Bangladesh J. Bot. **45**(5): 1225-1228, 2016 (December)

DETECTION OF GENOTYPE × ENVIRONMENT INTERACTION IN TRIPLE TEST CROSS FAMILIES IN BREAD WHEAT

Divya Phougat*, **IS Panwar and V Singh**

Wheat & Barley Section, Department of Genetics and Plant Breeding,
CCS Haryana Agricultural University, Hisar, India

Key words: Genotypes × environment interaction, Triple test cross, Grain yield, Bread wheat.

Abstract

Forty eight triple test cross families and 16 varieties of bread wheat were raised into environments (timely and late sown) to detect and measure the interactions between the environments and additive, dominance and epistatic effects of the genes for seven metric traits including grain yield and its component traits. Epistasis was important for all the traits. The additive gene effects were more sensitive to environmental changes than dominance gene effect suggesting superiority of hybrids in terms of stability. Additive × additive epistasis (i) was relatively less sensitive to environmental change than additive × dominance and dominance × dominance (j and l) components of epistasis.

The sampling errors associated with the estimates of additive (D) and dominance (H) components and genetic variation obtained by applying triple test cross (TTC) analyses are similar. The TTC method therefore provides a unique opportunity for testing the presence of interactions of additive and dominance gene effects with environment and the comparison between these two types of interactions on the basis of their relative magnitude (Melchinger *et al.* 2008). This analysis was used in spring wheat by a number of workers (Sarmah *et al.* 1997, Sarmah and Pawar (2000), Noori and Sokhansanj (2004), Zafar *et al.* 2008, Dawwam *et al.* 2015 and El-Nahas 2015).

Perkins and Jinks (1971) suggested an extension of triple cross design to account for macro-environmental factors, these allow the detection and measurement of interaction between the additive, dominance and epistatic effects of genes and macro-environmental differences.

Eighteen varieties/lines of bread wheat (*Triticum aestivum* L. em. Thell), *viz*., DPW621-50, HD2967, *Tobari*, WH1080, DBW17, PBW550, *Aus*15854, WH147, WH711, WH1021, WH542, *Veery's*, WH730, Raj3765, Raj MR-1, WH525, WH1105 and WH283 were randomly chosen from the wheat germplasm collection maintained by the Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar which is 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 North Western zone of India. To produce 48 triple test cross (TTC) families of these, two agronomically superior varieties, WH 1105 and WH 283 (phenotypic extremes for tillers per plant, grains per ear, 1000-grain weight and grain yield per plant) and their F_1 (WH 1105 × WH283) were crossed as male testers (L_1, L_2 and L_3, respectively) to each of the remaining 16 varieties/lines in a triple test cross fashion and 48 progeny families were produced during *Rabi* 2013 crop season. The 48 TTC families alongwith their 16 parents were evaluated in randomized block design (RBD) with three replications in two environments (timely and late sowings on November 15 and December 15, 2013, respectively). Each family was represented by 2.5 m long paired row plots spaced 20 cm apart with 10 cm distance among plants within rows in the experiment. The observations were recorded on five competitive plants randomly selected from

---

∗Author for correspondence: <divyaphougat786@gmail.com>

each genotype in each replication for days to heading, plant height (cm), tiller number, number of grains per ear, 1000-grain weight (g), biological yield per plant (g) and grain yield per plant (g). The data were subjected to the analysis of Perkins and Jinks (1971) to test and estimate the interaction between additive, dominance and epistatic gene effects, and environment (different dates of sowing).

Epistasis and its interaction with environments: The results of the test of epistasis for seven metric traits in wheat grown in two environments have been presented in Table 1. The partitioning of epistasis into- i, j and l types i.e. (additive/additive), (additive/dominance and dominance/ dominance) of epistatis indicated that ‘i’ type epistasis was significant for all the seven metric traits, while j and l type of epistasis were significant for almost all traits except for plant height. These results, thus, indicate that epistatic variation as an integral component of the genetic architecture of all the characters studied. Further, both the sub-components of epistasis were equally important in the control of these traits.

