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Variability for Different Characters and Screening for Heat Tolerance in Lentil

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Abstract

Climate change and subsequent global temperature rise has become a threat to pulse production. Terminal heat stress results in forced maturity with low yield. The most worrying part of prediction is the estimated increase in winter and summer temperature by 3.2 degrees and 2.2 degrees Celsius respectively by 2050. So tolerant and early maturing germplasms that are well suited to heat stress environment are needed to enhance and sustain lentil production in present condition. Studies were conducted to screen a large number of lentil germplasms for heat tolerance in laboratory and field condition. Firstly fiftyfour lentil germplasms were selected for this experiment which are collected from different parts of West Bengal, Berhampore Pulses and Oil Seed Research station and from NBPGR , New Delhi. The seeds were sown in randomized block design (RBD) with 3 replications. The observations were recorded for each genotypes in both normal as well as late sown conditions. Data collection and analysis were done for the eight different characters. Over three years of study, a very close correspondence between PCV and GCV was observed for different characters. GCV is high for pods/ plant, seed yield/ plant.In another experiment seeds of fifty four cultivars of lentil were grown in plant growth chamber at 34 degree Celsius with 70% relative humidity. Germination percentage was calculated. After one month of survival percentage were evaluated. Cell membrane thermostability test is an useful way to evaluate heat tolerance. Relative injury was calculated. All the germplasms were further evaluated in field condition in Baruipur experimental farm. One field trial was conducted in normal sowing condition and another in late sowing condition. Considering the laboratory (including growth chamber study and cell membrane thermostability test) and field screening it was observed that Asha, Ranjan, Moitree, IC 201693, Howrah local 2, IC 201749, WBL 3, WBL 13, IC 208356, IC 208329 gave overall better performance n respect to heat tolerance.

Introduction

Lentil is an important cool season crop of rain fed agriculture and is one of the importantpulse crops for varying cereal-based cropping systems. It is a nutritious rabi pulse crop andplays an important role in the food and nutritional security of millions. In global context, India is the largest producer of lentil, accounting for about 27% contribution of the world's 3.65 million tons of lentil production in 2005 (FAOSTAT 2006). States like Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar and West Bengal together account for 80-90% of total area and production of lentil, respectively (Rao *et al*., 2011). It can be a source of protein for the poor people who cannot be able to afford animal protein. Lentil grain isnutritious, rich in protein, minerals and vitamins. Rice and lentil dal is a popular every daydish of the poor of Bangladesh, Nepal and India (Sarker *et al*. 2009). The benefit of it's Cultivation is soil fertility. Its cultivation improves soil nutrient condition by adding nitrogen,carbon and organic matter stimulating sustainable crop production system (Sarker *et al*., 2004). The productivity of lentil has not been able to increase due to shortening of its growth cycle due to terminal heat stress and shorter winter period, as it grows well in drier and cool climates. Heat stress, specially when linked to moisture stress, even for a few days during flowering and pod filling drastically reduces seed yield in lentil because of damage to reproductive organs, accelerated development and shortened reproductive period (Boote *et al*., 2005; siddique et al. 2002). With atmospheric temperatures expected to rise due to climate change, an increased

incidence of heat stress in lentil may be anticipated (cutforth 2000).

Lentil is highly sensitive to heat at flowering time. High temperature during flowering causes heavy loss due to flower drop and pod abortion. It can reduce seed set and accelerate senescence simultaneously reducing the seed yield. Since lentil is a highly remunerative crop, it grows well under low input situation and serves as a valuable and balanced source of protein coupled with its ability to thrive on relatively marginal land there is a immense scope to introduce the crop in rabi season, which not only gives additional profit to farmers at the same time increases the fertility of the soil by fixing atmospheric oxygen via root noodules. So the present investigation was undertaken to screen some high yielding, heat tolerant germplasms of lentil which can thrive well in present climatic situation. The global mean temperature increased by 0.6^0C between 1990 and 2000 and is expected to increase by another 1.4 to over 5^0C by 2100 (Houghton *et al*., 2001; McCarthy *et al*., 2001). It is also estimated that about 11.7 million ha of rice area in India, currently remains fallow after late harvest of rice during the winter season in the central and north-eastern India (Subbarao et al. 2001). These lands can be used in the expansion of lentil cultivation with the germplasms capable of standing heat stress. Heat stress is expected to be gradually more important constraint in near future due to climate change and global warming. It can be envisioned that the increases in temperature will have more adverse effects on cool-season crops than the rainy-season crops (Kumar, 2006).

