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ASSOCIATION OF DROUGHT AND HEAT TOLERANCE PARAMETERS IN WHEAT

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ABSTRACT

The association of different plant characters with drought tolerance of genotypes was studied in wheat under rainfed condition in winter season. The leaf samples were subjected to heat injury at 45°C on 45-day-old seedlings, and stomata on upper and lower surfaces were counted in the laboratory. Among *T. aestivum* varieties, HD 2189 exhibited 45.2 and 31.5 stomata per microscopic field at upper and lower surfaces, while among *T. durums*, Bijiga Yellow recorded the highest number of stomata (56.4/mm^2) and flag leaf area (30.51 dm^2). The variety HI 7483 had the highest flag leaf area of 43.22 dm^2. Waxy coat on the leaf was 100% in UP 2029 and HS 90, while N 59, MACS 9, Bijiga Yellow and Ajantha were characterised by glossy leaf surface. Leaf folding was very low in varieties K 68, Hindi 62, N 59 and Bijiga Yellow (3–4%). The number of stomata had significant negative association with waxiness, leaf folding, temporary wilting and grain yield per ear. Similar trend was observed for number of stomata on the lower surface. Therefore, waxiness, leaf folding, wilting percent, heat injury and stomata number are suggested as the most reliable traits in screening for drought and high temperature tolerance.

Key words: *Triticum* spp., wheat, character association, drought, heat parameters.

In India, about 44% of the total wheat area is rainfed [1]. The local and released varieties of wheat are susceptible to drought at flowering stage. Therefore, inadequate rains often cause partial or complete failure of the crop on large scale in Maharashtra, Gujarat, Madhya Pradesh and Uttar Pradesh.

Drought causes dehydration and desiccation of protoplasm. Hence, it is essential to evaluate the relative importance of morphological as well as protoplasmic factors in relation to drought and heat tolerance. Several criteria have been suggested by different workers to screen for drought and heat tolerance in wheat and other crops [2–5]. The present study aims to find out the most reliable screening technique and tolerant genotypes for breeding drought and heat tolerant wheat varieties.

MATERIALS AND METHODS

The material consisted of 94 genotypes of *T. aestivum* and T. *durum* received from the Project Director, All India Coordinated Wheat Improvement Project, New

Delhi, during 1979-80. The material was sown in randomised block design at Parbhani in 3 m rows sapced 22.5 cm apart, the interplant distance being 5 cm. Each treatment was accommodated in three-row plots. Recommended doses of FYM and NPK were applied. The soil moisture, 45 days after sowing, was 2.76% in the top 15-cm and 6.25% in the second 15-cm layers.

Observations were recorded on productive tillers, waxiness (blum), leaf folding (straight, wavy, or rolled), days to flower, temporary wilting at flowering, flag leaf area, 100-grain weight, and grain yield/per ear. The wilting percentage was evaluated at flowering stage in the temperature range of 12.0-32.0°C during the 6th meteorological week (8–15 February). Drought tolerance was determined on the basis of the grain yield/ear under rainfed conditions, while temperature tolerance was measured by chlorophyll disintegration at 45°C on 45-day-old seedlings. The data on all these characters were collected from ten randomly selected plants in each replication.

In the laboratory, the stomata (both on lower and upper surfaces) per 3.73 mm^2 microscopic field were counted and chlorophyll disintegration estimated at 45°C in 45-day seedlings [4].

RESULTS AND DISCUSSION

The character means of genotypes used in the study are presented in Table 1. The differences between wheat genotypes for No. of stomata at the upper and lower surfaces, No. of productive tillers, days to flower, and 100-grain weight were statistically significant. Among *T. aestivum* varieties, HD 2189, an established variety of Peninsular Zone, exhibited 45.2 and 31.5 stomata/3.73 mm^2 of microscopic field at the upper and lower surfaces, respectively, which was comparable with all other varieties except Kalyan Sona and HD 2160 on upper surface and HS-90 on lower surface. It is interesting to note that all the *T. durum* varieties exhibited significantly higher No. of stomata at both surfaces than in *T. aestivum*. Among the *T. durum* varieties, Bijiga Yellow recorded the highest number of stomata (56.4/mm^2), which was statistically at par with the drought tolerant and well adapted variety N 59. The stomatal density at lower surface was, however, highest in var. MACS 9, which was comparable with Bijiga Yellow, while N 59 recorded lowest number of stomata at the lower leaf surface.

