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Research Article

Identification of drought tolerant recombinant inbred lines (RILs) based on selection indices in bread wheat

Vikrant Khare*, Suneeta Pandey, Sanjay Singh and Rama Shanker Shukla

Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishivishwa, Vidyalaya Jabalpur, MP-482004

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****Corresponding author:***
E-mail: vickykhr@gamil.com

Abstract

Water scarcity throughout wheat-growing periods is a major issue in India, therefore breeding methods, as well as the efficient selection approaches for moisture stress conditions are required to retain the level of crop production. In the current study recombinant inbred lines were developed through a donor, WH 730 crossed with recipient MACS 2496. Further segregating generations were advanced through the single seed descent method at Karnal. The F_7 and F_8 generations of 231 recombinant inbred lines along with five checks were planted in Alpha Lattice design for screening under normal and restricted irrigated conditions. A significant yield reduction was observed under restricted irrigated conditions than the normal irrigated condition during cropping season 2019-20 & 2020-21. Under stress condition significant association was found among yield and selection indices *viz*., stress susceptibility index (SSI), tolerance index (TOL), mean productivity (MP), stress tolerance index (STI), yield index (YI), drought resistance index (DI), sensitivity drought index (SDI), relative drought index (RDI), yield stability index (YSI) and percentage of yield reduction (PR). Based on selection indices, 22 superior recombinant lines were identified. These selected recombinant inbred lines may be subjected to further evaluation and also incorporated as donor parents in future hybridization programs.

Key word: Recombinant inbred line, drought, selection indices and correlation

1. Introduction

Wheat has very wide adaptability hence it is grown in diverse agro-climatic zones of India. It is a self-pollinated, hardy cereal crop with having a good amount of carbohydrates to fulfill global demand. The world population rises continuously and the production of a sufficient amount of calories to satisfy the population demand is a great challenge (Anwaar *et al.,* 2020). In the scenario of global climate change, temperature is constantly increasing and water is depleting, thus resulting in limiting agricultural productivity (Patel *et al.,* 2020). Abiotic stresses *viz*, drought, heat, cold, and salt were major challenges to cope during crop growth period therefore; identification of genetically potential lines withstanding ability in stress conditions will open the bottleneck of wheat genome to facilitate farmers. The level of water availability to a sufficient extent for crop cultivation is the major problem in India, Moreover; water insufficiency is a worldwide issue that predicts sustainable agricultural production (Jaleel *et al.,* 2007). An optimum number of irrigations based on the soil type and climatic conditions were an important factor to achieve a suitable economic yield. Wheat is affected by drought or moisture stress severely at the jointing, flowering and milking stages. Water is an essential component of physiological processes which limits photosynthesis, respirations, dry matter content and availability of plant nutrients. Drought leads to stomata termination, a decline of water content and turgor loss. Sometimes it leads to the demise of the plant by disturbing deployment (Jaleel *et al.*, 2008). It is the most momentous environmental stress in farming worldwide, which prevents plant growth and field produces more than any further environmental anxieties (Cattivelli *et al.,* 2008). Therefore, identification of genetic variation for different drought selection indices, related to moisture stress tolerance has been an enduring breeding objective in wheat. The stability of inbred lines concerning yield is highly required both as cultivar and as font parents for drought lenience breeding programs.

In the context of recent and predicted water inadequacy scenarios, irrigation is generally not a feasible option to ease drought problems. Therefore, there is an imperious requirement for a different tactic such as varietal expansion for drought-prone situations. Although, varietal development for drought acceptance is complicated by the lack of fast, reproducible screening methods and the ability to usually create defined repeatable water anxiety conditions where huge populations can be proficiently evaluated (Ramirez and Kelly, 1998). The initial point in the selection of required genotypes is distinctive genotypes expressing comparative supremacy in both stress and non-stress environments due to erratic rainfed conditions (Mohammadi *et al.*, 2010). Although some researchers have faith in selection under favorable conditions (Betran *et al.*, 2003) in target stress conditions (Mohammadi *et al.,* 2011) and selection under both fortunate and stress conditions (Nouriet *et al.,* 2011). The selection of appropriate genotypes based on relative yield act has been considered a consistent technique for evaluating a huge number of genotypes in drought-stressed conditions (Panthuwan *et al.,* 2002). Several selection principles have been planned for selecting genotypes based on their presentation in stress and non-stress environments (Fischer and Maurer, 1978; Rosielle and Hamblin, 1981). Drought indices, which offer a measure of drought based on yield injury under drought conditions in contrast to normal conditions, have been castoff for screening genotypes for drought tolerance (Mitra, 2001). Although there are numerous studies on the usage of drought indices for selection in barley (Amini *et al.,* 2012), bread wheat (Abdi *et al.,* 2012; Dehbalaei *et al.,* 2013; Drikvand *et al.,* 2012; Nouraein *et al.,* 2013), corn (Kiani, 2013; Moradi *et al.,* 2012; Naghavi *et al.,* 2013). Assortment of drought accepting lines between progressive breeding lines through drought-tolerant indices may demonstrate to be a decent selection standard in hurrying and refining selection procedures for cultivar advancement programs.