Lentil is a cool season food legume and is sensitive to terminal heat stress. Flower drop, pod drop and ultimate yield loss were occurred due to increase of both maximum and minimum temperature (Dhuppar *et al*, 2012). Heat tolerant genotypes may thrive well in the climatic situations of West Bengal. Therefore, genotypes with tolerance to heat stress during grain filling will be needed. So present investigation was undertaken to study the variability parameters of lentil as well as to screen the lentil germplasms for heat tolerance by laboratory and field screening for ultimate development of heat tolerant early maturing genotypes.

Materials and methods

Our present study comprised of fifty four lentil germplasms. Effect of heat stress on these germplasms was observed in both laboratory as well as field condition.

The experimental material comprises of fifty four lentil germplasms which are collected from different parts of West Bengal, Berhampore Pulses and Oil SeedReseach station and from NBPGR, New Delhi. The seeds were sown in randomized block design (RBD) with 3 replications. The field experiment was conducted in two sowing time- normal (November) in Calcutta university experimental farm, Baruipur, South 24 Parganas and in late sown condition (late December)

Requisite quantity of seeds were sown in RBD in an experimental plot with three replications. Seeds were sown by giving a row to row spacing of 30 cm.

Data collection and analysis : plant height (cm), branches/plant, pods/plant, pod length (cm), seeds/pod, 100 seed weight, seed yield (g)/plant and harvest index (it was calculated by dividing grain yield by biological yield and expressed in percentage following Wilcox (1974). Harvest index= Economical yield/biological yield X 100) were recorded.

Stastical analysis is done by statistical package spar 2.

Experiment 1:Variabity parametersof fifty four lentil genotypes.

The mean of different characters were analysis in on the basis of different variability parameters G.C.V., P.C.V, Heritability, Genetic Advance and Genetic Advanced as percentage of mean were computed.

Experiment 2 : Screening of germplasms in laboratory for heat tolerance.

Fifty four Lentil germplasms as mentioned in experiment 1 were taken for conducting this experiment. These fifty four germplasms were screened for heat tolerance in plant growth chamber in water culture method. The set up was placed in plant growth chamber at 34 degree Celsius to assess their heat tolerance. In this experiment requisite quantity of seeds

of each germplasms were allowed to germinate in the petridish method. Then those germinated seeds were grown in water culture method in three replications (ten healthy germinated seeds per replication) by inserting their roots through the holes of thermocol kept in glass container. Effect of heat stress was measured in terms of survival percentage and seedling vigour i.e, root length,shoot length, fresh weight, dry weight mean of which were calculated by averaging ten seedlings.

After one-month survival percentage and the above mentioned data were recorded and the mean was computed.

Survival percentage = (no. of survived seedlings after 1 month of germination/ total no. of seedlings) X 100.

EXPERIMENT 3: Assessment of germplasms for heat tolerance in laboratory by cell membrane thermostability test

Cell membrane thermostability test for assessment of heat tolerance of lentil was performed as per Martineau *et. al*., 1979 and Srinivasan et.al.,1995 with slight modification. Relative injury percentage was calculated and represented in table 2. The germplasms with low grade of relative injury value have chance of more heat tolerance in comparison to other germplasms. Relative injury was determined as follows:

% injury = [1-{(1-(T1/T2)) / (1-(C1/C2))}] x 100

T and C refer to as treatment and controlrespectively and the subscripts 1 and 2 of T and C refer to initial and final conductance respectively.

EXPERIMENT 4: Evaluation of the germplasms for heat tolerance in optimum and late sown condition

Lentil germplasms were sown late in the month of December for effective screening of lentils for reproductive stage heat tolerance. The germplasms were sown in both normal (first week of November) and late sown condition (between 2nd to 4th week of december) for three consecutive years from 2015-2017. The experiment was conducted in the Calcutta university experimental farm, Baruipur, South 24 parganas. Performance of the germplasms were observed and recorded for both normal and late sown condition. Seeds were sown in RBD in the experimental plot with three replications with 10 cm row to row spacing. After harvesting, seed yield / sq.meter were recorded.

Results and Discussion

Experiment 1:Variabity parametersof fifty four lentil genotypes.

Over three years of study in normal sown condition, a very close correspondence between PCV and GCV was observed for different characters. GCV is high for pods/ plant, seed yield/ plant (Table 1)

In three consecutive years the broad sense of heritability was consistently recorded as high as 80% and above in characters pods/plant, 100 seed weight, harvest index, seed yield/ plant. When genetic advance was expressed as percentage of mean pods/ plant, seed yield/ plant, recorded more than 50%of gain. Thus considering GCV, broad sense heritability and GA% of mean for three characters pods/plant, seed yield/plant recorded consistently high and according to Panse, 1957 these characters are governed by additive genes, and selection are effective on the basis of these characters.

