh *et al.,* 2013; Mishra *et al.,* 2014).

Therefore, the present investigation was undertaken to develop drought-tolerant lentil variety with the potential to achieve high yields in difficult climatic conditions. The release of this variety, named Binamasur-10 is the result of a long-term collaborative research partnership between ICARDA and the Bangladesh Institute of Nuclear Agriculture. It was selected from among 150 lines that were provided by ICARDA including some advanced lines of BINA as it demonstrated outstanding performances in field trials, which were held in the drought-prone zones of the Rajshahi and Chapainwabgonj districts. Binamasur-10, with its drought-tolerant trait, is expected to be gradually adopted throughout the North-Western drought-prone districts of the country.

MATERIALS AND METHODS

Lentil accessions were collected from International Centre for Agricultural Research in the Dry Areas (ICARDA) including some advanced mutant lines from Plant Breeding Division, BINA. The field evaluation with 150 lentil accessions was conducted at BINA sub-stations Ishurdi and Magura, representative lentil growing areas of Bangladesh during 2006-2007. Thirteen accessions were selected based on yield and yield contributing characters. Preliminary yield trial was conducted with these 13 accessions along with popular, high yielding and widely cultivated variety BARI Masur-5 as a check to compare the performance of the accessions at Ishurdi and Magura during 2008-09, the study followed the randomized complete block design with three replications. Unit plot size was 2 m x 1.2 m. Row to row and plant to plant distances were 30 cm and 2-3 cm, respectively. Nine promising lines were selected based on earliness, disease reaction, yield and yield contributing characters. The advanced yield trials were conducted with these nine promising lines and BARI Masur-5 at the same locations during 2010-2011. The regional yield trials were also conducted with two accessions (amongst from nine promising lines) and BARI Masur-5 at Magura and Ishurdi during 2011-12. Yield related data were recorded from the study. Based on the yield performance of the previous years, on-station and farmers' field trials were also carried out with two promising lines and a popular check with BARI Masur-5. On-station trials (during 2012-13 & 2015-16) were replicated in thrice at Ishurdi, Magura,

Rajshahi and Chapainawabganj and farmers' field trials (during 2012-13 & 2015-16) were non- replicated and practised at Ishurdi, Magura, Rajshahi and Chapainawabganj. The unit plot size was 10 m x 10 m in each location. Here also only yield data were recorded. Mean differences of different parameters including seed yield were tested by Duncan's Multiple Range Test (Steel and Torrie, 1960). Three accessions along with two check varieties, BARI Masur-4 and Utfala were tested against stemphylium blight, Rust and root rot/wilt at BINA sub-station farm Ishurdi and Magura. The incidence of foot and root rot of lentil was recorded at 10 days interval. The incidence of the disease was calculated by the following formula:

Incidence (%) = Total number of plants/Number of infected plants *100
Foot and root rot of lentil was recorded according to the scale below

Scale	Infected plants
1	0-5%
3	5-10%
5	21-40%
7	61-80%
9	100%

(Adopted from ICARDA International Nursery Guideline described for small grain legumes)

The incidence and severities of stemphylium blight were recorded at maximum pod ripening stage of crop growth. Stemphylium blight rating was recorded according to the scale below (Bakr and Ahmed 1992).
Scored on a scale of 0-5, where

0 = No infection (highly resistant, HR)
1 = Few scattered leaf infected but no twig blighted (Resistant, R)
2 = 5-10% leaf infected and/or few scattered twig blighted (Moderately resistant, MR)
3 = 11-20% leaf infected and/or 1-5% twig blighted (Moderately susceptible, MS)
4 = 21-50% leaf infected and/or 6-10% twig blighted (Susceptible, S)
5 = Above 50% leaf infected and/or more than 10% twig blighted (Highly susceptible, S)

Rust severities (RS) were scored on a 1-9 scale (Khare, Bayaa and Beniwal, 1993).
RS (%) = (Number of plants/ scale x scale value)/ Highest scalex total number of plants*100

