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EFFECTS OF CHANGING ENVIRONMENT ON WHEAT DRY MATTER YIELD

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SUMMARY

A set of 42 genotypes of bread was grown in four different environments at the experimental area of Wheat and Barley Section, Department of Genetics and Plant breeding, CCS Haryana Agricultural University, Hisar during **rabi** season 2012-13, to identify of stable genotypes. The considerable genetic differences among genotypes for various traits were evident in all the four environments. From the mean performance of the genotypes for different quantitative traits based on all the four environments, it appeared that genotypes, HD 2967, DBW 17, WH 542, PBW 343, WH 711, DPW 621-50 and C-306 were promising for dry matter yield. Analysis of variance for phenotypic stability indicated that both linear and non-linear components contributed to total G×E interaction for all the characters. However a major portion of G×E was accounted by non-linear component for dry fodder yield per plant. The linear portion was higher for days to maturity. However, the genotypes WH 1098, WH 1126, PBW 343, WH 1081, WH 542 and HD 2851 were found stable for dry matter yield in all the environments because they had above average mean, âi value equal to zero and non-significant S^2di value. It means that these were less responsive to the environmental changes and therefore, more adaptive.

Key words : Environment change, g x e interaction, stability, dry matter yield, wheat

Today, entire world is concerned about the impact of climate change on plants and animals. Climate change and agriculture are interrelated activities, both of which take place on global scale. Moreover, wheat is best suited for growing in cool climatic conditions. The ideal temperature for wheat cultivation is 15°C, which is very low. Therefore, heat can influence the different stages of crop growth during crop cultivation in India. Moreover, thirty six million hectares of wheat cropped area was affected by terminal heat shock in the temperate growing regions. Today, climate change especially increasing temperature will be the main challenge in the coming years as far as increasing yield is concerned. As per UN report, earth will be warmer be 2.4°C by 2020 and crop production in India would fall by upto 30 per cent by the end of year 2020 (Sharma *et al.*, 2013).

India is a thickly populated country of world; therefore, to satisfy their appetite, cultivation of food fodder crops is must. But, in our country livestock population is also very huge and we are unable to produce sufficient green fodder for them, due to lack of resources. Therefore, it is an instant need to cultivate those varieties, which are good in fodder as well as straw production (Satpal *et al.*, 2010)

In India, wheat is the major crop, which is mainly cultivated for grain production. However, in addition to this, we also get straw as by-product, which is generally utilized as dry fodder for animals during lean period. The quantity of wheat straw is determined by the cultivars and environment, which directly depends on plant height, number of tillers, number of leaves per plant and days taken to mature. The maximum level of production and stability of yield are the two desired features in a commercial cultivar. Indeed, development of varieties showing wide adaptability has received increased attention in recent past. Considering the above facts in view, the present study was carried out.

MATERIALS AND METHODS

A set of 42 genotypes of bread wheat representing different agro-climatic zones, were selected for the present study (Table 1). The material was grown in four different environments at the experimental area of Wheat and Barley Section, Department of Genetics and Plant breeding, CCS Haryana Agricultural University, Hisar situated at a latitude of $29^0 10'$N, longitude of $75^0 46'$E and altitude of 215.2 m above sea level in semi-tropical region of western zone of India during rabi season 2012-2013, in randomized block design (RBD) with three replications for identification of stable genotypes. Resulting four test environments were designated as E_1 Timely (November) sown, high fertility, NPK, 150:60:40(kg/ha)), E_2 (Late (December) sown , high fertility, NPK, 120:60:40(kg/ha), E_3 (Early (last week of October) sown, medium fertility, NPK, 90:60:40(kg/ha)) and E_4 (Timely (November) sown, low fertility, NPK, 60:30:20(kg/ha)). The soil of Hisar was sandy loam (Type Ustrochrepts). The metrological observations at weekly intervals during experimental period were recorded and depicted in Fig. 1. Each entry was accommodated in a paired row of three meter length with spacing of 30 cm between row to row and 10 cm between plant to plant in each replication. Sowing was done by dibling method. All recommended packages of practices were followed to raise the crop. Five competitive plants of each genotype in each replication and in each environment were randomly selected for data recording. The observations were recorded on various traits viz. days to maturity, plant height, effective tillers per plant, dry matter yield per plant. The data of experimentation were subjected to statistical analysis like mean, range, S.E. & C.D. for every character under each environment as described by Panse and Sukhatme (1967). The phenotypic stability analysis was carried out following model by Perkins and Jinks (1968).