2. Material and Methods

2.1 Experimental material and site of experiment

The present experiment was takeout in 2019-20 and 2020-21 at Seed Breeding Farm Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, which is situated 21°45’N latitude, 80°50’E longitude and 301.5m altitude from mean sea level. The experimental material consisted of 231 recombinant inbred lines, 2 parents (WH 730 and MACS 2496) and 3 checks (MP 3288, MP 3382 and GW 322). The experimental material was developed at IIWBR Karnal, through bi-parental crosses whereas, WH 730 was used as stress tolerance and MACS 2496 was used as stress susceptible parent. The selection program was initiated by Screening, F_7 and F_8 generations under irrigated and restricted irrigated conditions. The experimental material was planted in the Alpha Lattice design along with two replications. Three rows of each line were planted however, five plants were randomly selected to estimate grain yield per plant in grams. Recommended fertilizer doses were applied as basal application. Under the irrigated conditions, five irrigations were provided at the crown root initiation stage, tillering stage, jointing stage, flowering stage and dough stage. Whereas, under restricted irrigation, only two irrigations were delivered at the crown root initiation stage and flowering stage. Over both the years, weeds were controlled manually in irrigated and restricted-irrigated conditions. The rainfall pattern of crop seasons is depicted in figure 1.

2.2 Statistical analysis

Randomly five plants were selected from each line to characterize the recombinant inbred lines in 2019-20 and 2020-21. The heading days was counted from sowing date to 50% heading and maturity days was counted from sowing date to physiological maturity of the plant. The plant height was taken from ground level to tip of spike excluding awns at the maturity stage. tiller number per plant, thousand kernel weight, number of kernel per spikes, kernel weight per spike, spikelet’s per spike and grain yield were estimated manually for each of line.

The mean grain yield data of 2019-20 and 2020-21 under irrigated and restricted irrigated conditions were used to compute the following drought selection indices: Stress susceptibility index (SSI), Relative drought index (RDI), Tolerance Index (TOL), Mean productivity (MP), Yield stability index (YSI), Stress tolerance index (STI), Yield index (YI), Drought resistance index (DI) Sensitivity drought index (SDI) and percent reduction of grain yield (PR). The statistic summary, frequency distribution and Pearson correlation coefficient were performed by R package.

2.3 Drought selection indices

SSI	1-(YS/YP)/1-(ȲS/ȲP)	Fischer and Maurer (1978)
RDI	(YS/YP)/(ȲS/ȲP)	Fischer and Maurer (1978)
TOL	(YP–YS)	Rosielle and Hamblin (1981)
MP	(YP+YS)/2	Rosielle and Hamblin (1981)
YSI	(YS/YP)	Bouslama and Schapaugh (1984)
STI	(YS*YP)/ȲP	Fernandez (1992)
YI	(YS/ȲS)	Gavuzzi *et al.* (1997)
DRI	YS*(YS/YP)/Ȳs	
SDI	(YP-YS)/YP	Farshadfar and Javadinia (2011)
PR	(YP-YS)/YP*100	

Based on performance every line along with checks was ranked over each selection indices and individual selection indices rank was used to estimate rank mean by simple mathematical mean formula $(R_s+R_r+R_t+R_m+R_y+R_{st}+R_{yi}+R_d+R_{sd}+R_p)/10$ whereas, R_s = rank by SSI, R_r = rank by RDI, R_t = rank by TOL, R_m = rank by MP, R_y = rank by YSI, R_{st} = rank by STI, R_{yi} = rank by YI, R_d = DRI, R_{sd} = SDI and R_p = PR.

3. Result and discussion

3.1 Association study

In the present study moisture stress, tolerance lines were identified based on the correlation among drought selection indices and grain yield under stress conditions. The mean data of grain yield of two subsequent years and 4 environments were subjected to estimate drought selection indices. From two years pooled data the stress susceptibility index (r = 0.51), tolerance index (r = 0.82), mean productivity (r = 0.89), stress tolerance index (r = 0.78), sensitivity drought index (r = 0.59) and percent yield reduction (r = 0.59) were significantly and positively associated with grain yield under irrigated condition whereas, relative drought index (r = -0.59), yield stability index (r = -0.59), and drought resistance index (r = -0.24) were significantly and negatively associated with the grain yield under irrigated condition. On the other hand mean productivity (r = 0.65), relative drought index (r = 0.62), yield stability index (r = 0.62), stress tolerance index (r = 0.78), yield index (r = 1) and drought resistance index (r = 0.87) were significantly and positively associated with grain yield under restricted irrigated condition whereas, tolerance index (r = -0.35), stress susceptibility index (r = -0.6), sensitivity drought index(r = -0.62) and percent of yield reduction (r = -0.62) were significantly and negatively associated with grain yield under restricted irrigated condition (Table 1). Based on the degree and direction of the correlation coefficient among drought selection indices and grain yield under restricted irrigated conditions, stress tolerance inbred lines were selected. The positive and significant association was recorded for mean productivity, relative drought index, yield stability index, stress tolerance index and yield index along with grain yield under restricted irrigation condition. In the earlier study, the positive and significance association among mean productivity and grain yield under restricted irrigated condition was observed by (Geravandi *et al.*, 2010). Similarly, among relative drought index, yield stability index and stress tolerance index found significant positive correlation with grain yield under restricted irrigation (Darzi *et al.,* 2016), Whereas The positive and significant association was found among yield index and grain yield under irrigated and restricted irrigated condition (Amare *et al.,* 2019) in wheat which support the current findings. Therefore, it may be determined that the positive and significant correlation among selection indices as well as with grain yield will permit breeders to picked high yielding genotypes via indirect selection for correlated selection indices under restricted irrigated condition for enhancing drought tolerance.