Drought screening was carried out with three varieties and four lines at the glasshouse of Sibersdorf Laboratory in Vienna. Simultaneously, on-station trial was carried out at BINA sub-station Chapainawabganj and farmers field trials were conducted at drought-prone areas i.e in Rajshahi and Chapainawabganj district under rainfed condition. Four concentrations 0.0%, 10%, 15%and 20% of polyethene glycol (PEG-6000) were used to induce plant-water deficit stress in an aerated hydroponic system. For evaluating tolerance in the studied lines, STI (Stress Tolerance Index) were computed (Fernandez, 1992) as follow:

STI = Yp *Ys/n

where, Y*Pi* and Y*Si* are the seed yield of lines in normal and stress conditions, respectively, and n is the mean of all lines in normal conditions.

RESULTS AND DISCUSSIONS

Crop plants can be improved by natural or induced genetic variations through mutation, gene recombinant and germplasm collection (Ghafoor *et al*., 1989).Through the preliminary yield trial during Robi 2008-2009, 13 accessions were selected comparing with the check variety BARI Masur-5 following randomized complete block design with three replications at Ishurdi (Table 1) and Magura (Table 2). From the Table 1, it was

observed that significant differences were found for all the characters among the accessions except number of branches per plant. The shortest duration was observed for the accessions LG-96, and LG-22. LG-129 was the shortest and LG-137 was the tallest among the tested accessions for plant height. LG-208 produced the highest number of pods followed by LG-73. The boldest seed with the highest 100-seed weight was observed in the accessions LG-73, LG-208 and LG-137. The accession LG-208 produced higher number of pods and the highest seed yield of 1987 kg/ha. Performance of accessions grown at Magura is presented in Table 5. Maturity period was the shortest for the accessions LG-96. The accession LG-73 was the tallest among the other accessions and the check variety. In case of 100-seed weight the highest 100-seed weight was observed in LG-208. Accessions, LG-208 and LG-73 produced higher seed yield of 1845 kg/ha and 1816 kg/ha and yield increased 31.21% and 22.11%, over the check, respectively. Evaluating the performance of the accessions, the better performed nine lines were selected for advanced yield trial with a popular check variety at Ishurdi and Magura during Rabi 2010-2011 (Table 3).

Table 1. Performance of 13 promising accessions along with a check variety, BARI Masur- 5 grown at Ishurdi during 2008-2009

Accessions	Maturity period (days)	Plant height (cm)	Branches /plant (no.)	Pods/ plant (no.)	100-seed weight (g)	Seed yield (kg/ha)	% yield increase over check
Barimasur-5 (Check)	115.3ab	37.4bcd	3.1bc	146.7cd	1.50efg	1675cde	
LG-107	110.7d	35.4cd	3.6ab	140.0cdef	1.53def	1658cde	
LG-138	117.3ab	41.5b	3.1bc	98.9 f	1.46efgh	1600de	
LG-143	117.3ab	40.5b	3.5abc	101.3f	1.33h	1420ef	
LG-73	112.0cd	39.3bc	3.6ab	171.7abc	1.70abc	1879abc	13.83
LG-208	111.3d	38.3bcd	3.7a	188.7ab	1.70abc	1987ab	21.15
LG-95	116.7ab	38.4bcd	3.6ab	154.0bc	1.46efgh	1754bcd	
LG-114	114.7bc	38.4bcd	3.1bc	103.0ef	1.43fgh	1700cd	
LG-129	116.0ab	34.9d	3.3bc	131.7cdef	1.50efg	1729bcd	
LG-22	109.7d	40.5b	3.1bc	133.7cdef	1.50efg	1616cde	
LG-117	110.0d	38.6bcd	3.5abc	143.3cde	1.56cdef	1662cde	
LG-150	110.3d	40.8b	3.5abc	143.3cde	1.50efg	1762bcd	
LG-96	108.7d	35.5cd	3.2bcd	145.7cd	1.36gh	1683cde	
LG-137	118.7a*	45.7a	2.8cd	111.7def	1.70abc	1325f	
CV %	1.1	4.2	8.3	11.5	4.2		

*Figures followed by same letter in a column did not differ significantly at 5% level of probability by DMRT