RESULTS AND DISCUSSION

Mean Performance

Days to maturity ranged from 141.32 (WH 1163) to 147.00 (WH 590) in E_1, 116.33 (WH 416) to 127.33(DBW 17) in E_2, 136.33(WH1100) to 145.66 (WH 147) in E_3, 113.33 (WH 1154) to 125.33 (DBW 17) in E_4. General mean values were 144.31, 122.86, 142.61 and 120.15 in E_1, E_2, E_3 and E_4, respectively. Twelve varieties showed better response. The plant height ranged from 84.33 (DBW 17) to 119.00 (C-306) in E_1, 84.00 (PBW 343) to 104.66 (C 306) in E_2, 82.33 (WH 711) to 128.00 (C 306) in E_3 and 77.33 (WH 711) to 107.33 (C 306) in E_4. General means for this character were 103.07, 96.54, 101.31 and 91.38 in E_1, E_2, E_3 and E_4, respectively. There were eighteen, twenty three, twenty five and twenty genotypes which showed significantly higher mean height than general mean in E_1, E_2, E_3 and E_4, respectively. The number of effective tillers per plant ranged from 12.00 (WH 1158) to 20.33 (WH 1105) in E_1, 9.00 (PBW 343) to 17.00 (WH1151) in E_2, 12.00 (DBW 17) to 19.33 (WH 1105) in E_3 and 10.33 (WH 542) to 14.33 (WH 1105) in E_4. General means for this character were 15.90, 12.98, 15.33 and 12.53 in E_1, E_2, E_3 and E_4, respectively. Twenty one varieties had significantly higher effective tillers than general mean in E_1. In E_2, twenty one varieties were significantly better than general mean. In E_3, twenty two varieties were significantly better than general mean. In E_4 sixteen varieties were significantly better than general mean than general mean, Twenty four varieties showed

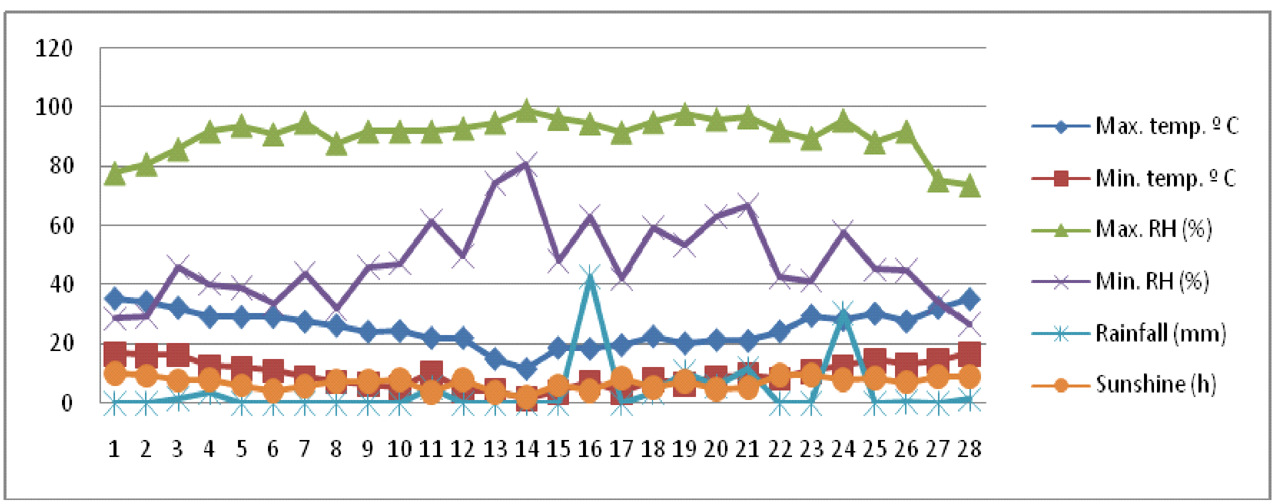

Fig. 1. Weekly meteorological data of Hisar station for the crop *rabi* season 2012-13.

significantly better response than overall mean in E_2. Twenty varieties were found significantly superior to the general mean in E_3, while thirteen varieties were found better then general mean in E_4.