3.2 Study of drought selection indices

The positive value of relative drought index, yield stability index and drought resistance index were used for selection of drought-tolerant lines under moisture stress condition whereas, negative values were used for stress susceptible index, tolerance index, sensitivity drought index and percent reduction of grain yield. The positive value of the stress tolerance index, mean productivity and yield index were used for the selection of moisture stress-tolerant lines under both the irrigated and restricted irrigated conditions. Cultivars with the highest YSI exhibit the low yield under non-stressed and the high yield under stressed conditions (Sio *et al.,* 2006). However, similar selection criteria were followed by Clarke *et al.,* 1992; Winter *et al.,* 1988; Dorostkar *et al.,* 2015; Khakwani *et al.,* 2011 and Aghaei *et al.,* 2009). On the basis of pooled data over the years the minimum value of stress susceptible index was 0.0, tolerance index was 0.2, sensitivity drought index was 0.0 and percent reduction of yield was 1.1, while the average maximum value of relative drought index was 1.6, mean productivity was 21.5, yield stability index was 1.0, yield index was 1.5, stress tolerance index was 1.0 and drought resistance index was 1.5 (Table 2). More recombinant inbred lines having a desirable value of drought selection indices were obtained during cropping season 2020-21.

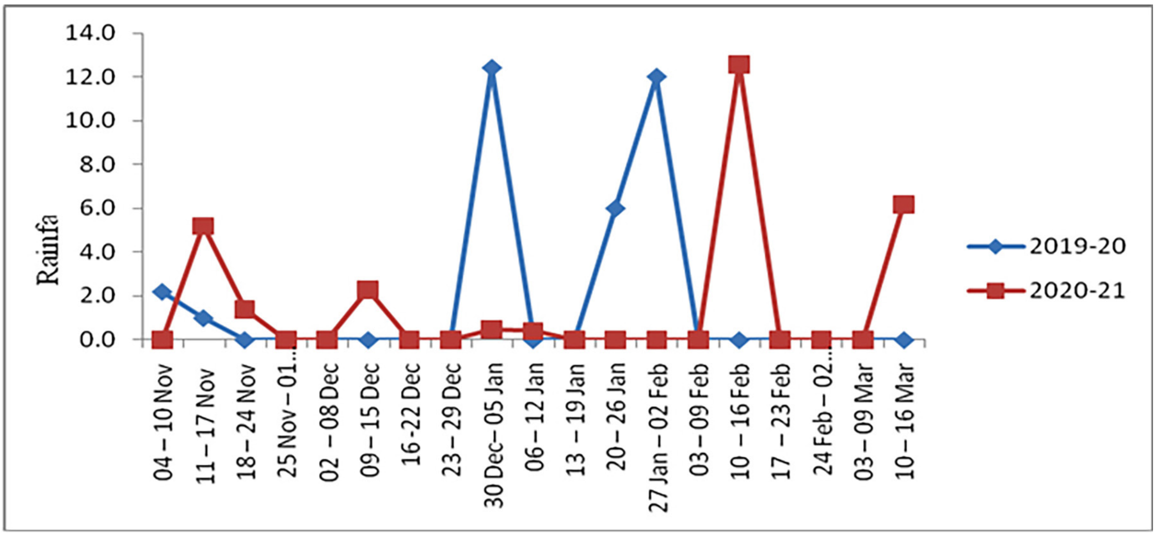
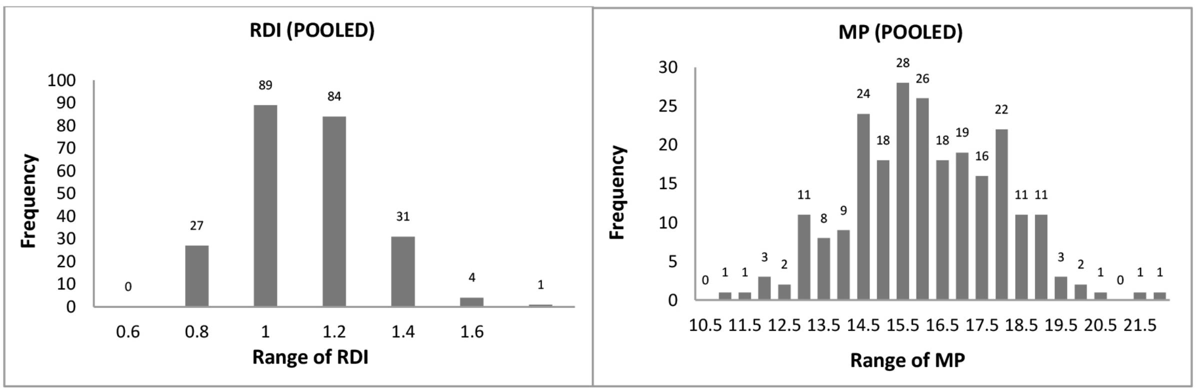