The accessions LG-150 was the tallest among the entries. The accession LG-208 produced the highest number of pods/plant. The shortest maturity period was required for the entry LG-208 and also the highest seed yield was found in LG-208 at Ishurdi and Magura. Considering the superior performance of the selected accessions, multi-location yield trials were conducted with three selected line at three locations: Ishurdi, Magura and Jessore during Robi 2011-12 (Table 4). Results revealed that the accession LG-208 produced the highest number of primary branches as well as the highest number of pods per plant. This accession LG-208 also produced the highest seed yield at all the locations. Accession LG-208 also required the shortest maturity period. On-station and farmers' field trials were carried out with two promising lines and a check BARI Masur-5 at Ishurdi, Magura, Rajshahi and Chapainawabganj. On-station trials were replicated and farmers' field trials were non-replicated. Only seed yield per plot was recorded in Kg/ha. The exotic line LG-208 produced the highest seed yield in the research management practice at all the locations (Table 5). Similar trend of seed yield was found by the lines in farmers' management practices (Table 6). Average seed yield of 1852 and 1780 kg per hectare, for LG-208 and LG-209, respectively (Table 7).

Table 2. Performance of 13 promising accessions along with a check variety, BARI Masur-5 grown at Magura during 2008-2009

Accessions	Maturity period (days)	Plant height (cm)	Branches /plant (no.)	Pods/plant (no.)	100-seed wt. (g)	Seed yield (kg/ha)	% yield increase over check
Barimasur-5 (Check)	104.7dcde	32.3bc	2.0abcdef	106.7bc	1.7b	1425 cde	
LG-107	103.3def	32.3bc	2.4ab	100.7bcd	1.7bc	1620 abcd	
LG-138	107.3b	33.7bc	2.1abcde	102.0bcd	1.5cde	1537 abcd	
LG-143	106.7bc	34.8bc	2.1abcdef	77.6cd	1.4e	1329de	
LG-73	105.7bcd	34.6bc	2.4abc	112.6abc	2.0a	1816ab	22.11
LG-208	104.7cde	32.5bc	2.3abcd	121.3ab	2.1a	1845ab	31.21
LG-95	105.7bcd	34.2bc	2.1abcdef	104.7bc	1.6cd	1470de	
LG-114	101.7fgh	33.4bc	1.7ef	91.3bcd	1.5de	1541 bcde	
LG-129	100.3gh	30.3c	1.5f	80.0cd	1.5de	1400de	
LG-22	100.7gh	30.7bc	1.8cdef	86.0cd	1.5cde	1429de	
LG-117	102.3efg	31.1bc	2.0abcdef	87.6bcd	1.7bc	1220e	
LG-150	100.0gh	35.8b	1.7ef	104.7bc	1.6cd	1541 bcde	
LG-96	99.3h	31.1bc	1.8def	80.6cd	1.4e	1416 de	
LG-137	110.3a*	42.0a	1.9bcdef	68.6d	2.0a	1233 e	
CV %	0.9	5.9	10.7	13.8	3.5		

*Figures followed by same letter(s) in a column did not differ significantly at 5% level of probability by DMRT

Table 3. Mean of yield and yield contributing characters of eight promising accessions and a check variety BARI masur-5 during**,** Ishurdi and Magura during 2010-2011

Strains	Plant height (cm)	Branches (No.)	Pods (No.)	Maturity (days)	Seed yield (kg/ha)		
					Ishurdi	Magura	combined
BARI masur-5	40.1dc	2.2bc	111e	104c	1858bcd	1611d	1737cde*
LG-9	42.9abc	2.4bc	115de	103cd	1881bc	1633cd	1755cde
LG-110	42.0bcd	2.7a	135bc	102de	2061b	1620d	1840bc
LG-107	42.1bcd	2.1bc	108e	103cd	1804cd	1813bc	1809bcd
LG-129	36.2e	2.2bc	118de	103cd	1372e	1764bcd	1566f
LG-135	43.8ab	2.4bc	130bcd	108a	1665d	1678cd	1669ef
LG-137	40.3d	2.5ab	133bc	103cd	2016bc	1345e	1678def
LG-150	45.0a	2.1c	126cd	108a	2007bc	1651cd	1831bc
LG-208	39.ed	2.5ab	142b	101e	1962bc	1899ab	1930b

