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Performance of wheat (*Triticum aestivum*) genotypes as influenced by low moisture and temperature regimes under mid-hill conditions of Jammu and Kashmir*

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Wheat (*Triticum aestivum* L. emend. Fori & Paol.) is cultivated over vast areas of Jammu and Kashmir with a total production of 4 959 thousand q and average productivity of 17.82 tonnes/ha (MOA 2008) which is far below than national average (27.88 tonnes/ha). In hills wheat is raised as rainfed crop which mainly thrives on receding moisture of rainy season. Maximum yield potential of crop can be realized in presence of favourable environment. Thresholds like rainfall and temperature do always exist to determine the yield in addition to describe physiological and developmental features of plant characteristics and to delineate the length of cropping season at growing site. At mid hills climate remains cool, with maximum ranging from 32°C to 12°C and minimum ranging from 11°C to–2°C, but random occurring of intermittent drought poses to be a potent constraint in realizing the optimum level of wheat yields. The recurrence of drought like situation and to overcome the problem of chilling temperatures during early stages of crop growth provide the impetus for the development of cultivars with stress tolerance in order to bring stability towards wheat yields under mid hill conditions.

The material for the present study include seven wheat genotypes, viz VL 900, VL 898, VL 804, VL 872, VL 738, HS 295 and HS 240 including two standard checks (i e VL 738 and HS 240) for mid hills and five recommended cultivars for Himalayan region of India. Field experiments were conducted at an altitude of 950 m above mean sea level at Regional Agricultural Research Station, SKUAST-J, Rajouri under rainfed condition. Environment with scarce rainfall on 2007–08 was categorized as water-deficit stress condition of drought for wheat cultivation at mid hills, while 2008–09 was categorized as normal and/or stress-free situation. Seeds were sown on 29 October and 20 October, respectively for 2007–08 and 2008–09 in the field @ 100 kg/ha. Experiments were laid out in a randomized block design with three replications. The distance between two rows and the length of single row was maintained 0.23 m and 3 m, respectively with plot size 4×1.38 m^2. Recommended doses of fertilizers were applied to maintain the normal growth and development of crop plants. Weather data for rainfall, maximum and minimum temperature was recorded at this station as per standard meteorological weeks (Fig 1). The influence of water-deficit stress on wheat cultivars was examined by comparing the performance in field trials

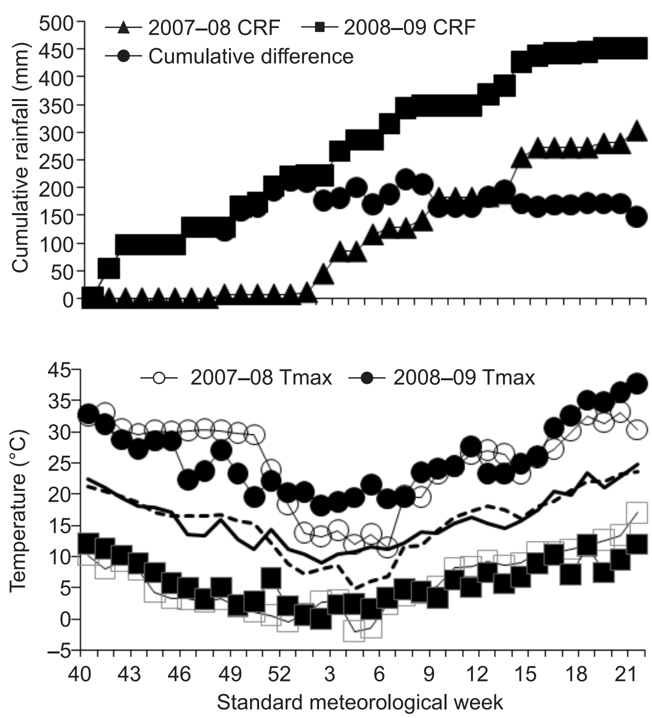

Fig 1 Rainfall and maximum and minimum temperatures during the wheat growing seasons of 2007–08 and 2008–09 as recorded at agro-meteorological observatory, RARS, Rajouri

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Table 1 Mean performance of seven characters under non-stress and stress environments, yield loss (%) at stress environments and DSI of wheat genotypes at mid hill altitude

