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EFFECT OF HEAT AND MOISTURE STRESS TREATMENTS ON SEEDLING GROWTH OF WHEAT (*TRITICUM AESTIVUM* L.) VARIETIES

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ABSTRACT

A pot experiment was conducted in sand culture to evaluate the effect of heat and moisture stress treatments on seedling growth parameters of eight wheat varieties sown on two dates under laboratory condition in 2003. Seeds obtained from normal sowing recorded significantly higher shoot length and root and shoot dry weights than those from late sown crop. Unfavorable conditions (moisture/heat) for growth of the seedlings under moisture/ temperature stress adversely affected seedling growth. Among varieties, UP 2425 and Raj 3765 consistently showed higher seedling vigour values compared to other varieties which may be attributed to their large seed size. Variety WH 542 with lowest grain size produced lowest shoot and root dry weight. Therefore, it appears that seedling vigor parameters are related to seed size which was evident from significantly positive correlation between 1000 grain weight and shoot length, shoot dry weight and root dry weight. The values for acquired moisture stress tolerance were higher than acquired heat stress tolerance. The result of acquired stress tolerance of seedlings showed that varieties UP 2425, Raj 3765 and PBW 373 had better tolerance to stress situation as compared to other varieties. Acquired stress tolerance for heat stress (r = 0.87) and moisture stress (r = 0.80) showed positive correlation with 1000 grain weight.

Key words: Shoot length, Root length, Shoot dry weight, Root dry weight, Moisture stress, Temperature stress.

INTRODUCTION

In India, wheat is the main cereal crop. It stands next to China both in area and production in the world. India's share in world wheat area is about 12.5 % whereas it occupies 12.05 % share in the total world wheat production. The attainable production potential of wheat varieties cultivated in India is about 6 t ha^{-1}, whereas the national productivity remained at 2.75 t ha^{-1} (Anonymous, 2002). Improved seedling growth and its performance are becoming increasingly important in modern agriculture. The genetic purity, physical purity, viability and uniform seed size are the most important parameters to determine the quality of seed (Sinha *et al.*, 2001). High seed germination and vigour are pre- requisites for the success of stand establishment of crop plants. Generally stress (moisture/heat) has deleterious effect on germination and vigour of crop. The rate and degree of seedling establishment are extremely important factors in determining both yield and time of maturity (Brigg and Aylenfisu, 1979). Germination rate and seedling growth have been reported to decrease at low moisture levels. The rate of decline was found to be obvious, varying with crop species and cultivars (Ashraf and Abu- Shakra, 1978). Cellular thermo tolerance in terms of cellular membrane thermostability often implies as an indication of crop heat tolerance and it is, therefore, considered as a possible selection criteria for heat tolerance (Blum *et al.*, 2001). Genetic differences in seedling growth parameters were observed by several workers (Rakesh *et al.*, 1999; Khan *et al.*, 2002; Sahoo, 2001). In view of the above context, the genetic differences in the seedling vigour were studied under control, heat stress and moisture stress conditions with seeds of eight wheat varieties sown on two dates, with the objective to find out association, if any, between seedling vigour parameters under stress and field performance under heat stress condition.

MATERIAL AND METHODS

The seed crop was raised at Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar during *rabi* 2001-02. After harvesting of the crop, the seed obtained through the experimental field was used for laboratory testing. Seedling vigour and acquired stress tolerance (AST) of different varieties were studied in the laboratory conditions. For this study sand culture experiment was conducted in plastic pots. All pots were uniformly filled with sand and kept at 25 ± 1^0C temperature for proper germination. To induce inherent mechanism of stress tolerance, seedlings were exposed to stress after 7 days of seed incubation. One set of pots was kept at 35 ± 1^0C for heat stress treatment and rests of two sets were retained at 25 ± 1^0C. For moisture stress, pots were irrigated with -1.5 MPa osmotic solution of Manitol. The control and heat stress pots were irrigated with tap water. Seedling vigour parameters namely root and shoot length and their dry weight were analyzed when the symptoms of stress were observed on seedling. For studying the acquired stress tolerance (AST), top portion (approximately 5 cm from the tip) of leaves of the seedlings was cut and 200 ± 5 mg of leaf tissue were taken into a test tube containing 10 ml of 0.5 % triphenyl tetrazolium chloride (TTC) solution. After reduction of tetrazolium to formazan, the leaf pieces were kept in another test tube containing 10 ml of methyl cellosolve for extraction of formazan. The absorbance of formazon extracted was recorded at 530 nm in spectrophotometer using methyl cellosolve as blank. The AST was calculated separately for heat stress and moisture stress by following formula,

$$\text{AST for heat stress} = \frac{\text{Absorbance for heat stress seedlings}}{\text{Absorbance for normal grown seedlings}} \times 100$$

$$\text{AST for moisture stress} = \frac{\text{Absorbance for moisture stress seedlings}}{\text{Absorbance for normal grown seedlings}} \times 100$$

