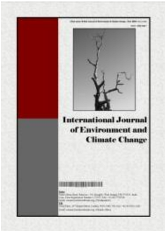

International Journal of Environment and Climate Change

11(9): 74-80, 2021; Article no.IJECC.75700
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Screening of Pearl Millet Genotypes for High Temperature and Drought Tolerance Based on Morpho-Physiological Characters

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Authors' contributions

This work was carried out in collaboration among all authors. Authors RCM, MR and SA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VK and RBM managed the analyses of the study. Authors JPB and KDM managed the literature searches. Author CTS gave final shape to the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2021/v11i930480
Editor(s):
(1) Dr. Daniele De Wrachien, State University of Milan, Italy.
Reviewers:
(1) Rumesh Ranjan, Punjab Agricultural University, India.
(2) Esra Cebeci, Bati Akdeniz Agricultural Research Institute, Turkey.
Complete Peer review History: https://www.sdiarticle4.com/review-history/75700

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Received 05 August 2021
Accepted 11 October 2021
Published 13 October 2021

ABSTRACT

Aims: Screening of pearl millet genotypes lines for high temperature and drought tolerance.
Study Design: Randomized Block Design (RBD) with three replications.
Place and Duration of Study: ICAR-AICRP on Pearl Millet, Mandor during summer 2017-18.
Methodology: Fifteen genotypes (J-2290, J-2340, J-2479, J-2500, J-2503, J-2507, J-2517, J-2534, JMSB-9904, JMSB-101, JMSB-20064, JMSB-20102, JMSB-20071, JMSB-20082 and JMSB-20091) of pearl millet received from Main Pearl millet Research Station, Junagadh Agricultural University, Jamnagar were evaluated during summer season of 2017-18 at research Farm of ACIRP on pearl millet, Mandor, Agricultural University, Jodhpur under terminal moisture stress and irrigated conditions in two sets of randomized block design with three replications. Grain yield,

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stover yield, Relative Water Content (RWC), harvest index, threshing percentage and chlorophyll content were recorded.
Results: The suitability of the genotypes was judged in terms of grain yield, stover yield, RWC, harvest index, threshing percentage and chlorophyll content. The results showed that due to the terminal stress, the mean performance of all yield attributing characters including grain yield and chlorophyll, RWC and seed setting was reduced. The inbreds J-2479, J-2503 and J-2507 were high yielders due to high seed setting percentage under terminal stress conditions.
Conclusion: The lines viz., J-2479, J-2503 and J-2507 can be used for further breeding programme to develop varieties suitable under high temperature and low moisture conditions.

Keywords: Stress; drought; pearl millet; yield; RWC; chlorophyll and temperature.

1. INTRODUCTION

Pearl millet is the most important millet crop for human as well as animal feeding. It is grown in arid and semi-arid regions occupying fourth position among the cereals next to rice, wheat and sorghum, both in term of area (7.41 mha) and in production (10.30 mt) with average productivity of 1391 kg/ha [1]. Drought is the most severe abiotic stress reducing pearl millet yield in rainfed drought areas. It is known that pearl millet thrives well under drought prone condition but variant in intensity and severity of drought from season to season and place to place requires cultivation of such varieties of pearl millet which have a different level of drought tolerance in different areas. Nevertheless, there is a greater variability for yield performance of different pearl millet genotypes under drought situations. Efforts to measure the degree of tolerance with a single parameter have limited value because of the multiplicity of the factors and their interactive condition. Different workers used different methods to evaluate genetic differences in drought tolerance [2]. One of the greatest challenges in drought is to sow a seed type that has the capacity to produce abundant biomass and can mature in a short period of time. The objective of the present study was to identify genotypic differences in adaptation of fifteen pearl millet genotypes to drought and high temperature conditions under arid and semi-arid areas. For breeding such cultivars, it will require parents having sufficient tolerance/ resistance power against moisture stress situations. Hence, it becomes necessary to breed a variety which can fit well in varied moisture stress conditions. The present experiment was therefore conducted to find out genotypes for high temperature and drought tolerance to reduce the risk of yield loss in the same conditions.