*Figures followed by same letter(s) in a column did not differ significantly at 5% level of probability by DMRT

Table 4. Mean of yield and yield contributing characters of three promising accessions and a check variety, BARI Masur-5 during 2011-12 at two locations (Ishurdi and Magura)

Germplasm/ variety	Plant height (cm)	Primary branches (no.)	Pods (no.)	Maturity (days)	Seed yield (kg/ha)			
					Ishurdi	Magura	Jessore	Average
LG-209	37.1	2.1c	112.1b	117a	1433c	1977ab	1662b	1690
LG-208	38.3	3.0a	132.2a	110b	2090a	2037a	1950	2025
BARI masur-5	39.0	2.8a	103.7b	117a	1683b	1792b	1593b	1689

*Means followed by same letter(s) in a column did not differ significantly at 5% level of probability by DMRT

Table 5. Seed yield of selected lines and check grown at research station during 2012-13 and 2015-16

Lines/Variety	Seed yield (kg/ha)						
	2012-13			2015-16			
	Ishurdi	Magura	Average	Ishurdi	Magura	Chapainawabganj	Average
LG-209	2120	1924	2022	1912	1860	1540	1770
LG-208	2132	1940	2036	1900	1880	1760	1846
BARI Masur-5	2051	1900	1975	1870	1780	1550	1733

Table 6. Seed yield of selected lines grown at farmer's field during 2012-13 and 2015-16

Lines/ Variety	Seed yield (kg/ha)								
	2012-13					2015-16			
	Magura	Natore	Rajshahi	Chapain	Average	Ishurdi	Chapain-1	Chapain-2	Average
LG-209	2011	1524	1610	1660	1701	1960	1473	1450	1627
LG-208	2000	1620	1690	1700	1767	1912	1730	1640	1760
BARI Masur-5	1960	1590	1650	1630	1707	1920	1420	1410	1583

Table 7. Comparative seed yield (kg/ha) of the selected germplasm/variety grown at research station and farmer's field during 2012-13 and 2015-16

Genotype/ Varity	Seed yield (kg/ha)				
	Research management (kg/ha)		Farmer's management (kg/ha)		Average
	2012-13	2015-16	2012-13	2015-16	
LG-209	2022	1770	1701	1627	1780
LG-208	2036	1846	1767	1760	1852
BARI masur-5	1975	1733	1707	1583	1749

Table 8. Incidence of root rot/wilt disease in some selected accessions/ varieties of lentil at Ishurdi and Magura

Genotypes/Variety	Root rot/wilt (Scale 1-9)			
	2006-07		2007-08	
	Ishurdi	Magura	Ishurdi	Magura
LG-206	16.5	12.8	14.5	16.8
LG-903	17.4	15.6	13.4	15.6
LG-208	11.2	11.3	9.2	11.3
BARI masur-4	18.5	16.5	17.2	18.5
Utfala	19.8	20.0	19.7	20.0

Table 9. Incidence of stemphylium blight disease in some selected accessions/varieties of lentil at Ishurdi and Magura

Genotypes/Variety	Stemphylium blight (0-5 scale)			
	2006-07		2007-08	
	Ishurdi	Magura	Ishurdi	Magura
LG-206	MS	MS	MS	MS
LG-903	S	MS	MS	MS
LG-208	MR	MR	MS	MR
BARI masur-4	MS	MR	MS	MS
Utfala	S	S	S	S

S = Susceptible, MS = Moderately Susceptible, MR = Moderately Resistant

Table 10. Incidence of rust in some selected accessions/varieties of lentil at Ishurdi and Magura

Genotypes/Variety	Rust severity (1-9 scale)			
	2006-07		2007-08	
	Ishurdi	Magura	Ishurdi	Magura
LG-206	3.1	4.8	4.1	4.6
LG-903	4.9	4.2	4.9	4.8
LG-208	3.5	2.5	3.6	2.1
BARI masur-4	3.9	2.9	4.9	3.9
Utfala	5.0	4.9	4.9	4.6