Dry matter yield ranged from 46.66 (WH 416) to 98.00 (C-306) in E1, 37.37 (WH 147) to 77.67 (HD 2967) in E_2, 55.67 (WH 283) to 94.33 (HD 2967) in E_3 and 43.00 (WH 1025) to 67.33 (WH 1100) in E_4. Overall means for this character were 74.76, 51.64, 71.45 and 52.57 in E_1, E_2, E_3, E_4, respectively. Twenty varieties were significantly better than general mean and three varieties responded significantly better than check variety in E_1. In E_2, twenty eight varieties responded significantly better than general mean. In E_3, twenty one varieties were significantly better than general mean. In E_4, twenty varieties were significantly better than general

TABLE 1
The Pedigrees of wheat genotypes used in the present investigation

S. No.	Genotypes	Pedigree
1.	WH416	WH147/UP368
2.	WH1163	HPW42/WH542
3.	WH1100	PBW65/2*PASTOR
4.	WH1132	PBW65/2*PASTOR
5.	WH1134	PRL/2*PASTOR
6.	WH1156	TILHI/PASTOR
7.	WH1154	WH337/HD2255//RAJ3077
8.	WH1102	WBLL1/KAMB//PASTOR
9.	WH590	WH594/RAJ3814//W485
10.	WH147	PJ SIB/P14//KT54B/3/C286/C273/4/S339/PV-18
11.	WH1123	NI5663/CHTO//AMSEL
12.	WH1158	PBW65/2*PASTOR
13.	DPW 621-50	KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUITES
14.	WH1164	RL6043/4*NAC//2*PASTOR
15.	WH1131	MUNIA/CHTO//AMSEL
16.	WH283	HD1981/RAJ821
17.	WH1133	BABAX/LR42//BABAX*2/3/VJV1TS1
18.	WH1165	CH1R/3/SIREN//ALTAR84
19.	WH1162	HP1744/WH711
20.	WH1098	TILHI/PASTOR
21.	WH1105	MILAN/S87230//BABAX
22.	WH1151	RL6043/4*NAC//PASTOR
23.	WH1135	HD29/2*WEAVER
24.	WH1155	SERI*3//RL6010/4*TR/3/PASTOR/4/BAU92
25.	WH1142	CHEN/Ae.Sq.(TAUS)//FCT/3/2*WEAVER
26.	WH1127	RL6043/4/NAC//PASTOR/3/BABAX
27.	WH1153	P15065/LH1750
28.	WH1126	WBLL1*2/VIVITSI
29.	PBW343	ND/VG1944//KAL//BB/3/YACO's'/4/VEE5's'
30.	PBW550	WH594/RAJ3856//W485
31.	WH1021	NY0T95/SONAK
32.	WH1081	PBW65/2*PASTOR
33.	WH542	JUPATECO/BLUEJAY//URES
34.	RAJ3765	HD2402/VL639
35.	PBW373	ND/VG1944//KAL//BB/3/YACO's'/4/VEE5'S'
36.	HD2851	CPAN3004/WR426/HW2007
37.	C306	REGENT1974/3*CHZ//*2C599/3/119/C281
38.	WH1080	PRL/2*PASTOR
39.	DBW17	CMH79A.95/3*CN079//RAJ3777
40.	WH1025	C591/PBW231
41.	HD2967	ALD/CUC//URES/HD2160/HD2278
42.	WH711	ALD'S'/HUAC//HD2285/3/HFW17

TABLE 2
Joint regression analysis of Perkins and Jinks (1968a) for different characters

S. V.	d. f.	Days to maturity	Plant height (cm)	Effective tillers/ plant	Dry matter yield/ plant (g)
Genotype	41	14.31**	115.19**	5.52**	218.15**
Environments (joint regression)	3	6823.34**	1156.69**	117.95**	4984.98**
Genotype x Environment	123	2.442	19.18**	3.14*	68.08**
Heterogeneity between regression	41	2.463	21.78**	3.95**	62.37**
Remainder	82	2.432	17.87**	2.74*	70.94**
Pooled Error	328	0.170	3.92	1.04	12.57

*,**Significant at 5 and 1 percent level, respectively.