Experiment 2: Screening of germplasms in laboratory for heat tolerance.

Seedling vigour and survival percentage data were recorded from one month old seedling and presented in table 2. Germplasms like WBL81, IC201655, WBL77, 14-4-1, IC201678, IC 201655, IC 201786, IC 201794, IC 212683, WBL 37, WBL 3, WBL 26, WBL 19 shows good potential under normal condition. Survival percentage ranges from 100 to 50 percent where many of germplasm like Purulia local, North 24 Pargana local, WBL 81, Asha, Ranjan, Moitree, Howrah local 2, IC201661, IC201662, IC201675, IC201693, IC 201698, IC 201705, IC 201743, IC 201749, IC 201785, IC 201786, IC 208342, IC212666, IC248956, WBL14, WBL21, WBL33, WBL37, WBL8, WBL11, WBL13, WBL22 shows maximum survival.

Table 1. Estimate of different variability parameters in lentil

PARAMETERS	CHARACTERS								
	Plant height	Branch no.	Pods/ Plant	Pod length	Seeds/ Pod	100 seed Weight	Harvest index	Days to maturity	Seed yield/Plant
Baruipur 2015-16									
GCV	11.67	22.68	27.22	12.42	4.14	28.67	24.06	3.655	35.75
PCV	16.30	34.03	49.75	24.04	6.44	29.15	24.27	3.656	54.65
Heritability%	51.21	44.40	29.93	26.68	41.26	96.72	98.26	99.92	42.80
GA	8.02	2.30	24.70	0.12	0.11	1.10	25.74	8.90	1.42
GA % of mean	17.20	31.13	30.68	13.21	5.47	58.08	49.13	7.53	48.18
Baruipur 2016-17									
GCV	11.16	25.96	25.25	16.21	4.14	16.07	18.20	4.167	28.38
PCV	13.80	34.46	36.96	17.54	6.44	19.33	25.39	4.170	41.82
Heritability%	65.43	56.75	46.74	85.43	41.26	69.10	51.35	99.86	46.06
GA	8.94	2.24	54.43	0.30	0.11	0.88	10.55	10.19	1.44
GA % of mean	18.60	40.29	35.56	30.87	5.47	44.33	26.86	8.58	39.67
Baruipur 2017-18									
GCV	13.05	26.47	28.69	11.87	14.62	18.59	19.27	3.92	32.01
PCV	16.71	30.29	29.02	17.55	16.21	19.27	20.17	3.93	34.97
Heritability%	61.00	76.42	97.70	45.74	81.31	92.97	91.20	99.79	83.79
GA	9.30	2.55	55.78	0.15	0.49	0.56	14.66	9.21	1.37
GA % of mean	21.00	47.68	58.41	16.54	27.15	27.51	37.90	8.07	60.36
Normal sown pooled									
GCV	10.14	15.15	12.42	9.80	2.88	17.20	10.15	3.16	17.16
PCV	13.27	30.58	31.90	16.11	10.19	21.81	22.41	3.89	38.82
Heritability%	58.37	24.55	15.17	37.06	8.01	62.23	20.52	66.25	19.55
GA	7.39	0.95	10.94	0.12	0.03	0.56	4.12	6.21	0.46
GA % of mean	15.96	15.47	9.97	12.29	1.68	27.96	9.47	5.30	15.63

In high temperature Condition, survival percentages ranges between 100 to 0 percent , Some genotypes 1-4-1, IC 201675, IC 201693, IC 201705, IC 201749, IC 201785 Shows highest survival percentage consecutively for all three seasons .So on the based on overall performance of the genotypes in respect of seedling vigour index and survival percentage WBL 77, 14-4-1, Howrah local 2, IC 201675, IC 201678, IC 201710, IC 201786, IC 201787, IC 208356, WBL 19 shows good outcome, so further evalution can be done in those germplasm for heat tolerance. Seedling heat tolerance is an important source of breeding to find out he attolerantgenotypes (Setimela*etal.,*2005). Truong*etal.,*2017; Li *et al.,* 2016; Gulen *et al.,* 2016; Abu-Romman, 2016; Harsh *et al.,* 2016 also carried out seedling study to find out suitable heat tolerant genotypes.

Seedling vigour and survival percentage data were represented from one month old seedlings and represented in table 5. Germplasms like in respect of seedling vigour index and survival percentage WBL 77, 14-4-1, Howrah local 2, IC 201675, IC 201678, IC 201710, IC 201786, IC 201787, IC 208356, WBL 19 shows good outcome. They were categorised as tolerant germplasms. Some moderately tolerant germplsms were also found like WBL 81, Ranjan, IC 201664 etc. Rest were highly susceptible.