Figure 1. Rainfall pattern of 2019-20 & 2020-21



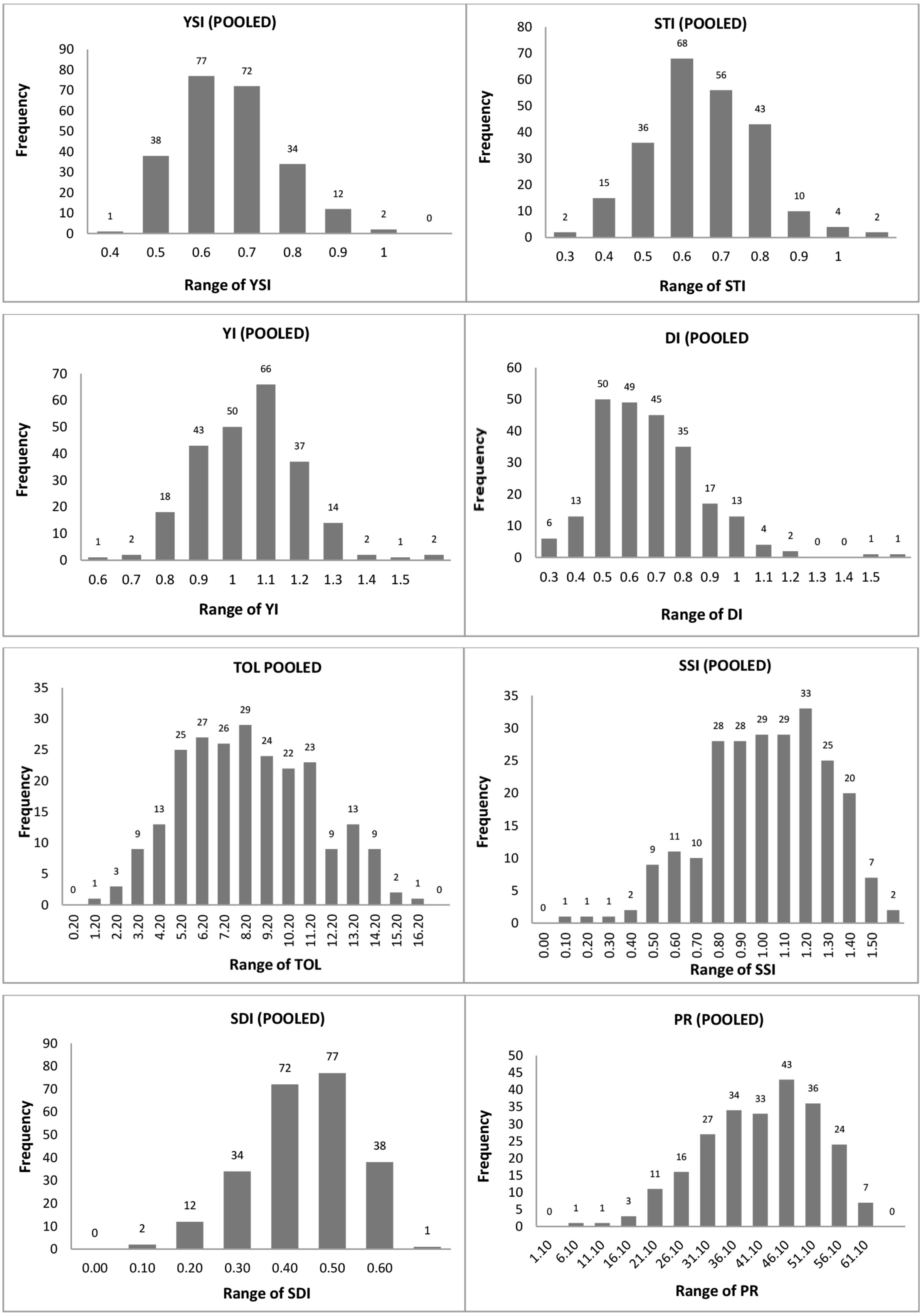


Figure 2. Frequency distribution for drought selection indices for pooled data

3.3 Assessment of recombinant inbred lines along with checks for drought

Based on pooled data recombinant inbred lines were ranked over selection indices and mean rank was considered where 51, 90, 110, 137 and 143 mean rank was attained by MP 3288, MP3382, WH730, GW322 and MACS 2496 accordingly; however, MP 3288 was confirmed the best performing check under moisture stress condition attain top mean rank among checks, while WH 730 perform best over both irrigated and restricted conditions. From pooled data, selection indices along with rank, SSI (0.8 & 50), TOL (5 & 48), SDI (0.3 & 34), PR (27 & 34), DI (0.8 & 33), RDI (1.1 & 34), YSI (0.7 & 34), YI (1.1 & 45), MP (15.9 & 107) and STI (0.6 & 94) were observed for MP 3288, whereas, WH 730 conferring highest values of STI (1.1), YI (1.3) and MP (21.5). Individually by SSI, TOL, SDI, YSI, RDI and MP 63, 47, 33, 45, 75 and 29 lines were found better than MP 3288 based on frequency distribution (Figure 2). While, through SSI, TOL, SDI, PR, RDI, YSI and DI simultaneously 33 lines were identified as promising (Table 3 & 4). Likewise, identification of drought-tolerant recombinant inbred lines simultaneously through selection indices was found to be contradictory because selection indices are simultaneously not able to give the same rank for the same line, therefore each recombinant inbred line along with checks was ranked over drought selection indices and rank mean was considered. Different selection indices introduced different entries as drought-tolerant, therefore, for identification of the most promising entry, the mean of ranks of all selection indices was calculated (Wasae, 2021).

3.4 Identification of drought tolerant lines

Water stress is the most common problem during the crop growth period in India; therefore appropriate screening and efficient selection criteria are essential factors to enhance the germplasm for water stress conditions. In the current investigation, 22 lines were selected out of 231 recombinant inbred lines by considering the rank mean of selection indices under drought conditions. The negative strong (r = -0.72) correlation was found between rank mean and grain yield under stress conditions, meanwhile the lines having the lowest mean rank was best performing under water stress condition. Twenty-two lines *viz.,* 35, 47, 54, 56, 93, 114, 116, 117, 118, 120, 121, 124, 141, 147,