TABLE 3
Estimation of environmental additive effect (Ij) for eleven characters in four environments expressed as deviation from mean

Character	I_1	I_2	I_3	I_4
Days to maturity	11.82	-9.62	10.13	-12.33
Plant height (cm)	4.99	-1.53	3.23	-6.69
Effective tillers per plant	1.71	-1.21	1.14	-1.65
Dry matter yield per plant (g)	10.90	-7.21	7.59	-11.28

(Table 4). Average over the environments for dry matter yield revealed that HD 2967 (80.75), DBW 17 (75.50), WH 542 (75.43), PBW 343 (74.33), WH 711 (72.08), DPW 621-50 (70.83) and C-306 (70.33) were significantly superior.

Genotype X Environment Interactions

The significant of the mean square due to genotypes in the joint regression analysis indicated that a considerable genetic variability existed among the genotypes for almost all the characters (Table 2). The environment mean squares were significant for all characters. This not only revealed the amount of variability existing among the genotypes but also reflected that the environment varied considerably. Either the heterogeneity between regression M.S., the remainder M.S. or both were significant for all the character, indicating the presence of G×E interaction for all the characters. Occurrence of such interaction has also been reported by several workers in wheat (Sareen *et al*., 2012 and Kant *et al*., 2014).

The whole genotype x environment interaction was partitioned into two components, namely heterogeneity between regression and remainder, the former accounting for linear component, whereas the latter for non-linear component. The significance of both heterogeneity between regression and remainder indicated that both linear and non-linear components significantly contributed to total genotype x environment interaction for all the character. However, relative magnitude of both these positions varied with the characters.

Environmental Effects

The estimates of environment additive effects (Table 3), which are expressed as deviation form grand mean showed that E_1 was the most favourable environment for all characters. For effective tillers E_2, E_3 and E_4 had negative effective and for biological yield E_2 and E_4 had negative effect. In E_2 and E_4 days to heading, days to maturity, effective tillers per plant and dry matter yield showed negative effect joint regression analysis.

Generally, the high temperature higher than the optimum shorted the growing period of plants, resulting in a shorter time of biomass accumulation, which ultimately responsible for low dry matter yield. Under high temperature stress, even high fertility inputs also remained unable to support the biomass enhancement, which generally remained low due to shortened lifespan of the crop plants. Arya *et al*. (2014) reported that under stress conditions, yield reduction was not homogeneous in the genotypes. Moreover, it depends upon the crop phenology, crop type and growing environmental conditions.

TABLE 4

Average yield and estimates of stability parameters for biological yield per plant (g) under different environments