Genotypes can be classified as tolerant or susceptible to heat at particular stages of development or termed as heat resistant based on overall reaction and preservation of yield at higher temperatures (Hall,1992; Mahan *et al*.,1995).

EXPERIMENT 3. Assessment of germplasms for heat tolerance in laboratory by cell membrane thermostability test

Cell membrane thermostablity analysis exposed a wide range of variability among the genotypes which is represented in Table 3. Genotypes having low injury level can be further used as a materials for experiment. Genotypes below 50% injury level can be used as a standard for heat tolerant. In my present study genotypes like, WBL 185, Bihar local, North 24 Pargana local, Asha, Ranjan, WBL 77 (Moitree), 14-4-1, Howrah local 2, IC 201675, IC 201678, IC 201698, IC 210705, IC 201710, IC 201749, IC 201785, IC 201786, IC 201787, IC 208329, IC 208356, WBL 22 shows low injury level. Different thermostablity analysis to genotypes also been reported by Roy Choudhury *et al.,* 2012; Barghi *et al.,* 2013; Chakraborty and Pradhan, 2010 for lentil. Cell membrane thermostablity is also been reported by Kakani, 2015; Azar, 2009 in cotton, Nyarko, 2008 incabbage.

In cell membrane thermostability test, relatively less injury was observed in genotypes like: Asha, Ranjan, WBL 77 (Moitree), Howrah local 2, IC 201698, IC 201749, IC 208329, WBL 13, IC 208356 and IC 201693., WBL 3.

EXPERIMENT 4. Evaluation of the germplasms for heat tolerance in optimum and late sown condition

Three consecutive varietal screening was performed in normal and late sown condition (Table 4 & 5)

High survival percentage i.e, more than 70% was observed in the germplasms like Purulia local, North 24 pargana local, WBL 81, Asha, Ranjan, Moitree, Howrah local 2, IC 201661, IC 201693, IC 201698, IC201743, IC 201749, IC 208329, IC 248956.

- The mean performance of the genotypes in seed yield/plant is ranges from 2.34 gm to .32 gm. **WBL 77 (Moitree)** has the highest seed yield followed by Krishnanagarlocal, North 24 Pargana Local, Purulialocal, WBL 7, IC 201749, 14-4-1, Ballia local, WBL 12, WBL 26, Ranjan, WBL 25, IC 201662, WBL 6, Howrah local 2, Asha, WBL 13 has seed yield 1.40 g.m and more. The lowest seed yield observed in WBL19.
- Some early maturing genotypes like Howrah local 2,Purulia local was also identified. Among these Purulia local showed the duration of 102.67 days which iscomparetively lowest among all.

Among the 54 lentil germplasms, in late sown condition under severe heat stress situation only the best

Table 2. Mean Performance of the genotypes at seedling stage in plant growth chamber (34^0C)