RESULT AND DISCUSSION

Seed obtained from November 28 sowing produced significantly longer shoots (Table 1), higher shoot and root dry weights (Table 2) than those from December 28 sowing but the differences in root length of seed obtained from two sowing dates was non-significant. The high root and shoot dry weight and shoot length of the seeds obtained from November 28 sowing may be because of the differences in their seed size due to environmental conditions prevalence during seed filling. The high seed index (3.66 g) of early sown crop might be responsible for supplying higher amount of carbon and energy required for growth and development of seedlings than the seeds of late sown crop which had low seed index (3.24 g) as a result of high temperature experienced during seed development. In wheat, seed size is positively correlated to seed vigour and larger seed tends

Table 1: Effect of sowing dates, stress treatments and varieties on shoot and root length (cm) of seedlings of wheat

Treatment	Shoot length (cm)				Root length (cm)			
Sowing dates	Control	Heat stress	Moisture stress	Mean	Control	Heat stress	Moisture stress	Mean
Nov 28	20.5	14.8	16.4	17.2	6.45	6.33	5.76	6.18
Dec 28	19.3	13.5	17.0	16.6	5.87	6.15	5.76	5.93
Mean	19.9	14.2	16.7	16.9	6.16	6.24	5.76	6.05
Varieties								
PBW 343	19.3	14.3	15.7	16.4	5.28	6.23	5.27	5.59
PBW 373	18.7	15.1	16.2	16.6	5.90	6.52	5.08	5.83
Raj 3765	21.7	14.9	19.9	18.8	5.87	7.27	5.43	6.19
UP 2003	18.0	12.4	13.3	14.6	6.57	4.85	5.70	5.71
UP 2338	17.5	14.0	15.3	15.6	6.08	6.98	7.23	6.76
UP 2382	20.0	14.0	17.8	17.3	6.70	5.75	5.80	6.08
UP 2425	25.9	14.7	20.8	20.4	6.22	6.33	5.83	6.13
WH 542	18.3	13.9	14.8	15.6	6.68	5.95	5.72	6.12

	SEm ±	CD (5%)	SEm ±	CD (5%)
Date	0.2	0.6	0.11	NS
Stress	0.2	0.7	0.13	NS
Variety	0.2	0.6	0.16	0.45
Date x stress	0.3	1.0	0.18	NS
D x V for two varieties at same date	0.3	NS	0.23	0.64
D x V for two dates at same or different varieties	0.3	NS	0.24	0.68
S x V for two varieties at same stress	0.4	1.0	0.28	0.79
S x V for two stress at same or different varieties	0.4	1.2	0.29	0.84

to produce vigorous seedlings which increase its productivity (Singh and Kailasanthan, 1976).

Different stress treatment showed significant effects on seedling vigour parameters of wheat except root length. The effect of stress treatment varied with the stress parameter studied. Heat stress had most severe adverse effect on shoot length which was observed to be significantly different for each stress treatment. But shoot dry weight of moisture stress treatment and control were at par with one another and significantly higher than heat stress treatment. Whereas root dry weight was highest under moisture stress followed by control and heat stress treatment. Root dry weight of all the stress treatments significantly differed from each other. Heat stress treatment had more adverse effect on all the vigour parameters. It is well known that temperature increases rate of respiration. As seedlings of other two treatments were maintained at a lower temperature (10^0C) than heat stress treatments (35^0C), therefore, the loss of stored food material due to high rate of respiration by heat stressed seedlings might have resulted in lowest shoot length and shoot and root dry weights of this treatment. In case of moisture stress treatment, the highest root dry weight might be due to increase their volume (number) so that root volume can be increased leading to extraction of moisture by increased contact area. In field studies, it has been reported that length and number of roots increase in the seedlings germinating under moisture stress condition. However, in the

Table 2: Effect of sowing dates, stress treatments and varieties on shoot and root dry weight (g) of wheat seedlings

Treatment	Shoot dry weight (g)				Root dry weight (g)			
Sowing dates	Control	Heat stress	Moisture stress	Mean	Control	Heat stress	Moisture stress	Mean
Nov 28	13.0	11.4	13.0	12.5	8.89	7.04	9.68	8.54
Dec 28	12.2	9.5	11.7	11.1	8.34	6.37	8.68	7.73
Mean	12.6	10.5	12.3	11.8	8.52	6.70	9.18	8.13
Varieties								
PBW 343	12.6	8.7	11.5	11.3	8.33	6.43	7.40	7.65
PBW 373	12.7	10.0	7.6	10.8	10.17	6.60	10.70	9.46
Raj 3765	12.0	9.8	13.5	12.6	8.93	6.70	8.87	8.82
UP 2003	11.0	9.4	12.3	11.3	6.37	5.40	7.93	6.65
UP 2338	10.5	10.9	10.6	12.0	7.87	5.86	6.40	6.98
UP 2382	10.9	8.9	9.5	10.6	8.83	7.93	11.33	9.77
UP 2425	17.8	10.4	17.9	15.6	8.30	7.07	11.13	9.64
WH 542	9.8	8.0	10.5	10.2	6.30	4.93	5.63	6.10