S. No.	Genotypes	E_1	E_2	E_3	E_4	Mean	$bi = b_{i-1}$	S^{-2} di
1	WH416	46.66	43.00	57.33	57.33	51.08	-1.036*	68.680**
2	WH1163	69.00	40.00	57.33	61.67	57.00	-0.428	156.781**
3	WH1100	60.00	43.33	91.00	67.33	65.42	-0.233	470.436**
4	WH1132	76.00	51.33	76.67	60.33	66.08	0.010	36.079*
5	WH1134	57.33	55.67	75.33	56.33	61.17	-0.550*	85.974**
6	WH1156	60.67	42.67	59.33	52.00	53.67	-1.389	23.410*
7	WH1154	61.33	54.00	77.67	59.00	63.00	-0.429	86.842**
8	WH1102	64.67	54.00	81.67	55.00	63.83	-0.114	94.668**
9	WH590	67.33	59.33	65.00	53.00	61.17	-0.433	-8.349
10	WH147	55.00	37.67	64.67	47.67	51.25	-0.210	72.069**
11	WH1123	61.67	58.00	64.67	53.33	59.42	-0.597*	-5.584
12	WH1158	55.33	47.00	69.33	49.67	55.33	-0.352	61.662**
13	DPW621-50	97.33	62.67	74.67	48.67	70.83	0.761*	7.464
14	WH1164	68.67	56.67	67.67	49.67	60.67	-0.175	-8.472
15	WH1131	59.00	56.00	60.33	44.67	55.00	-0.456*	10.940
16	WH283	53.00	48.00	55.67	44.67	50.33	-0.577*	-7.771
17	WH1133	71.33	49.33	60.67	48.67	57.50	-0.063	4.264
18	WH1165	80.00	52.33	63.67	48.00	61.00	0.223	25.708
19	WH1162	63.33	39.33	65.67	51.00	54.83	-0.073	56.716**
20	WH1098	85.00	59.33	65.00	49.67	64.75	0.213	58.763**
21	WH1105	95.00	76.00	74.00	55.33	75.08	0.194	7.822
22	WH1151	72.00	55.33	69.33	48.33	61.25	0.031	-10.439
23	WH1135	88.00	67.00	91.00	46.66	73.17	0.799*	49.990**
24	WH1155	83.67	66.33	57.67	51.00	64.67	-0.167	163.936**
25	WH1142	81.00	75.00	77.00	49.67	70.67	0.029	102.093**
26	WH1127	95.33	52.00	68.00	53.67	67.25	0.615*	125.787**
27	WH1153	71.67	47.66	79.00	45.33	60.92	0.477*	29.314*
28	WH1126	82.10	58.33	72.67	58.00	67.78	0.044	0.216
29	PBW343	90.33	72.00	84.00	51.00	74.33	0.483	5.468
30	PBW550	77.33	68.33	69.00	54.00	67.17	-0.255	29.544*
31	WH1021	73.66	58.66	72.00	52.00	64.08	-0.478	-10.067
32	WH1081	82.00	63.00	78.00	52.67	68.92	0.229	-5.306
33	WH542	97.00	63.67	81.33	59.67	75.42	0.524	17.077
34	RAJ3765	90.33	52.67	64.33	54.33	65.42	0.349	116.781**
35	PBW373	70.67	55.00	72.67	47.67	61.50	0.089	-2.593
36	HD2851	76.33	61.67	67.33	54.33	64.92	-0.197	2.131
37	C306	98.00	54.00	78.33	51.00	70.33	0.961*	37.201*
38	WH1080	73.33	50.67	72.00	52.67	62.17	0.085	-0.569
39	DBW17	89.33	74.67	77.67	60.33	75.50	-0.032	34.146*
40	WH1025	64.33	43.33	70.67	43.00	55.33	0.236	21.204**
41	HD2967	91.67	77.67	94.33	59.33	80.75	0.365	41.434**
42	WH711	84.33	76.33	77.33	50.33	72.08	0.090	10.088**
	Mean	74.76	51.64	71.45	52.57	63.85	0.000	
	SE(m)	2.61	2.83	4.86	3.43	2.99	0.441	
	CD	7.34	7.97	13.6	0.79			

*,**Significant at P=0.05 and P=0.01 levels, respectively.

Estimates of Stability

For days to maturity, varieties WH 1127 and WH 1153 were found suitable for favourable environment, since they had, bi value more than zero and S^2di non-significant varieties WH 1156, WH 1102 and WH 1165 had average mean bi value below zero and S^2di value non-significant are suitable for poor environment. Variety WH 1126 had below average mean, zero regression and S^2di value equal to zero hence more responsive for this character. For plant height, the significant of S^2_{di} for non-linear response was recorded for five genotypes. Varieties WH 416, WH 1132, WH 1102, WH 1131, WH 1105, WH 542, RAJ 3765, PBW 373 and WH 711 were stable, which had low mean, âi value equal to zero and non-significant S^2_{di} value. Genotypes WH 1134, WH 590 and PBW 550 also had S^2_{di} value equal to zero with âi value less than zero and therefore, were more suitable for poor environment. A critical examination of the result on effective tillers per plant indicated that the varieties WH1135and WH 1126 were stable which had high mean, âi value equal to zero and non-significant S^2_{di} value. Varieties WH 1105, WH 1153 and HD 2967 found for poor environment, since they had high mean, âi value more than zero and non-significant S^2_{di} stable for unfavourable environment. Variety WH 1165 found for fertile environment, since they had high mean, âi value less than zero and non-significant S^2_{di} stable for favourable environment.

The data presented in (Table 4) for dry matter yield indicated that fourteen genotypes had both âi and value S^2_{di} non-significant indicating the absence of G×E interaction. Five genotypes had both âi value and S^2_{di} significant indicated that the presence of linear and non-linear component of G×E interaction. Genotypes WH 1098, WH 1126, PBW 343, WH 1081, WH 542 and HD 2851 were stable for all environment since they possessed high mean, âi value equal to zero and non-significant. Genotypes DPW 621-50 were stable for poor environment since they possessed high mean, âi value more than zero and non-significant S^2_{di}.More or less similar findings were also reported by Rane *et al*. (2007) and Kant *et al*. (2014).

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