2. MATERIALS AND METHODS

Fifteen genotypes (J-2290, J-2340, J-2479, J-2500, J-2503, J-2507, J-2517, J-2534, JMSB-9904, JMSB-101, JMSB-20064, JMSB-20102, JMSB-20071, JMSB-20082 and JMSB-20091) of pearl millet received from Main Pearl millet Research Station, Junagadh Agricultural University, Jamnagar were evaluated during summer season of 2017-18 at research Farm of ACIRP on pearl millet, Mandor, Agricultural University, Jodhpur under terminal moisture stress and irrigated conditions in two sets of randomized block design with three replications. The metrological data of summer 2017-18 is present in Fig. 1. Each entry was sown in two rows of 4 m length with 60 cm row spacing and 15 cm plant spacing. One set of experiment was sown under rainfed situation whereas other set under sufficient soil moisture condition ensuring good germination. Additional irrigations were given to plots of the irrigated experiment only at flowering stage of the crop. The observation on RWC and Chlorophyll (SPAD reading) were taken after 50% flowering at five selected plants whereas seed setting was observed on five selected plants at maturity. Grain yield and fodder yield was recorded plot wise and converted into hectare basis. Chlorophyll content referred to as SPAD value using a portable chlorophyll meter (Minolta SPAD-502, Osaka, Japan) after 50% flowering at third leaf. RWC was estimated according [3].

RWC = (Fresh weight- dry weight) / (Turgid weight- dry weight) x100

$$\text{Threshing index (\%)} = \frac{\text{Grain yield(kg)}}{\text{Dry ear head weight (kg)}} X100$$

$$\text{Harvest index (\%)} = \frac{\text{Econimic yield}}{\text{Biological yield}} X100$$

3. RESULTS AND DISCUSSION

Chlorophyll loss is interrelated with environmental stress, and deviations in the carotenoids /chlorophyll ratio may be a good indicator of stress in plants [4]. The SPAD measurements in the present study, which indicated leaf chlorophyll content /unit area, were taken from different points on a leaf. The changes in SPAD values in response to irrigation conditions depended on the temperature regime. In the present study, the genotypes, JMSB-20091, J-2500, J-2534 and J-2507 maintained higher SPAD values (53.06, 51.30, 51.18 and 49.63%) (Fig. 2). The SPAD values varied among the 15 genotypes. Averaging several measurements to obtain a mean value improves the selection efficiency and reduces measurement and recording times and costs [5]. Many researchers reported mean SPAD values for screening and selection of drought tolerance [6]. Additionally, the assessment of photosynthetic pigments and their relationships is an important indicator of senescence [7]. SPAD values declined in irrigated condition, but increased in a warm condition [8]. In other reports, SPAD values decreased under high temperature and drought conditions [9]. In the present study, the SPAD values increased from 44.12 to 53.06 in some genotypes. Previous studies have also showed that SPAD values increased under heat stress [10] and drought stress condition [11]. Plant water stress was measured in terms of leaf water potential or leaf relative water content Deivanai et al., [12] and Farooq et al., [13] considering that the most important and primary effects of drought stress include a reduction in leaf water status. Liu et al., [14] also suggested that a decrease in RWC in plants under drought and heat stress might be depending on plant vigour reduction and which was observed in many plants. Reduction in RWC results in loss of turgidity which leads to stomatal closure and in turn to reduce photosynthetic rates. In the present study, the genotypes, J-2340, J-2500, J-2507, JMSB-101, JMSB-20071, JMSB-20082 and J-2517 maintained higher relative water content in terminal stress condition (Fig. 3). Thus, a higher rate of water flow from the soil to the plant helps in better stomatal conductance and more leaf area which help to sustain better transpiration thereby improving the ear head numbers, its size (in terms of length) and final grain yield. Seed set per cent showed wide variability among different genotypes (Fig. 4). Genotypes, J-2479, J-2503, J-2507, J-2517, JMSB-9904, and JMSB-101and JMSB-20091 had high seed set in terminal stress condition in which J-2503 and J-2507 had the highest seed set of 58.67% and 55% in terminal stress condition. There are few studies on pearl millet showing the effect of terminal stress and high temperature on various traits including seed set. Gupta et al., [15] reported reduced seed set per cent, rice [16] and wheat [17]. Among ten genotypes, J- 2503 showed maximum grain yield