Genotypes	Germi-nation %	Germination (arcsine value)	Root length (mm)	Shoot length (mm)	Root +Shoot length (mm)	Fresh weight (g.)	Dry weight (g.)	Fresh +Dry weight (g.)	Survival %	Seedling Vigour Index
Purulia local	93.33	75.42	61.73	101.83	163.57	0.15	0.02	0.17	72.00	15265.05
WBL 185	50.00	45.00	59.27	120.99	180.26	0.10	0.02	0.12	83.13	9013.00
Bihar local	86.66	68.69	69.01	110.04	179.05	0.18	0.02	0.20	60.56	15516.47
North 24 Parganas local	100.00	90.00	100.86	140.52	241.38	0.22	0.04	0.26	64.33	24138.00
WBL 81	96.66	80.54	77.82	107.49	185.31	0.15	0.02	0.17	73.33	17912.06
Asha	83.33	65.98	73.30	122.26	195.57	0.12	0.02	0.14	70.30	16296.01
Ranjan	76.66	61.12	49.77	87.51	137.28	0.14	0.01	0.16	77.20	10523.88
WBL 77 (Moitree)	90.00	71.69	63.15	110.98	174.13	0.19	0.03	0.22	75.55	15671.70
14-4-1	90.00	71.65	46.76	96.72	143.48	0.15	0.02	0.17	65.67	12913.20
Ballia local	96.66	80.01	60.86	105.10	165.96	0.20	0.03	0.23	83.64	16041.69
Krishnanagar local	66.66	54.74	78.18	100.63	178.82	0.30	0.01	0.29	66.67	11919.47
Howrah local 2	88.00	69.79	83.78	108.10	191.88	0.21	0.03	0.24	64.96	16885.44
IC 201655	100.00	90.00	51.93	100.75	152.68	0.20	0.01	0.21	63.89	15268.00
IC 201661	60.00	50.78	63.43	86.07	149.50	0.20	0.03	0.23	44.66	8970.00
IC 201662	100.00	90.00	51.33	104.77	156.10	0.30	0.01	0.31	54.43	15610.00
IC 201664	90.00	71.91	47.37	120.17	167.53	0.23	0.01	0.24	66.19	15078.60
IC 201675	86.66	68.63	53.33	95.67	149.00	0.20	0.03	0.23	60.00	12912.34
IC 201678	46.66	43.08	121.20	168.67	289.87	0.35	0.04	0.39	87.22	13525.33
IC 201681	96.66	79.47	71.35	132.86	204.22	0.21	0.02	0.24	72.50	19738.94
IC 201693	90.00	71.73	87.52	145.63	233.15	0.24	0.02	0.26	80.56	20983.50
IC 201698	90.00	71.64	62.47	83.53	145.99	0.16	0.01	0.17	70.24	13140.00
IC 201705	100.00	90.00	67.93	113.00	180.93	0.17	0.01	0.18	90.30	18093.00
IC 201710	100.00	90.00	100.39	127.95	228.34	0.20	0.03	0.23	86.90	22834.00
IC 201743	36.00	36.87	39.59	82.22	121.81	0.06	0.01	0.09	49.89	4385.16
IC 201749	90.00	71.67	77.43	102.66	180.09	0.16	0.02	0.18	86.67	16208.10
IC 201785	46.00	42.71	88.77	108.88	197.65	0.30	0.05	0.35	73.63	9091.90
IC 201786	90.00	71.60	54.58	95.23	149.82	0.22	0.02	0.24	66.63	13482.90
IC 201787	90.00	71.75	72.43	101.02	173.46	0.18	0.03	0.21	76.67	15610.50
IC 201794	33.00	35.06	44.99	95.32	140.31	0.08	0.02	0.10	46.56	4630.23
IC 208329	75.00	60.03	81.64	136.59	218.23	0.33	0.03	0.37	81.67	16367.25
IC 208342	93.33	75.05	62.50	111.43	173.93	0.18	0.03	0.21	60.00	16232.89
IC 208356	66.60	54.70	43.82	117.31	161.12	0.27	0.02	0.29	64.62	10731.26
IC 208377	73.33	58.94	61.66	105.15	166.82	0.20	0.02	0.23	81.58	12232.18
IC 212666	63.33	52.73	60.96	118.81	179.77	0.21	0.02	0.22	76.97	11384.83
IC 212683	80.00	63.48	64.50	120.77	185.27	0.24	0.03	0.26	83.89	14821.60
IC 248956	90.00	71.71	58.58	102.90	161.47	0.17	0.02	0.19	69.26	14533.20
WBL 25	80.00	63.51	77.52	114.27	191.78	0.13	0.01	0.14	64.05	15343.20

WBL 7	90.00	71.70	61.05	113.76	174.81	0.13	0.01	0.14	76.97	15732.90
WBL14	70.00	56.80	63.25	91.33	154.58	0.21	0.01	0.21	62.13	10820.60
WBL21	83.33	65.93	66.64	99.13	165.77	0.18	0.03	0.21	61.90	13813.61
WBL 3	83.33	65.99	44.50	82.22	126.72	0.16	0.01	0.17	63.33	10559.58
WBL 33	96.66	79.47	95.72	93.89	189.61	0.24	0.01	0.22	80.56	18327.70
WBL 37	86.66	68.69	79.57	107.61	187.18	0.18	0.01	0.20	79.17	16221.02
WBL 31	90.00	71.67	51.18	91.08	142.27	0.19	0.01	0.20	55.28	12803.40
WBL 26	56.66	48.83	58.30	118.47	176.77	0.17	0.03	0.20	64.70	10015.79
WBL 8	56.66	48.83	76.28	95.51	171.79	0.16	0.01	0.17	72.83	9733.62
WBL 11	43.33	41.17	44.86	111.06	155.92	0.18	0.02	0.19	85.94	6756.01
WBL 13	60.00	50.77	50.83	80.13	130.97	0.06	0.01	0.09	44.33	7857.60
WBL 6	42.21	46.34	44.6	80.22	125.61	0.23	0.01	0.17	43.22	7665.90
WBL 12	54.66	53.00	58.61	79.34	135.63	0.17	0.01	0.21	61.11	8176.76
WBL 22	72.33	63.64	66.75	95.43	145.67	0.2	o.o1	0.13	65.47	9230.43
WBL 24	67.41	55.70	61.91	86.95	121.47	0.24	0.02	0.22	63.77	6793.26
WBL 19	57.71	60.23	56.77	110.43	126.79	0.15	0.02	0.17	51.47	1623.44
WBL 15	63.79	57.96	47.34	77.65	117.66	0.16	0.02	0.09	59.79	1765.49
Mean	79.19	65.66	66.33	108.08	174.41	0.19	0.02	0.21	70.07	13873.89
CD value	3.31	3.08	38.96	46.53	78.36	0.17	0.02	0.17	44.25	-