Table 1. Pearson correlation between different selection indices and grain yield

		YP	**YS**	**SSI**	**RDI**	**TOL**	**MP**	**STI**	**YSI**	**YI**	**DI**	**SDI**
	2019-20	0.109										
YS	**2020-21**	0.357***										
	Pooled	0.240***										
	2019-20	0.677***	-0.623***									
SSI	**2020-21**	0.517***	-0.599***									
	Pooled	0.593***	-0.628***									
	2019-20	-0.677***	0.623***	-1.000***								
RDI	**2020-21**	-0.517***	0.599***	-1.000***								
	Pooled	-0.593***	0.629***	-1.000***								

	2019-20	0.907***	-0.320***	0.909***	-0.909***							
TOL	**2020-21**	0.687***	-0.432***	0.966***	-0.966***							
	Pooled	0.824***	-0.353***	0.939***	-0.939***							
	2019-20	0.922***	0.486***	0.352***	-0.352***	0.673***						
MP	**2020-21**	0.861***	0.781***	0.018	-0.018	0.223***						
	Pooled	0.890***	0.657***	0.165*	-0.165*	0.475***						
	2019-20	-0.677***	0.623***	-1.000***	1.000***	-0.909***	-0.352***					
YSI	**2020-21**	-0.517***	0.599***	-1.000***	1.000***	-0.966***	-0.018					
	Pooled	-0.593***	0.629***	-1.000***	1.000***	-0.939***	-0.165*					
	2019-20	0.772***	0.701***	0.098	-0.098	0.439***	0.953***	-0.098				
STI	**2020-21**	0.785***	0.851***	-0.106	0.106	0.095	0.987***	0.106				
	Pooled	0.786***	0.782***	-0.014	0.014	0.302***	0.979***	0.014				
	2019-20	0.109	1.000***	-0.623***	0.623***	-0.320***	0.486***	0.623***	0.701***			
YI	**2020-21**	0.351***	0.999***	-0.605***	0.605***	-0.439***	0.778***	0.605***	0.848***			
	Pooled	0.240***	1.000***	-0.627***	0.627***	-0.351***	0.658***	0.627***	0.783***			
	2019-20	-0.375***	0.853***	-0.919***	0.919***	-0.719***	0.003	0.919***	0.250***	0.853***		
DI	**2020-21**	-0.091	0.889***	-0.885***	0.885***	-0.781***	0.424***	0.885***	0.530***	0.894***		
	Pooled	-0.240***	0.875***	-0.915***	0.915***	-0.742***	0.226***	0.915***	0.393***	0.875***		
	2019-20	0.677***	-0.623***	1.000***	-1.000***	0.909***	0.352***	-1.000***	0.098	-0.623***	-0.919***	
SDI	**2020-21**	0.517***	-0.599***	1.000***	-1.000***	0.966***	0.018	-1.000***	-0.106	-0.605***	-0.885***	
	Pooled	0.593***	-0.629***	1.000***	-1.000***	0.939***	0.165*	-1.000***	-0.014	-0.627***	-0.915***	
	2019-20	0.677***	-0.623***	1.000***	-1.000***	0.909***	0.352***	-1.000***	0.098	-0.623***	-0.919***	1.000***
PR	**2020-21**	0.513***	-0.605***	0.998***	-0.998***	0.964***	0.014	-0.998***	-0.11	-0.608***	-0.885***	0.998***
	Pooled	0.593***	-0.629***	1.000***	-1.000***	0.939***	0.165*	-1.000***	-0.015	-0.629***	-0.916***	1.000***