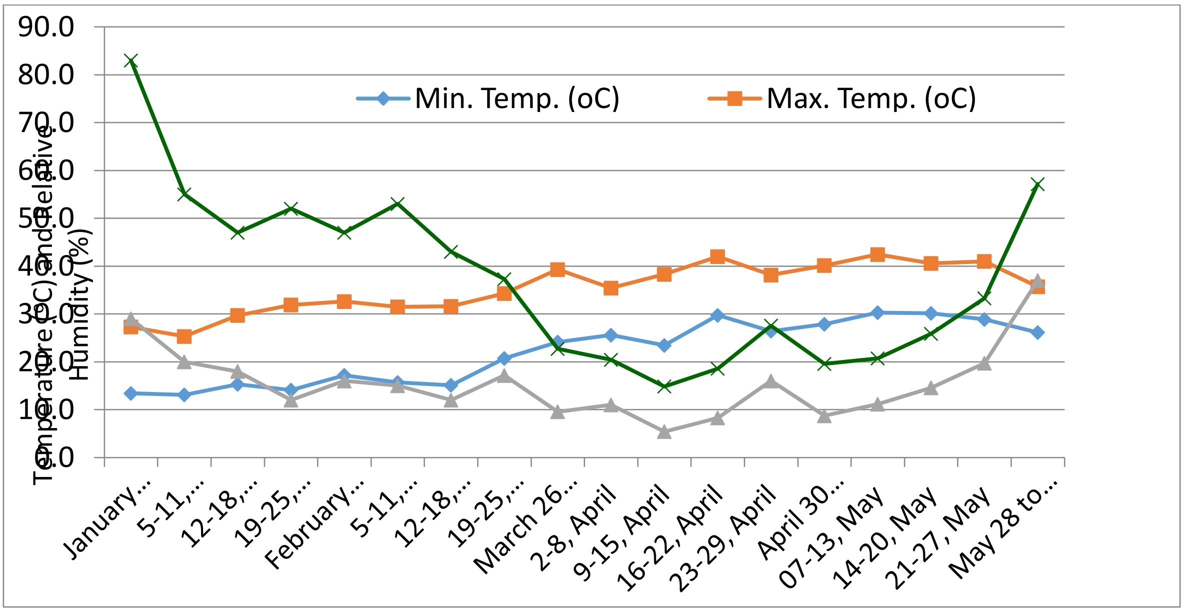

Fig. 1. Meteorological data during crop growth period

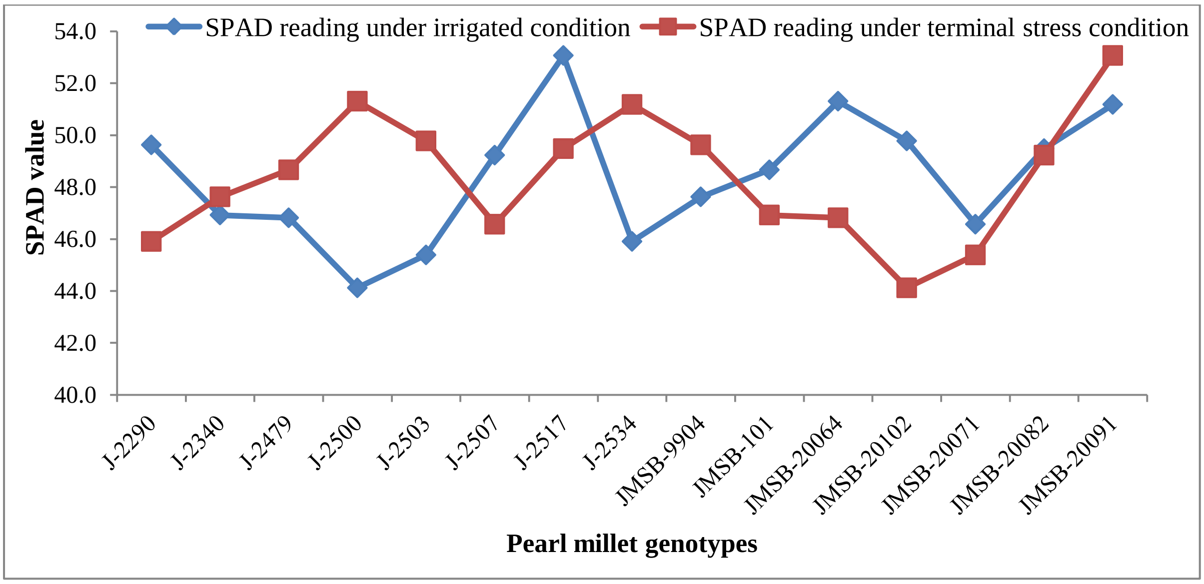

Fig. 2. Effect of high temperature and drought stress on Chlorophyll content of the genotypes