Table 11. Mean of seed yield and harvest index of seven genotypes in hydroponic system of PEG induced drought during 2014 at glasshouse, Sibersdorf, Vienna

Genotype	Seed yield (g/plant)				Harvest index (%)			
	0%	10%	15%	20%	0%	10%	15%	20%
BARI Masur-7	1.20 c	0.60 b	0.27 bc	0.01 b	0.646	0.743	0.658	0.159
LM-512-1	0.55 a	0.33 a	0.10 a	0.00 a	0.716	0.856	0.330	0.095
LG-208	1.10 c	0.49 a	0.36 c	0.19 c	0.525	0.633	0.952	0.619
LM-206-2	0.41 a	0.29 a	0.21 ab	0.01 b	0.212	0.754	0.300	0.137
LM-206-1	0.52 a	0.39 a	0.13 a	0.00 a	0.316	0.843	0.510	0.064
BARI- Masur-6	0.80 bc	0.56 b	0.33 c	0.04 c	0.486	0.865	0.855	0.187
Binamasur-6	1.13 c	0.59 b	0.26 bc	0.00 a	0.392	0.790	0.392	0.043

Table 12. Stress Tolerance Index (STI) in seven genotypes of lentil under normal (Yp) and water stress (Ys)

Genotype	Yp (g per plant) 0% PEG	Ys (g per plant) 20% PEG	STI
BARI Masur-7	1.20c	0.01b	0.048
LM-512-1	0.55a	0.00a	0.000
LG-208	1.10c	0.19c	0.836
LM-206-2	0.41a	0.01b	0.016
LM-206-1	0.52a	0.00a	0.000
BARI Masur-6	0.80bc	0.04	0.066
Binamasur-6	1.13c	0.00	0.000

Disease reaction against root rot and wilt complex, stemphylium blight and rust were examined in field from 2006 to 2008 at Ishurdi and Magura. Results are presented in Table 8, 9 and 10. The test accessions showed less infection than the check variety. The application of Rovral 50WP can control the disease when sprayed three times at an interval of 7 days starting from the initiation of the disease. The accession LG-208were found with less disease incidence against root rot compared to the susceptible and resistant variety Utfala and BARI Masur-4 (Table 8), respectively and this line also showed moderately resistant to moderately susceptible to stemphylium blight under natural condition (Table 9). The cultivar Utfala is highly susceptible to stemphylium blight which is similar to the present findings (Sarker *et al*. 2004). Rust is also a major foliar disease in Bangladesh but it can be controlled with seed treatment. All the tested accessions along with a check variety, LG-208 showed moderately resistant to moderately susceptible to the disease. Genotype LG-208 had significantly highest seed setting and harvest index under 20% PEG induced drought and considered as the most tolerant which is correlated with field trials in drought prone areas (Chapainawabganj and Rajshahi). Drought screening was carried out with three varieties and four lines at the glasshouse of Sibersdorf Laboratory in Vienna. Drought stress was imposed to 14-days old seedlings. Observations were recorded on seed yield (Table 11). Results of analysis of variance showed that significant differences exist in terms of yield and harvest index between normal and stress condition. It indicates that not only the levels of drought induction had different effects on characters, but studied /varieties/lines had also different reactions to drought stress. Kumar *et al.* (2012) observed high diversity for biological yield, seed yield and HI in 43 genotypes of lentil in drought stress condition. The results revealed that drought stress decreased traits of seed yield and harvest index and it was clear that reaction of characters due to drought stress was different. Drought stress or water deficient had significant impact on yield and its components and in a study of Panahyan-e-Kivi *et al.* (2009) drought stress reduced the pod number per plant, seed number per pod and 100