$P < 0.05$, $^{**}P<0.01$, $^{***}P < 0.001$

Table 2. Descriptive value of drought indices

Drought selection indices	Year 2019 – 2020			Year 2020 - 2021			Pooled		
	Min	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Stress susceptibility indices(SSI)	0.0	1.5	1.0	0.0	2.2	1.0	0.0	1.5	1.0
Relative drought index(RDI)	0.5	2.0	1.0	0.6	1.4	1.0	0.6	1.6	1.0
Tolerance index(TOL)	0.2	24.4	10.6	0.0	15	5.2	0.2	15.4	7.9
Mean productivity(MP)	9.1	25	15.5	10.9	22.4	16.2	10.6	21.5	15.8
Yield stability index(YSI)	0.2	1.0	0.5	0.4	1.0	0.7	0.4	1.0	0.6
Yield index(YI)	0.5	1.9	1.0	0.3	1.4	0.7	0.6	1.5	1.0
Stress tolerance index(STI)	0.2	1.2	0.5	0.5	1.6	1.0	0.3	1.0	0.6
Drought resistance index(DI)	0.1	1.7	0.5	0.2	1.5	0.8	0.3	1.5	0.6
Sensitivity drought index(SDI)	0.0	0.8	0.5	0.0	0.6	0.3	0.0	0.6	0.4
Grain Yield in normal condition(YP)	10.4	34.9	20.7	11.2	28.02	18.7	12.9	28.2	19.7
Grain Yield in stress condition(YS)	5.2	19.3	10.2	6.7	21.4	13.6	7.1	18.3	11.9
Percent Reduction(PR)	1.2	76.2	48.7	0.3	59.6	26.2	1.1	60.5	38.8

Min- Minimum, Max- Maximum

Table 3: List of selected recombinant inbred lines along with checks

Line code	Year	SSI	RDI	TOL	MP	YSI	STI	YI	DI	SDI	PR
	2019-20	0.9	1.1	9	14.4	0.5	0.4	1	0.5	0.5	47.6
35	2020-21	0.0	1.4	0.1	17.7	1.0	0.9	1.3	1.3	0.0	0.6
	Pooled	0.6	1.2	4.6	16.1	0.8	0.6	1.2	0.9	0.2	24.8
	2019-20	0.3	1.7	2.1	13.7	0.9	0.4	1.2	1.1	0.1	14.3
47	2020-21	0.4	1.2	1.8	17.2	0.9	0.8	1.2	1.1	0.1	9.9
	Pooled	0.3	1.5	2.0	15.4	0.9	0.6	1.2	1.1	0.1	11.9
	2019-20	0.6	1.4	6.2	15.7	0.7	0.5	1.2	0.8	0.3	33
54	2020-21	0.5	1.2	2.4	15.8	0.9	0.7	1.1	0.9	0.1	14.2
	Pooled	0.6	1.3	4.3	15.8	0.8	0.6	1.1	0.9	0.2	24.1
	2019-20	0.3	1.7	2.9	15.4	0.8	0.5	1.4	1.1	0.2	17.3
56	2020-21	1.0	1.0	5.2	15.9	0.7	0.7	1.0	0.7	0.3	28.1
	Pooled	0.6	1.3	4.1	15.6	0.8	0.6	1.1	0.9	0.2	23
	2019-20	0.5	1.6	4.0	15.1	0.8	0.5	1.3	1.0	0.2	23.4
93	2020-21	0.3	1.2	1.5	16.4	0.9	0.8	1.1	1.0	0.1	8.9
	Pooled	0.4	1.4	2.8	15.7	0.8	0.6	1.2	1.0	0.2	16.1
	2019-20	0.6	1.4	5.0	13.7	0.7	0.4	1.1	0.8	0.3	30.9
114	2020-21	0.5	1.2	2.8	17.3	0.9	0.8	1.2	1.0	0.1	14.9
	Pooled	0.6	1.3	3.9	15.5	0.8	0.6	1.1	0.9	0.2	22.3
	2019-20	0.6	1.4	4.3	11.5	0.7	0.3	0.9	0.6	0.3	31.6
116	2020-21	0.3	1.3	1.7	20.1	0.9	1.1	1.4	1.3	0.1	7.9
	Pooled	0.4	1.4	3.0	15.8	0.8	0.6	1.2	1.0	0.2	17.3