Genotype	Environment	Days to flowering	Days to maturity	Plant height (cm)	Seed weight (g)	Biomass (g/plot)	Harvest index (%)	Grain yield (g)	Yield loss stress (%)	DSI
VL 900	Non-stress	142.00	182.67	87.30	6.70	7355.55	34.67	2734.00	33.26	1.232
	Stress	151.64	200.33	80.83	5.80	5426.67	27.39	1824.67		
HS 295	Non-stress	141.66	181.67	83.00	6.10	6961.67	33.29	2707.67	29.44	1.091
	Stress	152.28	203.33	73.72	5.90	6531.67	30.57	1910.33		
VL 898	Non-stress	132.55	190.00	100.03	8.17	6525.67	33.45	2450.00	11.57	0.429
	Stress	141.10	200.67	89.03	7.80	6108.33	31.70	2166.33		
VL 804	Non-stress	135.66	185.00	97.37	5.70	7958.33	31.43	2085.00	19.42	0.719
	Stress	145.29	202.33	87.37	6.17	6226.00	29.84	1680.00		
VL 738	Non-stress	135.33	183.67	91.43	5.27	6705.00	31.47	2585.33	42.17	1.562
	Stress	146.28	203.67	80.63	7.13	5483.33	28.60	1495.00		
VL 872	Non-stress	133.33	181.67	92.85	7.03	6593.33	32.41	2116.67	20.24	0.750
	Stress	142.11	201.33	82.33	5.97	5959.33	30.98	1688.00		
HS 240	Non-stress	142.34	181.00	101.67	5.50	6358.33	31.17	1961.67	25.90	0.960
	Stress	152.33	201.33	91.60	6.17	5507.67	28.37	1453.33		
Mean	Non-stress	137.55	183.67	93.38	6.27	6922.55	32.56	2377.19	26.57	
	Stress	147.29	201.86	83.65	6.50	5891.86	29.64	1745.38		
SEm	Non-stress	1.03	2.21	1.61	0.20	243.31	1.59	58.21		
	Stress	1.40	1.41	1.27	0.35	153.07	1.47	49.76		
CD	Non-stress	2.24	4.82	3.50	0.44	530.18	3.48	126.85		
	Stress	3.06	3.07	2.76	0.77	333.55	3.20	108.43		
CV	Non-stress	86.00	1.47	2.11	0.57	4.05	6.01	2.99		
	Stress	1.16	0.85	1.86	6.72	3.18	6.07	3.49		

conducted during 2007–08 and 2008–09. Observation were recorded for days to 50% flowering, plant height (cm), days to 50% maturity, 100-seed weight (g), grain yield (g/plot), straw yield (g/plot) and harvest index (%). Data thus generated were subjected to computation of analysis of variance on individual environment and combined over two environments using WINDOSTAT ver. 8.5 software. Influence of drought effect on plant characters were observed by estimating drought intensity index (DII) by employing the formula: $DII=1-X_d/X_p$ where, X_d is the mean yield averaged across genotypes in the stress (drought) environment and X_p is mean yield averaged across genotypes in the non-stress environment. Accordingly, drought susceptibility index (S) was calculated by adopting the formula as follow:

$$S= (1-Y_d/Y_p)/DII,$$

where Y_d is mean yield of a genotype under stress and Y_p mean yield for the same genotype under non-stress environment.

The results indicated that during 2008–09 wheat genotypes registered flowering and maturity, at 138 and 184 days, respectively, while more number of days was required for flowering (147) and maturity (201) in water deficit stress situation during 2007–08 (Table 1). It seems that low temperature coupled with low moisture stress resulted in delayed flowering and maturity during 2007–08. Mean performance of grain yield (Table 1) showed that genotype which exhibited highest yield potential under non-stress condition has failed to produce the same level of yield under stress situation and vice-versa. This might be due to differing mechanism that contributes to yield under the two moisture regimes treatments with an exposure to low atmospheric temperature at mid hill altitude. Maximum grain yield under non-stress environment was registered for VL 900 (2734.0 g/plot), followed by HS 295 (2707.67 g/plot) and VL 738 (2585.33 g/plot). Greater biomass content 7355.55, 6961.67, 7705.00 g/plot and high harvest index 34.67, 33.29, 31.47 were also recorded for VL 900, HS 295 and VL 738 under both environments. This suggested that physiological mechanism involved in the partitioning of photosynthates for the development of structural and non-structural carbohydrates was least affected in these cultivars and showed their ability of productive potential at an exposure to moisture stress condition at mid hills. Drought intensity index (DII) at this elevation during experimental periods was estimated 0.312. This incurred a loss of 26.57% of grain production and seemed to represent a typical water deficit stress situation for mid hills to demonstrate a significant treatments effect on both populations. VL 738 exhibited a

Table 2 Genetic parameters of seven characters in wheat cultivars grown under non-stress and stress environments at mid hill altitudes