	SEm ±	CD (5%)	SEm ±	CD (5%)
Date	0.1	0.4	0.12	0.37
Stress	0.2	0.4	0.14	0.45
Variety	0.2	0.7	0.13	0.37
Date x stress	0.2	NS	0.20	NS
D x V for two varieties at same date	0.3	NS	0.19	NS
D x V for two dates at same or different varieties	0.3	NS	0.21	NS
S x V for two varieties at same stress	0.4	1.2	0.23	0.64
S x V for two stress at same or different varieties	0.4	1.2	0.26	0.75

present study root length of seedling under moisture stress treatment and control were statistically similar. This can be explained on the basis of differences in condition of the two systems. In field study, top soil has less moisture which increases with increasing soil depth and hence root under moisture stress grow fast to explore deeper layer of soil. However, in the present study, moisture stress was similar in all the directions as pots were irrigated with -1.5 MPa solution. Dhanda *et al,* (2004) also observed significant increased in root-to-shoot ratio in wheat genotypes under osmotic stress.

The highest shoot length (20.4 cm) was recorded in variety UP 2425 followed by Raj 3765, UP 2382 and PBW 373 (Table 1). Varieties showed significant variation in their root length. Variety UP 2338 recorded significantly longer roots (6.8 cm) than all other varieties. It was followed by Raj 3765, UP 2425, WH 542, UP 2382 and PBW 373 which were statistically at par with each other. Shoot length of varieties was influenced by moisture stress treatments. All the varieties produced longest shoots under normal conditions followed by moisture stress condition and heat stress condition. The differences in the shoot lengths under normal, moisture stress and heat stress conditions were significant for all the varieties except UP 2003, PBW 373 and WH 542. These three varieties produced shoots of statistically equal length under moisture stress and heat stress conditions.

Among the varieties, UP 2425 recorded significantly higher shoot dry weight (15.6 mg) than all other varieties (Table 2). It was followed by Raj 3765 which was statistically at par with UP 2338. Varieties UP

Table 3: Effect of sowing dates, stress treatments and varieties on acquired stress tolerance (%) of seedlings and seed index (g) of wheat

Treatment	Acquired Stress Tolerance (%)			Seed Index (g)	
Sowing dates	Heat Stress	Moisture Stress	Mean		
Nov 28	47.92	53.23	50.58	3.66	
Dec 28	48.63	54.35	51.49	3.24	
Mean	48.28	53.79	51.04	3.45	
Varieties					
PBW 343	69.35	81.50	75.43	3.55	
PBW 373	68.60	86.70	77.65	3.64	
Raj 3765	86.80	85.40	86.10	3.63	
UP 2003	51.00	50.85	50.93	2.93	
UP 2338	59.40	79.95	69.68	3.30	
UP 2382	54.65	47.85	51.25	3.18	
UP 2425	83.15	91.75	87.45	4.59	
WH 542	41.95	49.65	45.80	2.80	
	SEm ±	CD (5%)		SEm ±	CD (5%)
Date	0.06	0.21		0.07	0.31
Stress	0.06	0.21		-	-
Variety	1.02	2.89		0.13	0.36
Date x stress	0.09	0.30		-	-
D x V for two varieties at same date	1.44	NS		-	-
D x V for two dates at same or different varieties	1.35	NS		-	-
S x V for two varieties at same stress	1.44	4.09		-	-
S x V for two stress at same or different varieties	1.35	3.83		-	-

2382, UP 2425 and PBW 373 being at par with each other produced significantly heavier roots than all other varieties. Varieties and stress treatment interrelated to influence shoot dry weight. Varieties PBW 343, UP 2425, WH 542, UP 2003 and Raj 3765 recorded significantly lower shoot dry weight under heat stress condition compare to normal and moisture stress conditions, whereas varieties UP 2338 and UP 2382 had shoot dry weight statistically similar under moisture stress and heat stress condition.

In general, the highest root dry weight was noticed in UP 2382 followed by UP 2425 and PBW 373. These varieties being at par with each other produced significantly heavier roots than all other varieties. Under control, variety PBW 373 produced significantly higher root dry weight than all other varieties, under moisture stress, it was at par with UP 2382 and UP 2425 and under heat stress, UP 2382 showed significantly higher root dry weight than all other varieties including PBW 373.

Seed obtained from December 28 sown crop had significantly higher acquired stress tolerance than that of November 28 sown crop (Table 3). The value for acquired moisture stress tolerance was significantly higher than that of acquired heat stress tolerance. Acquired stress tolerance values for varieties UP 2425, Raj 3765 and PBW 373 which are recommended for late sowing were significantly higher than UP 2003 and WH 542 which are recommended for timely sown conditions. Variety UP 2338 which is released for both timely and late sown condition had values significantly lower than former one and higher than the latter group. This indicates that this criterion of AST can be used to select heat stress tolerant genotypes in laboratory without raising the crop. This is also evident from positive correlation between AST for both heat stress and moisture stress with 1000 grain weight under both the sowings and grain weight per spike which is major cause of yield reduction under late sown condition. Sahoo (2001) also observed positive correlation between root length in moisture stress and shoot length in heat stress with grain yield of wheat varieties grown under heat stress condition.

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