	2019-20	0.2	1.8	1.9	16.2	0.9	0.6	1.5	1.3	0.1	11.1
117	2020-21	0.1	1.3	0.8	21.8	1.0	1.3	1.6	1.5	0.0	3.7
	Pooled	0.2	1.5	1.4	19	0.9	0.9	1.5	1.4	0.1	6.9
	2019-20	0.0	2.0	0.2	16.1	1.0	0.6	1.6	1.5	0.0	1.2
118	2020-21	0.0	1.4	0.2	20.6	1.0	1.2	1.5	1.5	0.0	1.1
	Pooled	0.0	1.6	0.2	18.3	1.0	0.9	1.5	1.5	0.0	1.1
	2019-20	0.6	1.4	6.2	16.2	0.7	0.6	1.3	0.9	0.3	32.1
120	2020-21	0.3	1.2	1.6	16.2	0.9	0.7	1.1	1.0	0.1	9.3
	Pooled	0.5	1.3	3.9	16.2	0.8	0.7	1.2	0.9	0.2	21.4
	2019-20	0.0	2.0	0.2	12.5	1.0	0.4	1.2	1.2	0.0	1.6
121	2020-21	1.0	1.0	5.3	17.4	0.7	0.8	1.1	0.8	0.3	26.4
	Pooled	0.4	1.4	2.7	15	0.8	0.6	1.1	0.9	0.2	16.8
	2019-20	0.4	1.6	3.8	16.1	0.8	0.6	1.4	1.1	0.2	21.1
124	2020-21	0.2	1.3	1.0	15.7	0.9	0.7	1.1	1.1	0.1	5.9
	Pooled	0.3	1.4	2.4	15.9	0.9	0.6	1.2	1.1	0.1	13.9
	2019-20	0.9	1.1	8.0	13.5	0.5	0.4	0.9	0.5	0.5	45.7
141	2020-21	0.2	1.3	1.3	20.5	0.9	1.2	1.5	1.4	0.1	6.2
	Pooled	0.6	1.3	4.7	17	0.8	0.7	1.2	0.9	0.2	24.1
	2019-20	0.6	1.4	6.0	15.2	0.7	0.5	1.2	0.8	0.3	33
147	2020-21	0.3	1.3	1.2	16.1	0.9	0.7	1.1	1.1	0.1	7.4
	Pooled	0.5	1.3	3.6	15.6	0.8	0.6	1.2	0.9	0.2	20.7
	2019-20	0.8	1.2	9.7	18.3	0.6	0.7	1.3	0.8	0.4	42
151	2020-21	0.0	1.4	0.1	20.7	1.0	1.2	1.5	1.5	0.0	0.5
	Pooled	0.6	1.3	4.9	19.5	0.8	1.0	1.4	1.1	0.2	22.4
	2019-20	0.8	1.2	8.1	16.6	0.6	0.6	1.2	0.7	0.4	39.3
159	2020-21	0.6	1.2	2.8	17.1	0.8	0.8	1.2	1.0	0.2	15.3
	Pooled	0.7	1.2	5.5	16.8	0.7	0.7	1.2	0.9	0.3	27.9
	2019-20	0.8	1.2	9.2	18.6	0.6	0.8	1.4	0.8	0.4	39.7
161	2020-21	0.6	1.1	3.0	16.7	0.8	0.8	1.1	0.9	0.2	16.5
	Pooled	0.7	1.2	6.1	17.7	0.7	0.8	1.2	0.9	0.3	29.5
	2019-20	0.2	1.8	2.4	18.7	0.9	0.8	1.7	1.5	0.1	12.1
179	2020-21	1.2	0.9	6.9	16.6	0.7	0.7	1.0	0.6	0.3	34.3
	Pooled	0.6	1.3	4.6	17.6	0.8	0.8	1.3	1.0	0.2	23.2
	2019-20	0.2	1.8	1.6	14.1	0.9	0.5	1.3	1.2	0.1	10.7
182	2020-21	0.9	1.0	5.3	18.7	0.8	1.0	1.2	0.9	0.2	24.8
	Pooled	0.5	1.3	3.4	16.4	0.8	0.7	1.2	1.0	0.2	19
	2019-20	0.8	1.2	7.7	14.6	0.6	0.5	1.0	0.6	0.4	41.8
213	2020-21	0.2	1.3	1.4	20.9	0.9	1.2	1.5	1.4	0.1	6.4
	Pooled	0.6	1.3	4.5	17.7	0.8	0.8	1.3	1.0	0.2	22.7