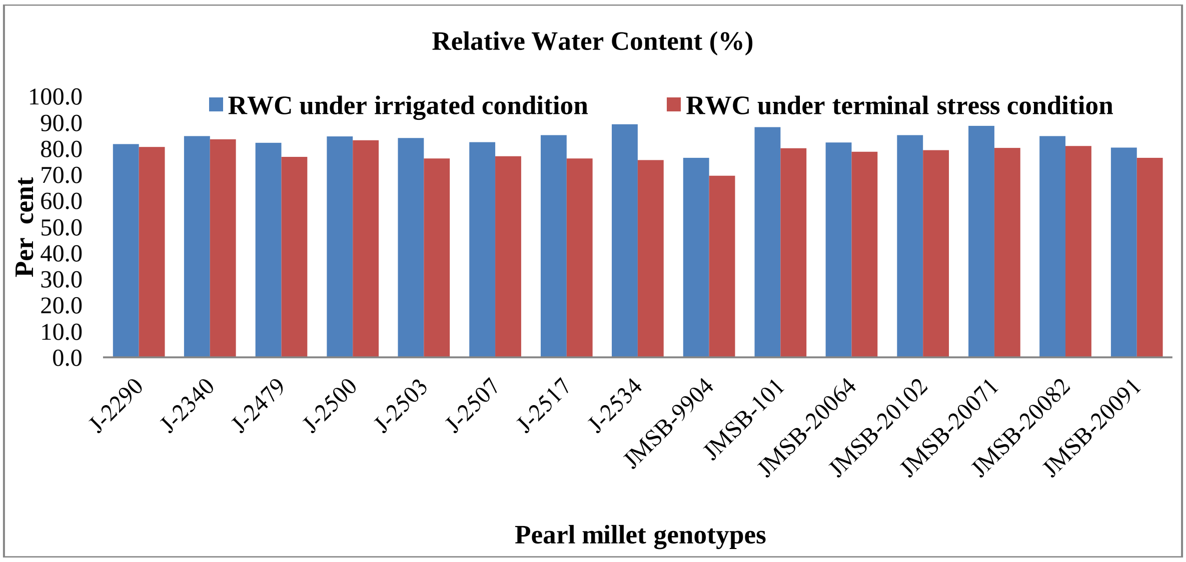

Fig. 3. Effect of high temperature and drought stress on RWC of the genotypes

levels under irrigated and moisture stress (1821 and 1178 kg/ha). The ability of genotype J-2503 to produce more biomass under stress conditions shows its ability to produce higher seed yield, it also maintained the highest values of harvest index under moisture stress (19.19%) as well as irrigated (22.55%) condition as compared to other genotypes (Table 1). Deshmukh et al., [18] reported that it maintained highest harvest index and very low values of membrane injury index under rainfed as well as irrigated condition. It also maintained the highest harvest index (HI) and had high threshing percentage (Table 2) under moisture stress condition which indicated that the genotype J-2503 may be rated as high temperature and drought tolerant genotype for moisture stress condition and heat stress. Yadav et al. [19] also reported that in pearl millet, co-mapping of the harvest index and panicle harvest index with grain yield revealed greater drought tolerance by greater partitioning of dry matter from stover to grains. In the present study the grain reduction percentage and harvest index under irrigated condition as well as in terminal stress condition was recorded by inbred J-2503 followed by J-2479 which showed better adaptability of the genotypes under high temperature condition.

Table 1. Effect of different high temperature and moisture situations on grain yield, fodder yield harvest index and threshing percentage