Table 1. Mean squares from the pooled analysis for test of epistasis for seven metric traits for wheat triple test cross families.

Source	df	Days of heading	Plant height	Tiller number	Grains/ ear	1000-grain wt. (g)	Biological yield/plant (g)	Grain yield/plant (g)
‘i’ type epistasis	1	64.84**	82.27**	104.98**	126.50*	94.64*	339.27*	136.50**
‘i’ type epistasis / environments	1	37.06**	25.37	39.93**	106.58*	42.98	116.67	73.87*
Replication within environments / ‘i’ type epistasis	4	2.67	27.82	14.32	66.27	22.98	89.09	13.48
‘j’ and ‘l’ type epistasis	15	28.66**	37.65	39.75**	76.35**	57.09*	216.82*	104.53*
‘j’ and ‘l’ type epistasis × environments	15	20.17**	41.77*	27.58**	72.93**	39.77*	125.19	37.96*
Replications within environments / ‘j’ and ‘l’ type epistasis	60	7.06**	24.19**	6.81**	26.74**	12.48	98.68**	20.21**
Within families Error	1152	2.04	7.59	4.46	22.96	24.21	75.08	11.16

*, ** indicate significance at 5 and 1%, respectively.

The interaction of the two components of epistasis with environments indicated that (i) type/ environment intersection was significant for days to heading, tiller number, grain per ear and grain yield per plant, whereas the interactions of j and l type epistasis with environments were significant for days to heading, plant height, tiller number, grains per ear, 1000-grain weight, and grain yield per plant. This indicated that j and l type epistasis was relatively more sensitive to environmental change than i type epistasis. Singh and Dahiya (1984), Singh *et al.* (1986), Singh *et al.* (1989) Singh *et al.* (1990), Sarmah *et al.* (1997), Pawar *et al.* (1996) and Singh and Pawar (2006) also reported a similar situation about the relative sensitivity of these sub-components of epistasis to environmental changes. Furthermore, in self-pollinated crops like Basmati rice and wheat, the fixable component of i type epistasis could be easily exploited for breeding of high yielding varieties (Esmail 2007).

Additive and dominance components and their interaction with environments: The mean squares due to sums and differences and their interaction with environments for seven metric traits in wheat triple test cross families in two environment have been presented in Table 2. The mean squares due to sums and differences in the pooled analysis were significant for all the traits except for 1000-grain weight where mean square due to differences was non-significant. The interaction of sums with environment was significant for all the characters. The interaction differences × environment was significant for biological yield per plant only. The results indicated that the additive gene effects were relatively more sensitive to change in environment than the dominance

Table 2. Mean squares from pooled analysis for sums and differences for seven metric traits for wheat triple test cross families.

Source	df	Days of heading	Plant height	Tiller number	Grains/ ear	1000-grain wt. (g)	Biological yield/plant (g)	Grain yield/ plant (g)
Sums ($L_1 + L_2 + L_{2i}$)	15	39.43**	135.50**	97.90**	374.21**	112.16**	2925.27**	427.45**
Sums × environments	15	30.87**	63.39*	23.21*	213.43*	39.61*	443.21**	131.11*
Replication within environments/ sums	60	13.09**	32.92**	11.51**	90.44**	26.70**	175.92**	61.02**
Within families error	1152	2.04	6.59	4.46	22.96	14.23	95.08	11.16
Differences ($L_1 + L_{2i}$)	15	9.89*	42.52*	21.59**	92.41*	29.06	332.46*	64.52**
Differences/ environments	15	7.63	20.12	9.25	53.72	24.74	263.84*	24.61
Replications within environments / differences	60	5.02**	20.06**	7.33**	45.07**	18.23**	168.24**	15.07*
Within families Error	768	1.93	4.72	4.11	21.22	15.62	65.61	10.74

*, ** indicate significance at 5 and 1%, respectively.

Table 3. Estimates of additive gene effects × environmental interaction (G_2D) and dominance gene effects × environmental interaction (G_2H).