grain weight. Stress Tolerance Index (STI) introduced by Fernandez (1992) is a perfect tool to select, determine and identify the genotypes that have the maximum yield in normal and stress conditions. STI index revealed that the studied lines had high diversity in reflected to drought stress (Table11). While lines LG-208 and BARI Masur-6 in normal condition and in stress condition had maximum values of seed yield and harvest index, line LM-206-1, LM-512-1 and LM-206-2 had the lowest productivity in both conditions. Seed yield of LG-208 was more than BARI Masur-6 in both conditions. In accordance with Table 11, it revealed that genotypes LG-208 was the most tolerant line comparing to other lines. Therefore to cultivate in the area where lentil lines faces drought stress, this line might be recommended. On other hand, lines LM-206-1, LM-512-1, LM-206-2 and Binamasur-6 were the most sensitive to drought stress. This line is also tolerant to rust and stemphylium blight and seedling mortality rate is less than the other traditional varieties. In respect of yield potential and diseases reaction, LG-208 performed the best over year and location. Therefore, this exotic line has been registered as a variety, Binamasur-10 for cultivation all over the country.

CONCLUSION

Climate change is an added concern, increasing overall temperatures, altering the distribution of precipitation and aggravating drought conditions in numerous regions worldwide. Drought stress caused the substantial reduction in yield and its components. Results indicated that considerable variations exist related to yield and harvest index among the lentil varieties and lines. These traits could be used for screening drought tolerance in lentil. The results revealed that yield and harvest index were the main keys for indirect selection for tolerance to water stress. The exotic lentil line LG-208 i.e., Binamasur-10 has been found that had remarkable tolerance to drought stress. Binamasur-10, developed by Bangladesh Institute of Nuclear Agriculture (BINA) in collaboration with International Centre for Agricultural Research in the Dry Areas (ICARDA), is the first drought tolerant lentil variety in Bangladesh that can provide more yields (8-10%) than the recent cultivated varieties in the northern districts of the High Barind Tract Rajshahi and Chapai Nawabganj. The variety has also economic significance to other districts that are Kushtia, Magura, Chuadanga, and Ishurdi. This variety can be cultivated in drought prone area to get a better yield.

ACKNOWLEDGEMENT

The authors sincerely express their gratitude to the authority of International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria. especially to Dr. Ashutosh Sarker, Regional Coordinator and Food Legume Breeder at ICARDA based in New Delhi, India for providing diverse germplasm of lentil which is the key to this drought tolerant lentil variety development.

REFERENCES

1. Afzal MA, Bakr MA and Rahman ML, 1999. Lentil cultivation in Bangladesh.Lentil, Blackgram and Mungbean Development Pilot Project, Pulses Research Station, BARI, Gazipur-1701.
2. Afzal MA, Bakr MA, Hamid A, Haque MM and Aktar S, 2003. Lentil in Bangladesh. Lentil, balckgram and mungbean pilot project, Bangladesh Agrilcultural Research Institute, Gazipur, Bangladesh.
3. Bhatty RS, 1988. Composition and quality of lentil (*Lens culinaris* Medik): a review. Canadian Institute of Food Science & Technology Journal, 21: 144-160.
4. Bakr MA and Ahmed F, 1992. Development of stemphylium blight of lentil and its chemical control. Bangladesh Journal of Plant Pathology, 8 (1 and 2): 39-40.
5. Cubero JI, 1984. Taxonomy, distribution and evolution of the lentil and its wild relatives. In: *Genetic Resources and Their Exploitation* - Chickpea, Faba Bean and Lentils. (Eds.): J.R. Witcombe and W. Erskine. MartinusNijhoff / Dr.W.Junk Publishers, The Hague/ Boston/ Lancaster. pp. 187-204.