TABLE 3. Relative Injury % Genotypes in Cell Membrane Thermostability Test

Germplasms	Relative Injury Percentage
Purulia Local	64.70
WBL 185	42.86
Bihar local	40.00
North 24 Pargana local	45.45
Asha	49.32
Ranjan	50.00
WBL 77(Moitree)	43.00
14-4-1	35.71
Ballia local	50.00
Krishnanagar local	68.42
Howrah local 2	33.33
IC 201655	56.34
IC 201662	53.84
IC 201664	66.66
IC 201675	48.32
IC 201678	37.89
IC 201681	54.62
IC 201693	50.34
IC 201698	47.30
IC 201705	34.50
IC 201710	49.00
IC 201743	59.87
IC 201749	48.60
IC 201785	36.00
IC 201786	48.00
IC 201787	46.31
IC 201794	70.26
IC 208329	48.40
IC 208356	48.32
IC 208377	80.95
IC 212666	57.15
IC 212683	74.15
WBL 25	61.78
WBL 14	69.54
WBL 21	63.33
WBL 33	67.62
WBL 37	66.04
WBL 31	66.35
WBL 8	55.11
WBL 13	67.69
WBL 22	46.20
WBL 24	65.99
WBL 19	59.45
Mean	54.16

Table 4. Agro Morphological Characters And Yield Related Attributes Of Lentil In Normal Sown Condition For Three Years

Genotypes	Plant Height (cm)	Branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	100 seed weight (gm)	Harvest index (%)	Seed yield per plant (gm)
Purulia Local	52.4	13.5	78.4	0.9	1.7	1.3	49.86	2.68
WBL 185	53.2	15.1	24.1	1	1.7	1.4	53.8	2.93
Bihar local	50.3	13.7	80.1	0.9	1.7	1.1	42.23	2.09
North 24 Pargana LOCAL	47.4	12.5	94.2	1	1.9	1.4	69.05	2.61
WBL 81	51.3	11.7	93.5	0.9	1.7	1.3	68.37	1.51
Asha	54.2	14.7	62.4	1.1	1.5	2.2	43.17	2.21
Ranjan	53.3	12.9	72.7	0.9	1.7	1.8	42.7	1.23
WBL77(Moitree)	55.2	10.9	51.9	1.1	1.7	1.7	72.83	2.95
14-4-1	53.1	17.2	69.1	1	1.7	1.3	63.09	2.03
Ballia local	52.3	18.3	66.3	1	1.9	1.7	46.12	2.13
Krishnanagar local	53.5	13.6	103.2	0.9	1.8	1.5	54.64	2.36
Howrah local 2	47	14.6	97.1	1.1	1.9	1.9	55.76	2.13
IC 201655	50.7	13.9	37.7	1	1.6	1.3	49.51	2.04
IC 201661	52.2	10.6	38.7	0.8	1.8	1.4	71.55	3.14
IC 201662	50	12.9	61.7	1.1	1.9	1.7	58.84	2.55
IC 201664	46.6	14.2	103.9	1	1.9	1.1	41.08	1.71
IC 201675	47.3	17.1	46.5	1	1.5	1.1	32.42	1.1
IC 201678	48.9	16.7	55.3	1	1.9	1.2	59.77	2.1
IC 201681	53.2	18.3	45.9	1	1.6	1.3	45.01	2.25
IC 201693	53.3	15.4	120.5	1	1.6	1.5	49.46	2.85
IC 201698	46.5	25.3	29.3	1	1.6	1.2	30.38	2.71
IC 201705	48	20.7	131.3	1.1	1.9	1.4	53.89	2.51
IC201710	52	14.3	112.3	0.9	2	1.6	53.79	1.77
IC 201743	54.2	17.1	72.7	0.9	1.7	1.3	58.13	2.64
IC 201749	54.7	15.6	70.1	1	1.7	1.6	60.67	5.75
IC 201785	53.1	20	39.7	0.8	1.6	1.1	70.63	4.46
IC 201786	54.5	19.5	42.3	1	1.5	1.6	60.12	4.2
IC 201787	55.2	9.8	21.3	0.9	1.9	1.5	52.15	2.98
IC 201794	52.1	12.4	53.7	1	1.9	1.1	41.76	4.07
IC 208329	52.3	14.2	32.4	0.9	1.8	1.6	62.58	6.26
IC 208342	47.2	16.1	52.1	1	1.7	1.9	71.5	4.85
IC 208356	49.9	9.9	86.1	1	1.9	1.5	37.88	1.65
IC 208377	52	16.5	57.9	0.9	1.4	1.5	36.56	1.72
IC 212666	54.1	13.9	60.3	1	1.8	1.4	36.39	1.86
IC 212683	54.3	16.6	45.1	0.9	1.7	1.5	45.8	3.76
IC 248956	51.9	15.7	127.2	0.9	1.8	1.4	29.05	2.41
WBL 25	55.3	18.9	77.6	0.9	1.5	1.4	64.19	3.59
WBL 7	49.3	16.9	99.4	1	1.5	1.3	37.94	3.17
WBL 14	50	15.7	48.2	1	1.7	1.5	39.69	2.15
WBL 21	45.8	14.7	33.3	1	1.5	1.6	60.92	3.28
WBL 3	50.1	21.5	98	1	1.8	1.6	67.63	6.38
WBL 33	54.4	16.1	38.7	0.9	1.7	1.4	59.28	3.11
WBL 37	52.7	11.9	111.9	0.9	1.9	1.5	74.21	6.14