Flag leaf studies indicated that among both wheat species, variety HI 7483 had the highest flag leaf area of 43.22 dm^2. The variety HD 2189 had 36.25 dm^2 flag leaf area and was at par with HD 2160, Mukta and Ajantha. Among *T. durum* varieties, Bijiga Yellow had the largest flag leaf area (30.51 dm^2). The variety K-68 with the highest absolute number of productive tillers was statistically comparable with Mukta. The variety HD 2189, known for it's shy tillering habit, had the lowest number of productive tillers. Hence, while making recommendation in the package of practices of wheat, the seed rate of HD 2189 is increased to 125 kg/ha [1].

The waxy coat on the leaf surface of different wheat genotypes indicated that varieties UP 2029 and HS-90 had 100% waxiness. Seetharama et al. [6] reported

Table 1. Mean values of different characters of wheat cultivars

Variety	No. of stomata/mm²		Flag leaf area, dm²	Productive tillers	Waxiness, %	Leaf folding, %	Days to flower	Wilting, %	100-grain wt., g	Grain yield per ear g
	upper surface	lower surface								
T. aestivum										
UP 2029	46.3	35.4	20.1	88	100	50	57	5	3.5	1.8
Ajantha	43.3	31.7	34.5	47	50	50	52	5	3.9	1.1
HD 2189	45.2	31.5	36.2	49	88	95	55	86	4.2	1.2
HS 90	44.9	26.6	28.4	65	100	95	50	86	3.1	1.8
K-Sona	39.7	28.1	29.0	83	55	95	48	75	3.1	1.4
K-68	48.6	35.3	18.5	110	45	3	57	10	4.0	1.9
HD 2160	30.4	27.9	37.9	62	90	90	46	90	3.2	1.0
Mukta	44.2	34.8	36.9	105	65	50	54	5	3.7	1.8
Hindi 62	44.9	31.2	31.7	68	60	5	70	5	2.5	0.9
HI 7483	43.3	28.7	43.3	76	80	95	45	95	3.2	1.7
T. durum										
N 59	53.5	41.6	23.9	62	80	5	54	5	4.8	1.7
MACS 9	52.9	45.9	26.0	70	80	50	57	5	4.7	2.1
Bijiga Yellow	56.4	47.6	30.5	85	56	4	57	5	4.0	1.8
SE at 5%	1.3	1.2	0.9	2.6	1.6	1.20	0.91	0.35	0.05	NS
CD at 5%	4.1	3.8	2.6	6.2	4.7	3.40	2.60	1.01	0.15	2.1

in sorghum that most drought resistant lines at seedling stage had light green leaves with a glossy surface, while the susceptible lines, in general, had dark green leaves. In our studies, *T. durum* and the rainfed varieties like N 59, MACS 9, Bijiga Yellow and Ajantha have less waxiness and are characterised by glossy leaf surface.

Leaf folding was very low in varieties K 68, Hindi 62, N 59 and Bijiga Yellow (range 3-4%), while HD 2189, Kalyan Sona, HS 90, HD 2160, HI 7830 had 90-95% folding, indicating the effect of drought and high temperature on these genotypes.

The single most important change that usually occurs in high yielding cultivars developed for drought or high temperature conditions is early maturity. Earliness has also made the wheat crop more widely adapted across the country and offers a more intensive cropping systems, reaching 100% cropping intensity. However, it may not be a universally successful strategy [6]. In our studies, HD 2160 and HI 7483 were earliest in 50% flowering (45-46 days). Most varieties are grouped under mid-late category. The variety Hindi 62 with 70 days to flower is the latest. There is a need to breed varieties maturing early (within 90-100 days) under high temperature conditions or mild winter.

The drought and high temperature tolerant genotypes N 59, MACS 9, Bijiga Yellow, Ajantha, Mukta, Hindi 62, and UP 2029 exhibited lowest wilting per cent, while HD 2189, HS 90, Kalyan Sona and HI 7483 had 75% or more wilting.

The ultimate test of tolerance to drought or high temperature is the yield, measured in field under typical temperature stress conditions. It is very difficult to

develop field techniques to evaluate a large number of genotypes for temperature tolerance. However, in this investigation, single plant yield gave nonsignificant results, the variety N 59 had significantly high 100-grain weight, followed by MACS 9.

According to these findings, varieties UP 2029, Ajantha, Mukta and Hindi 62 are superior for number of stomata, wilting per cent and test weight in *T. aestivum;* and Bijiga Yellow, N 59 and MACS 9 in *T. durum*. These varieties are tolerant to drought and high temperature.