6. Dhuppar P, Biyan S, Chintapalli B and Rao S, 2012. Lentil Crop Production in the Context of Climate Change: An Appraisal. Indian Research Journal Of Extension Education. 2 (Special Issue): 33-35.
7. Erskine W, Tufail M, Russell A, Tyagi MC, Rahman MM and Saxena MC, 1994. Current and future strategies in breeding lentil for resistance to abiotic and biotic stresses. *Euphytica,* 73: 127-135.
8. Fernandez GC, 1992. Effective selection criteria for assessing plant stress tolerance. *In:* Kuo CG (ed.) Adaptation of Food Crops to Temperature and Water Stress.Proceedings of International Conferences for water stress. Taiwan: Asian VegetableResearch Development Center. Pp. 257-270.
9. Gunes A, Inal A, Adak MS, Bagci EG, Cicek N and Eraslan F, 2008. Effect of drought stress implemented at pre or post-anthesis stages on some physiological parameters as screening criteria in chickpea cultivars. Russian Journal of Plant Physiology, 55: 59-67.
10. Hamdi A and Erskine W, 1996. Reaction of wild species of the genus Lens to drought. Euphytica, 91: 173-179.
11. Khare MN, Bayaa B and Beniwal SP, 1993. Selection methods for disease resistance in lentil. Breeding for Stress Tolerance in Cool-Season Food Legumes. John Wiley and Sons. pp. 107-121
12. Kurdali F, Kalifa K and Al-Shamma M, 1997. Cultivar differences in nitrogen assimilation, partitioning and mobilization in rain-fed grown lentil. Field Crops Research, 54: 235-243.
13. Kumar J, Basu PS, Srivastava E, Chaturvedi SK, Nadarajan N and Kumar S, 2012. Phenotyping of traits imparting drought tolerance in lentil. Crop and Pasture Science, 63: 547-554.
14. Ladizinsky G, 1979. The origin of lentil and its wild genepool. Euphytica, 28: 179-187.
15. Mishra BK, Srivastava JP and Lal JP, 2014. Drought stress resistance in two diverse genotypes of lentil (*Lens culinaris* Medik.) imposed at different phenophases. Journal of Food Legumes, 27(4): 307-314.
16. Mishra BK, Srivastava JP, Lal JP and Sheshshayee MS, 2016. Physiological and biochemical adaptations in lentil genotypes under drought stress. Russian Journal of Plant Physiology, 63(5): 695-708.
17. McWilliam JR, 1986. The national and international importance of drought and salinity effects on agricultural production. Australian Journal of Plant Physiology, 13: 1–13.
18. Oplinger ES, Hardman LL, Kaminski AR, Kelling KA and Doll JD, 1990. Departments of Agronomy and Soil Science, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin-Madison and Department of Agronomy and Plant Genetics, University of Minnesota.
19. Panahyan-e-Kivi, M, Ebadi A, Ahmad T and Jamaati-e-Somarin S, 2009. Evaluation of yield and yield components of lentil genotypes under drought stress. Research Journal Of Environmental Sciences, 3**:** 456-460.
20. Renfrew JM, 1969. The archeological evidence for the domestication of plants, methods and problems. In: The domestication and exploitation of plants and animals. (Eds). P.J. Ucko& G.W. Dimblery Aldine, Chicago.
21. Sio-Se Mardeh A, Ahmadi A, Poustini B and Mohammadi V, 2006. Evaluation of drought resistance indices under various environmental conditions. Field Crops Research, 98: 222-229.
22. Shrestha R, Turner NC, Siddique KH, Turner DW and Speijers J, 2006a. A water deficit during pod development in lentils reduces flower and pod numbers but not seed size. Australian Journal of Agricultural Research, 57: 427- 438.
23. Shrestha R, Turner NC, Siddique KH and Turner DW, 2006b. Physiological and seed yield responses to water deficits among lentil genotypes from diverse origins. Australian Journal of Agricultural Research*,* 57: 903-915.
24. Sarker A and Kumar S, 2011. Lentils in production and food systems in West Asia and Africa. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. Grain Legumes, 57: 46-48.
25. Singh AK, Srivastava JP, Singh RM, Singh MN and Kumar M, 2013. Selection parameters for pigeonpea (*Cajanuscajan* L. Millsp.) genotypes at early growth stages against soil moisture stress. Journal of Food Legumes, 26 (3&4): 97-102.
26. Yusuf M, Singh NP and Dastane NG, 1979. Effect of frequency and timings of irrigation on grain yield and water use efficiency of lentil. Annals of Arid Zone, 18: 127-134.