WBL 31	53.9	19.1	90.9	0.9	1.6	1.5	70.84	3.02
WBL 26	54	19.8	104.3	0.9	1.4	1.2	49.83	4.36
WBL 8	56.1	16.4	70.9	0.9	1.8	1.4	44.21	3.92
WBL 11	54.9	13.4	38.3	1	1.6	1.2	37.91	2.81
WBL 13	53.9	15.2	61.7	0.9	1.8	1.3	38.7	1.21
WBL 6	51.9	14	53	1	1.9	1.4	52.4	2.95
WBL 12	50.3	13.7	40.5	1	1.9	1.4	53.57	1.98
WBL 22	47.1	14.1	36.2	1	1.5	1.4	42.63	2.61
WBL 24	51.3	10.1	37.9	1	2	1.4	70.33	1.75
WBL 19	46.4	9.9	56.1	1	1.9	1.6	51.27	2.24
WBL 15	48.7	14.7	49.5	0.9	1.8	1.1	48.47	3.21
Mean	**46.64**	**15.24**	**80.53**	**0.95**	**1.96**	**1.9**	**52.40**	**2.95**
CD@ 5%	**2.29**	**1.29**	**5.64**	**0.07**	**0.27**	**0.12**	**14.24**	**1.68**
CD@ 1%	**3.05**	**1.72**	**7.50**	**0.10**	**0.36**	**0.16**	**1.95**	**2.24**
SE(+-)	**0.81**	**0.45**	**1.99**	**0.02**	**0.09**	**0.04**	**5.03**	**0.59**

performing 28 lines were selected for further experimentation. Among the 54 lentil germplasms, in late sown condition under severe heat stress situation only the best performing 28 lines were selected for further experimentation.

Out of 54 germplasms there are few germplasms that performed well in both normal and late sown condition in laboratory as well as field screening analysis. In laboratory condition the best performing lines in all aspects were: Asha, Ranjan, WBL 77 (Moitree), Howrah local 2, IC 201693, IC 201698, IC 201749, IC 208356, WBL 3,WBL 13, IC 248956 and IC 248956.

In field screening in normal sown condition, the best performing genotypes in all agromorphological attributes were: Asha, Ranjan, WBL 77 (Moitree), Howrah local 2, IC 201693, WBL 3, WBL 13, IC 201698, IC 201749, WBL 33 IC 208329 and IC 208356.

In late sown heat stressed condition, the genotypes that were comparatively tolerant to heat and performed as well as survived well in heat stressed condition were (Table 6): Asha, Ranjan, Wbl77 (Moitree), Howrah local 2, IC 201749, IC 201693, WBL 31, WBL 3, WBL 13, IC 208356, IC 208329, IC 201710 and IC 201678.

Hence, by compairing all the agro morphological attributes in normal, laboratory screening as well as heat stressed condition, genotypes like: **Asha, Ranjan, WBL 77 (Moitree), Howrah local 2, IC 201693, IC 201749, WBL 3, WBL 13, IC 208356** and IC **208329** were found to be promising line and these all lines have a very good promise for future breeding programme for the development of high productive heat tolerant cultivars for west Bengal.