Component	Days of heading	Plant height	Tiller number	Grains/ ear	1000-grain weight (g)	Biological yield/plant (g)	Grain yield / plant (g)
G_2D	7.90**	13.54*	5.2*	54.66*	5.73*	118.79**	31.15*
G_2H	1.74	0.04	1.28	5.76	4.34*	63.73	6.36

*, ** indicate significance at 5 and 1%, respectively.

gene effects. For biological yield, however, the two kinds of gene effects expressed equal sensitivity to environmental change. Similar results were reported by Singh and Dahiya (1984), Pawar *et al.* (1996), Sarmah *et al.* (1997) and many other in wheat. On the other hand Singh *et al.* (1986), Singh *et al.* (1989) and Singh *et al.* (1990) noted equal sensitivity of the additive and dominance gene effects to the change in environment for most of the characters.

The estimates of G_2D (additive gene effects × environments) and G_2H (dominance gene effects x environment) have been given in Table 3. The significance of these two components was similar to those of additive gene effects × environments and dominance gene effects x environments, respectively. The estimates of G_2D were greater than those of G_2H for all the traits.

References

Dawwam HA, Hendawy FA, Abo Shereif MA and Elmassry EL 2015. Utilization of triple test cross in bread wheat F_2 populations. 1. Predicting of new recombinant lines and genetic correlations Minufiya. J. Agric. Res. **40**(2): 431 443.

El-Nahas M Marwa 2015. Using Triple Test Cross Analysis to Estimates Genetic Components, Prediction and Genetic Correlation in Bread Wheat. Int. J. Current Microbiol. Applied Sci. **4**: 79-87.

Esmail RM 2007. Detection of genetic components through triple test cross and line × tester analysis in bread wheat World J. Agric. Sci. **3**(2): 184-190.

Melchinger AE, Utz HF and Schön CC 2008. Genetic expectations of quantitative trait loci main and interaction effects obtained with the triple test cross design and their relevance for the analysis of heterosis. Genetics **177**: 1827-1837.

Noori SAS and Sokhansanj A 2004. Triple test cross analysis for genetic components of salinity tolerance in spring wheat. J. Sci., Islamic Republic of Iran **15**(1): 13-19.

Pawar IS, Yunus M and Singh VP 1996. Study of interaction of additive, dominance and epistatic gene effects with environment in wheat Haryana Agric. Univ. J. Res. **26**: 17-21.

Perkins JM and Jinks JL 1971. Analysis of genotype/environment interaction in triple test cross data. Heredity **26**: 203-207.

Sarmah P, Pawar IS, Yunus M and Sharma SC 1997. Genotype/environment interaction analysis of some triple test cross families in bread wheat. Haryana Agric. Univ. J. Res. **27**: 117-120.

Sarmah P and Pawar I S 2000. Genetic architecture of some wheat crosses through triple test cross method National Journal of Plant Improvement **2**: 45-48.

Singh I, Pawar IS and Singh S 1989. Detection of genotype/environment interaction in spring wheat through triple test cross analysis. Crop Improv. **16**: 34-37.

Singh I, Paroda RS and Singh S 1986. Genotype/environment intersection analysis of TTC progenies for some metric traits in wheat Crop Improv. **13**: 117-121.

Singh S and Pawar IS 2006. Trends in Wheat Breeding. CBS Publishes and Distributors, New Delhi.

Singh S and Dahiya MS 1984. Detection and estimation of components of genetic variation and genotype × environment intersection in three wheat crosses. J. Agric. Sci. Camb. **103**: 543-547.

Singh S, Kumar S, Singh I and Pawar IS 1990. Interaction of gene effects with environment in wheat Haryana Agric. Univ. J. Res. **20**: 201-205.

Zafar M, Khan AS, Chowdhry MA and Bhatti MA 2008. Triple test cross analysis for salinity tolerance in wheat. Pak. J. Agric. Sci. **45**(3):40-43.

(Manuscript received on 4 August, 2015; revised on 23 August, 2016)