	2019-20	0.6	1.4	4.5	12.3	0.7	0.3	1.0	0.7	0.3	31
216	2020-21	0.3	1.3	1.6	17.8	0.9	0.9	1.2	1.1	0.1	8.5
	Pooled	0.5	1.4	3.0	15	0.8	0.6	1.1	0.9	0.2	18.4
	2019-20	0.2	1.9	1.7	20.2	0.9	0.9	1.9	1.7	0.1	8.1
221	2020-21	1.1	0.9	5.9	16.3	0.7	0.7	1.0	0.7	0.3	30.7
	Pooled	0.5	1.3	3.8	18.2	0.8	0.8	1.4	1.1	0.2	18.9
					Checks						
	2019-20	1.1	0.9	19.9	25	0.4	1.2	1.5	0.6	0.6	57
WH 730	2020-21	0.9	1.0	5.1	18	0.8	0.9	1.1	0.9	0.2	24.9
	Pooled	1.1	0.9	12.5	21.5	0.5	1.1	1.3	0.7	0.5	45.1
MACS	2019-20	1.3	0.7	18.7	17.4	0.3	0.5	0.8	0.3	0.7	65.2
2496	2020-21	0.6	1.2	2.7	13.6	0.8	0.5	0.8	0.9	0.2	15.9
	Pooled	1.2	0.9	10.7	15.5	0.5	0.5	0.8	0.5	0.5	46.9
	2019-20	1.0	0.01	10.1	15.5	0.5	0.5	1.0	0.5	0.5	49.3
GW 322	2020-21	1.3	0.9	6.4	15.5	0.7	0.6	0.9	0.6	0.3	34.3
	Pooled	1.1	1.0	8.2	15.5	0.6	0.6	1.0	0.6	0.4	42.1
	2019-20	0.7	1.3	6.6	15.7	0.7	0.5	1.2	0.8	0.3	34.7
MP 3382	2020-21	1.1	0.9	5.4	14.6	0.7	0.6	0.9	0.6	0.3	31.2
	Pooled	0.8	1.1	6.0	15.1	0.7	0.6	1.0	0.7	0.3	33
	2019-20	0.9	1.2	8.7	15.7	0.6	0.5	1.1	0.6	0.4	43.5
MP 3288	2020-21	0.3	1.3	1.2	16.2	0.9	0.7	1.1	1.1	0.1	7.4
	Pooled	0.8	1.2	5.0	15.9	0.7	0.6	1.1	0.8	0.3	27

Table 4. Rank and mean value for selected lines along with checks

Line code	Rank by SSI	Rank by RDI	Rank by TOL	Rank by MP	Rank by YSI	Rank by STI	Rank by YI	Rank by DI	Rank by SDI	Rank by PR	Rank Mean
35	29	29	34	103	29	85	28	25	29	29	42
47	3	3	3	135	3	110	17	5	3	3	29
54	28	28	27	119	28	100	34	26	28	28	45
56	22	22	26	127	22	106	35	23	22	22	43
93	7	7	9	121	7	97	18	7	7	7	29
114	19	19	22	132	19	114	40	22	19	19	43
116	10	10	11	118	10	93	19	10	10	10	30
117	2	2	2	11	2	5	1	2	2	2	3
118	1	1	1	22	1	9	2	1	1	1	4
120	18	18	21	97	18	77	20	14	18	18	32
121	9	9	8	160	9	137	38	12	9	9	40
124	4	4	5	109	4	87	12	6	4	4	24
141	27	27	38	67	27	49	13	15	27	27	32
147	16	16	16	128	16	105	26	19	16	16	37

151	20	20	46	6	20	3	3	4	20	20	16
159	37	38	59	77	38	57	23	29	38	38	43
161	44	45	77	41	45	30	16	27	45	45	42
179	23	23	36	43	23	26	8	11	23	23	24
182	14	14	15	91	14	71	14	9	14	14	27
213	21	21	33	40	21	20	6	8	21	21	21
216	12	12	13	159	12	133	43	18	12	12	43
221	13	13	17	24	13	12	4	3	13	13	13
Checks											
WH 730	160	160	216	2	160	1	9	73	160	160	110
MACS 2496	175	175	194	53	175	56	106	147	175	175	143
GW 322	135	135	134	134	135	136	148	141	135	135	137
MP 3382	71	71	71	151	71	140	105	78	71	71	90
MP 3288	50	34	48	107	34	94	45	33	34	34	51

151, 159, 161, 179, 182, 213, 216, 221(Table 4) were hold the lowest rank mean for selection indices under water stress condition. Similarly, five lines *viz.,* 117, 118, 221, 151 and 93 were identified as the most promising lines revealed 3, 4, 13, 16 and 29 mean rank respectively. Line no 117 was one of the most promising lines out of the whole population achieving 3rd mean rank.

4. Conclusion

Based on the significant correlation coefficient the positive value of the relative drought index, yield stability index and drought resistance index were used for selection of drought-tolerant lines under moisture stress condition whereas, negative values were used for stress susceptible index, tolerance index, sensitivity drought index and percent reduction of grain yield. While, the positive value of the stress tolerance index, mean productivity and yield index were used for the selection of moisture stress-tolerant lines under both the irrigated and restricted conditions.

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