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Table 5. Agro Morphological Characters And Yield Related Attributes Of Lentil In Late Sown Condition For Three Years:

Germplasms	1st Flowering (Days)	50% Flowering (Days)	Plant Height (c.m)	Branches/ Plant	Pods/ Plant	Pod Length (c.m)	Seeds\ pod	Seed Yield/ Plant (g.m)	100 Seed Weight (g.m)	Harvest Index
Bihar local	67.67	77.67	33.83	2.00	29.73	0.75	1.30	0.56	1.49	18.85
Asha	52.67	61.00	36.17	2.00	14.30	0.73	1.05	0.26	1.22	8.31
Ranjan	54.33	66.00	30.60	2.25	29.01	0.85	2.00	0.35	1.05	13.68
WBL 77(Moitree)	46.00	54.33	25.30	2.50	16.17	0.70	2.00	0.42	1.34	15.48
14-4-1	51.00	61.00	32.00	2.25	16.29	0.72	1.08	0.20	1.73	7.65
Howrah local 2	56.00	71.00	31.33	2.30	27.72	0.98	2.00	0.46	1.31	20.93
IC 201675	67.67	77.67	34.10	2.34	14.90	0.65	1.26	0.20	1.37	8.60
IC 201678	67.67	79.33	28.57	2.83	30.92	0.75	1.01	0.64	1.42	20.33
IC 201681	66.72	77.68	32.10	3.00	38.00	0.75	2.00	0.62	1.38	18.44
IC 201693	59.33	66.00	30.87	3.84	30.29	0.73	1.03	0.52	1.25	17.05
IC 201698	71.00	82.67	31.72	2.00	16.74	0.80	1.17	0.39	1.39	13.31
IC 201705	46.00	52.67	36.60	2.34	28.88	0.67	1.65	0.52	1.31	19.97
IC 201710	56.00	62.67	27.45	2.33	31.49	0.68	2.00	0.50	1.00	16.84
IC 201749	67.67	74.33	28.67	2.42	35.98	0.70	1.75	0.52	2.03	23.55
IC 201785	61.00	71.00	31.70	2.33	33.51	0.82	1.72	0.47	1.33	12.93
IC 201786	71.00	82.67	30.87	2.50	32.07	0.87	2.00	0.49	1.47	18.93
IC 201787	69.33	79.33	35.83	2.34	37.58	0.77	1.52	0.60	2.01	18.60
IC 208329	69.33	81.00	29.98	2.33	25.17	0.77	1.71	0.39	2.12	15.98
IC 208356	67.67	76.00	28.00	2.33	41.61	0.70	1.13	0.64	2.29	20.62
IC 248956	58.00	68.00	30.00	2.00	26.00	0.80	2.00	0.54	1.84	16.32
WBL 25	52.00	62.00	24.00	3.00	28.00	0.65	2.00	0.48	2.00	22.32
WBL 21	67.42	77.80	22.00	3.00	32.00	0.77	2.00	0.52	1.80	20.48
WBL 3	62.00	74.00	18.00	4.00	35.00	0.72	1.00	0.44	1.68	22.30
WBL 31	58.28	69.00	26.00	2.00	22.00	0.68	2.00	0.60	1.77	20.12
WBL 8	64.36	75.00	30.00	4.00	38.00	0.78	1.00	0.33	1.89	16.00
WBL 13	61.42	72.00	29.00	2.00	28.00	0.73	2.00	0.34	2.10	20.20
WBL 6	57.00	67.00	25.00	2.00	32.00	0.76	2.00	0.42	1.95	22.65
WBL 12	59.00	70.00	23.00	2.00	26.00	0.66	2.00	0.48	1.68	18.50
Mean	61.19	70.91	31.31	2.40	27.35	0.76	1.52	0.45	1.51	16.20
CD @ 5%	7.80	7.05	4.16	0.67	13.51	0.13	0.43	0.18	0.28	4.70
CD @ 1%	10.50	9.49	5.60	0.90	18.19	0.18	0.58	0.24	0.38	6.34
SE (+-)	2.70	2.44	1.44	0.23	4.68	0.05	0.15	0.06	0.10	1.63

TABLE 6. Grouping of Genotypes Under Heat Stressed Condition:

TOLERANT GERMPLASMS(>80%)	MODERATELY TOLERANT (61-80%)	SUSCEPTIBLE(50 -60%)	HIGHLY SUSCEPTIBLE (BELOW 50%)
WBL 77 (MOITREE)	Bihar local	WBL 185	WBL 3
14-4-1	NORTH 24 PARGANA LOCAL	IC 208342	IC 201655
Howrah local 2	WBL 25		IC 201661
IC 201675	WBL 12		IC 201662
IC 201678	IC 201693		IC 201664
IC 201710	IC 201698		PURULIA LOCAL
IC 201786	IC 201749		KRISHNANAGAR LOCAL
IC 201787			BALLIA LOCAL
IC 208356			IC 208377
ASHA			IC 212666
RANJAN			IC 248956
WBL 14			
WBL 21			
WBL 3			
WBL 13			

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