The regression analysis is the quantification of association of dependent and independent characters. The regression equation in Table 2 revealed that all the characters are significantly different from zero, except productive tillers. This indicates that No. of stomata, waxiness, leaf position, days to flower, temporary wilting, flag leaf area, 100-grain weight, and grain yield/ear are dependent on each other.

Table 2. Character associations in wheat

Character	No. of stomata at lower surface	Productive tillers	Waxiness	Leaf position	Days to flower	Temporary wilting	Flag leaf area	100-grain wt.	Grain wt. per ear
No. of stomata on upper surface	0.51**	−0.21**	−0.39**	−0.44**	−0.02	−0.28**	0.19	0.17	−0.75**
No. of stomata on lower surface		−0.20**	−0.34**	−0.47**	−0.25**	−0.35**	0.18	0.13	−0.03**
Productive tillers			0.24	0.15	0.21**	0.19	0.19	0.25**	0.28**
Waxiness				0.45**	0.23**	0.27**	−0.19	−0.08	0.18
Leaf position					0.01	0.52	−0.14	−0.15	0.07
Days to flower						−0.7	−0.06	0.18	0.23**
Temporary wilting							−0.15	−0.06	−0.16
Flag leaf area								0.02	0.26**
100-grain weight									0.60**
Chlorophyll disintegration									−0.26**

**Significant at 1% level.

The number of stomata on the upper leaf surface exhibited highly significant correlations with the number of stomata on the lower surface, and both stomatal densities showed significant negative association with waxiness, leaf folding, temporary wilting and grain yield/ear. Highly significant positive correlations were observed between productive tillers and days to flower, 100-grain weight and grain yield per

ear. Waxiness on leaf surface displayed highly significant positive correlation with leaf folding, days to flower, and temporary wilting. McDaniel [7] reported that wilting, leaf burn, and leaf folding or abscission serve as an early indication of high temperature-induced damage.

There was highly significant correlation between leaf folding and temporary wilting per cent. Days to flower and 100-grain weight also exhibited highly significant correlations with grain yield/ear.

Wheat crop is more sensitive to drought and high temperature conditions in Peninsular India, particularly in Maharashtra. The drought coupled with high temperatures from crown root initiation to flowering period often results in reduction in productive tillers and number of spikes, poor reduction and shrivelled grain setting and ultimately low yields.

Asana [2] and Bose et al. [8] are of the view that yield is the real test for assessing the relative merit and capacity for drought resistance under field conditions. Therefore, it will be quite appropriate to state that drought tolerance of these genotypes can be assessed best on the basis of their yield under limited moisture conditions. Therefore, yield and some plant characters related with stomata number, wilting per cent and waxiness were studied.

On the basis of grain yield per ear, the varieties UP 2029, HS 90, PV 18, NP 846, Bijiga Yellow, A 28, Mukta, Ajantha, K 68, MACS 9, HI 7483 (Meghdoot) yielded from 1.8 to 2.1 g/ear, which is significantly superior over the standard check NI 5439. The varieties NP 846, Bijiga Yellow, A 28, Mukta, K 68, Meghdoot, MACS 9 and Ajantha are recommended for rainfed cultivation in Central India, Maharashtra and Karnataka. Hence, these could be utilized for evolving drought and high temperature tolerant wheat varieties.

The entries with less stomata on both the leaf surfaces, straight leaf margin, waxy types, no wilting signs, and larger flag leaf yielded better. There was significant positive correlation between yield and 100-grain weight, Similar findings were reported earlier [3]. Several wheat and maize workers found close association between drought resistance of seedlings in the laboratory and yield potential in field under stress/rainfed conditions.

In our studies, the temporary wilting at flowering stage had correlation with yield. Heat injury can be considered as an index of drought tolerance [4, 9]. The present study has revealed that there is a significant correlation between yield and stability of chlorophyll when heated at 45°C for 1 h. There was high significant negative correlations between yield and chlorophyll disintegration of 15-day-old seedlings heated at 45°C for 1 h.

It can be concluded that, in addition to yield traits, stomata number, waxiness, straight leaf folding, absence of terminal sterility and temporary wilting, which exhibited positive correlation coefficients with yield, can be considered while selecting for drought resistance in wheat. The information on productive tillers, 100-grain weight and heat injury can also be utilized with advantage.

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