S. No.	Entries	Grain Yield (kg/ha)		Stover Yield (kg/ha)		HI (%)		Threshing %	
		Irrigated	**Terminal stress**	**Irrigated**	**Terminal stress**	**Irrigated**	**Terminal stress**	**Irrigated**	**Terminal stress**
1	J-2290	224	146	7083	6611	2.76	1.94	21.40	15.86
2	J-2340	1011	348	6317	2778	11.78	8.34	44.58	25.10
3	J-2479	1446	1199	5207	3856	16.77	15.61	55.78	49.25
4	J-2500	948	630	5133	2922	13.23	12.68	46.59	42.88
5	J-2503	1821	1178	4883	3813	22.55	19.19	57.91	50.85
6	J-2507	1696	922	4267	3101	22.48	9.84	51.91	41.30
7	J-2517	1760	708	6278	5167	18.59	10.00	56.20	35.74
8	J-2534	462	137	6444	6000	5.14	1.84	18.36	9.33
9	JMSB-9904	1141	767	7278	6733	11.88	8.86	49.60	35.75
10	JMSB-101	653	533	7187	5811	7.08	6.79	32.81	28.19
11	JMSB-20064	302	180	3278	2533	8.60	5.35	35.35	23.01
12	JMSB-20102	857	740	4000	2661	13.87	11.86	39.25	29.82
13	JMSB-20071	264	106	3462	2856	4.95	2.56	13.26	7.63
14	JMSB-20082	260	154	6206	3089	3.27	2.56	15.41	14.53
15	JMSB-20091	588	509	3033	2548	11.13	9.90	22.69	21.58
	CD at 5%	196.65	178.86	785.4	1281.0	2.13	3.78	10.04	10.49
	CV (%)	13.13	19.43	8.8	18.9	10.99	22.60	16.05	22.38

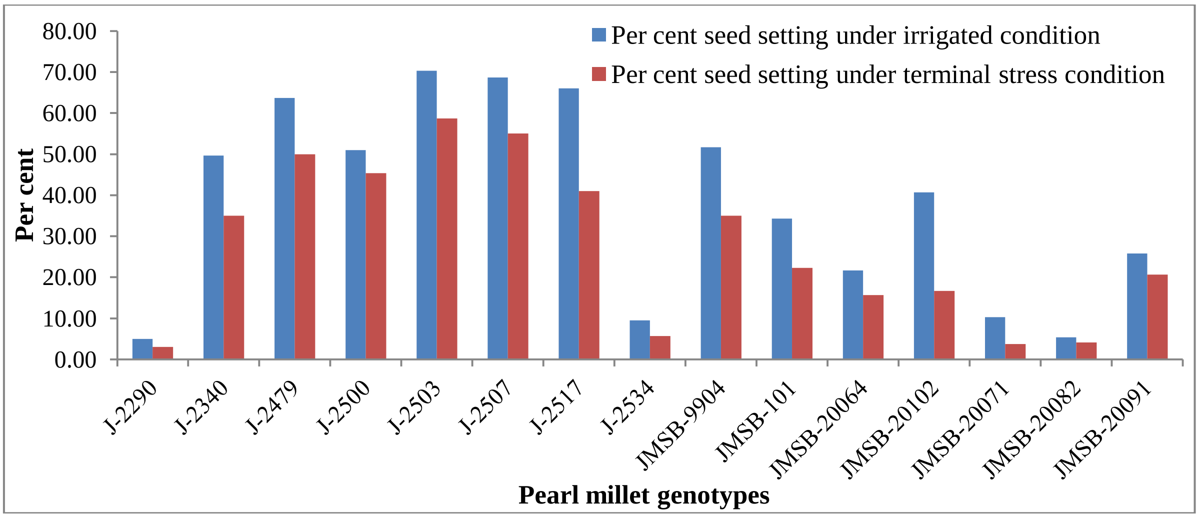

Fig. 4. Effect of terminal stress of seed setting of the pearl millet genotypes

Table 2. Percent decrease in grain yield, fodder yield, harvest index and threshing percentage from irrigated condition to stress condition by different entries

S. No.	Entries	Grain yield	Fodder yield	HI	Threshing percentage
1	J-2290	53	7	42	35
2	J-2340	191	127	41	78
3	J-2479	21	35	7	13
4	J-2500	50	76	4	9
5	J-2503	55	28	18	14
6	J-2507	84	38	128	26
7	J-2517	149	22	86	57
8	J-2534	237	7	179	97
9	JMSB-9904	49	8	34	39
10	JMSB-101	23	24	4	16
11	JMSB-20064	68	29	61	54
12	JMSB-20102	16	50	17	32
13	JMSB-20071	149	21	93	74
14	JMSB-20082	69	101	28	6
15	JMSB-20091	16	19	12	5

4. CONCLUSION

Pearl millet genotypes J-2479, J-2503 and J-2507 maintained comparatively high chlorophyll and relative water content of leaves and thereby resulted in high yields under stress condition. Therefore, these genotypes may be used further in breeding programme to develop drought tolerant hybrids.

ACKNOWLEDGEMENT

ICAR– All India Coordinated Research Project on Pearl Millet, Mandor-Jodhpur, Agriculture University, Jodhpur is highly acknowledged to provide financial assistance to carry out this research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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