Genetic parameter		Days to flowering	Days to maturity	Plant height (cm)	100-seed weight (g)	Grain yield (g)	Biomass (g)	Harvest index (%)
Phenotypic variance	Non-stress	47.46	14.57	48.37	0.91	105 232.50	346 420.30	32.42
	Stress	25.20	3.65	38.85	0.84	63 517.44	207 319.40	4.60
Genotypic variance	Non-stress	45.86	7.21	44.31	0.83	100 148.40	258 675.30	24.25
	Stress	22.25	0.66	36.43	0.65	59 082.80	172 170	1.37
GCV	Non-stress	4.63	1.46	7.15	15.05	13.31	17.03	1.99
	Sress	3.21	0.45	7.21	12.48	14.01	7.04	13.95
PCV	Non-stress	4.71	2.07	7.47	15.70	13.64	8.14	6.33
	Stress	3.40	0.94	7.45	14.18	14.43	7.72	7.20
Heritability	Non-stress	0.86	0.89	0.91	0.91	0.92	0.94	0.99
	Stress	0.96	0.91	0.93	0.87	0.84	0.83	0.59
Genetic advance	Non-stress	13.71	3.89	13.12	1.79	635.97	905.60	0.42
	Stress	9.12	0.71	12.04	1.47	488.10	778.94	1.31
Genetic gain	Non-stress	0.09	0.02	0.14	0.28	0.86	0.03	0.002
	Stress	0.04	0.03	0.14	0.22	0.08	0.26	0.007

maximum of 42.17% yield losses under stress situation. The higher losses were recorded by VL 900 (33.26%), contrarily, VL 898 and VL 804 showed minimum yield loss of 11.57 and 19.42%, respectively.

A reduction in heritability (Table 2) estimates of grain yield (0.84, 0.92), harvest index (0.59, 0.99) and plant height (0.91, 0.93) was observed in stress environment than non-stress environment. Low heritability and low gains from selection (0.08, 0.28) made it difficult to identify genotypes suitable for grain yield and greater harvest index under stress environment. Contrasts in the developmental timing and dissimilarities between stress initiation, intensity and duration might be responsible to constitute high estimates of heritability in stress environment for days to 50% heading (0.86, 0.96) days to 50% maturity (0.71, 0.87) and 100-seed weight (0.87, 0.91). Biomass production showed equivalent estimates of heritability (0.83, 0.94) and genetic gain per cycle of selection (0.03, 0.26) between treatments. Biomass registered higher values of GCV (17.03), heritability (0.94) genetic advance (905.6) and genetic gain from selection (0.03) under non-stress situation. These findings are also in concomitance with the earlier findings of Eid (2009). High genetic advance, as per cent of mean, coupled with high heritability suggested the preponderance of additive gene action with low environmental influence and could be effective in phenotypic selection of cultivars for high biomass under stress-free condition. Less variability between phenotypic and genotypic coefficient of variation of biomass under stress environment coupled with high heritability, genetic advance and genetic gain from selection also suggested the influence of additive gene effect on the expression of this characters under stress environment. The possible control of non-additive gene effect was observed for plant height (7.15, 0.91, 13.12, 0.14) and grain yield (13.31, 0.92, 635.97, 0.86) in non-stress environment and seed weight (7.21, 0.92, 12.04, 0.22) in stress condition. This indicated that indirect selection through characters would be more effective when exploited under favourable environment while constituted significant relation with desired characters.

In this investigation superiority of VL 900, HS 295 and VL 738 was established and likely to be preferred for cultivation both under stress and non-stress conditions at mid hills. Previous studies of different workers (Tomar *et al.* 2003) and Kazmi *et al.* (2005) also support the present findings of this investigation.

SUMMARY

The performance of seven improved wheat cultivars were examined on field trials under cool climatic conditions of mid hills (950 m above mean sea level) under water deficit stress and stress-free condition during 2007–08 and 2008–09. Results revealed that genotype which exhibited highest yield potential under non-stress condition has failed to produce the same level of yield under stress situation and vice-versa. Biomass production showed equivalent estimates of heritability (0.83, 0.94) and genetic gain per cycle of selection (0.03, 0.26) between treatments. In this investigation less variability between PCV and GCV of biomass under stress environment coupled with high heritability, genetic advance and genetic gain from selection suggested the influence of additive gene effect on the expression of these characters under stress environment. The possible control of non-additive gene effect was observed for plant height and grain yield in non-stress environment and seed weight in stress condition. This indicated that indirect selection through characters would be more effective when exploited under favourable environment

while constituted significant relation with desired characters. Therefore, three genotypes viz VL 900, HS 295 and VL 738 should be preferred for cultivation as they performed well both in stress and non-stress conditions under mid hills.

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