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DETECTION OF EPISTASIS COMPONENT OF VARIATION FOR YIELD CONTRIBUTING TRAITS OVER TWO ENVIRONMENTS IN BREADWHEAT

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ABSTRACT

The component of genetic variation were studied in 54 TTC progenies over two environments for grain yield and its component traits. The overall epistasis (i Type) was present for all the characters except number of ear bearing tillers and spike length under late sown conditions and weight of grains per spike under timely sown conditions. However, j and l type of epistasis was more pronounced than i type in both environments for all the characters. Both the additive and dominance components of genetic variation were highly significant for all the traits. All the attributes exhibited high heritability estimates under both the environmental conditions except ear bearing tillers under late sown conditions. The additive and dominance gene effects were equally sensitive to the change in environment. The j and l components of epistasis were more sensitive to environment than i component. The possible application of genetic variances prediction in wheat improvement programme has been discussed.

Key words: TTC, epistasis, genetic variation, environment.

The success of any plant breeding programme would greatly be enhanced if the plan is based on knowledge of nature and magnitude of genetic component of variance controlling important yield and other agronomic traits. Often reports are available on the estimation of additive and dominance effects only, the epistatic effects have been assumed to be negligible and thus ignored. Accordingly, most of the second degree statistical models assume that there independent distribution of genes and absence of linkage and epistasis. However, these assumptions are unrealistic, significant epistatic effects for yield and its component traits have been reported in wheat [3]. The epistasis interaction effect cannot be ignored and the genetic models employed must account for the estimation of interallelic interactions. Otherwise the estimates are likely to be biased and misleading.

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Among various mating designs, triple test cross suggested by Kearsey and Jinks [4] and later modified by many others, provides not only a precise test for epistasis variance but also gives unambiguous estimates of additive dominance components of genetic variance together with directional element F and test for i and j+l type epistasis. Since all kind of gene effects generally exhibit different degree of sensitivity to environmental differences, it is essential to have precise information about the relative sensitivity to additive, dominance and epistatic effects of genes to the environment. The present study aims to explain the genetic system controlling yield and its component traits in a set of cultivars with special emphasis on detection of epistasis.

MATERIALS AND METHODS

Two agronomically superior varieties of breadwheat (*Triticum aestivum* L. em Thell), HD 2402 and K 8804 were crossed to produce F_1 hybrid. According to the model proposed by Kearsey and Jinks [4], these two genotypes were referred as L_1 and L_2 and their F_1 hybrid as tester L_3. These three testers (L_1, L_2 and L_3) as per models of Ketata et al. [5] were crossed to 18 true breeding genotypes including some cultivars. The set of 18 TTC progenies along with their parents (L_1, L_2 and L_3) were grown in randomized complete block design with 3 replications under two environments (normal and late sown) of timely (November) and late (December) sowing. Observations were recorded for grain yield and its components traits. Test for epistasis was done as suggested by Kearsey and Jinks [4]. Analysis of variance for sums and differences and estimation of component of genetic variance was done as per method of Jinks and Perkins [6].

RESULTS AND DISCUSSION

Variance arising due to differences among progenies was highly significant for all the characters studied in both environments. The variance due to replication x families was also highly significant for all the attributes under timely as well as late sown conditions.

The i type of epistasis was highly significant under timely sown condition and j+l type of epistasis under timely as well as late sown conditions for number of ear bearing tillers (Table 1). The magnitude of i type of epistasis was appreciably higher as compared to j+l type. Spike length revealed some what different trend. The overall epistatic component (i type epistasis) under timely sown condition and j+l type epistasis under both sowings were highly significant. The i type epistasis was more important under timely sown condition whereas j+l type was more significant under late sown condition. For grains per spike, the overall epistatic component i and j+l were highly significant in both the environments, grain yield per spike showed nonsignificant differences for i type epistasis in timely sown environment. It was highly significant under late sown condition. The j+l type epistasis was

Table 1. Analysis of variance (MSS) for sums and differences in triple test cross progenies for yield contributing traits in breadwheat under two environments

Source	Environment	d.f.	No. of productive tillers	Spike length	Grains per spike	Grain yield per spike	Grain yield per plant
Sums ($L_{1i} + L_{2i} + L_{3i}$)	Timely sown	17	3.20**	2.27**	92.13**	0.19**	25.49**
	Late sown	17	13.16**	1.45**	119.90**	0.11**	9.51**
Sums x replicates	Timely sown	34	1.06**	0.76**	30.60**	0.07**	8.17**
	Late sown	34	5.00**	0.53**	12.42**	0.04**	3.05**
With families	Timely sown	324	0.43	0.43	0.76	0.009	0.74
	Late sown	324	0.29	0.19	0.52	0.006	0.76
Sums ($L_{1i} + L_{2i}$)	Timely sown	17	5.71**	2.59**	105.83**	0.21**	28.55**
	Late sown	17	12.17**	1.24**	132.18**	0.12**	9.33**
Sums x replications	Timely sown	34	2.03**	0.92**	35.27**	0.07**	12.11**
	Late sown	34	4.34**	0.41*	8.91**	0.04**	3.45**
Within families	Timely sown	216	0.84	0.49	0.78	0.01	0.83
	Late sown	216	0.41	0.24	0.41	0.004	0.56
Differences ($L_{1i} - L_{2i}$)	Timely sown	17	4.18**	1.47**	42.31**	0.05**	18.03**
	Late sown	17	5.92**	1.33**	99.81**	0.08**	12.60**
Differences x replicates	Timely sown	34	1.74**	0.96**	14.58**	0.02**	6.05**
	Late sown	34	2.18**	0.46**	8.29**	0.93**	4.34**
Within families	Timely sown	216	0.48	0.48	0.79	0.01	0.83
	Late sown	216	0.41	0.24	0.41	0.004	0.55

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

highly significant under both environments. With respect to grain yield, the overall epistatic component i and j+l were highly significant in both timely as well as late sown conditions.

Analysis of variance for two sums items ($L_{1i} + L_{2i} + L_{3i}$), ($L_{1i} + L_{2i}$) and differences (L_{1i}–L_{2i}) for all the traits for timely and late sown conditions (Table 1) showed that the variance due to both sums were highly significant for all the traits under both environments. Similarly the differences (L_{1i}–L_{2i}) were also important for all the attributes under both timely as well as late sown conditions. Thus these tests provide evidence of additive as well as dominance component of variation.

Highly significant additive and dominance effects were detected for grains per spike, grain yield per spike, and grain yield per plant under timely as well as late sown conditions. The magnitude of additive component was higher as compared to the dominance components for spike length, number and grain yield per spike under timely sown environmental conditions, and number of productive tillers under late sown conditions. A preponderant role of dominance components was for grain yield per plant under both timely and late sown conditions; spike length, number and grain yield per spike under late sown, and number of productive tillers under timely sown conditions (Table 2). Overdominance was observed for spike length, grain per spike and grain yield per plant under late sown condition, and for number of productive tillers under timely sowing (Table 2). All the yield and its components exhibited high heritability estimate under both sowings except number of ear bearing tillers under late sown condition where the value was moderate (Table 2). The expected genetic advance was high for all the traits studied both under timely and late sown conditions except for number of productive tillers under late sown condition where it was moderate.

Table 2. Estimation of genetic component (D and H), degree of dominance $(H/D)^{0.5}$, heritability (h^2) and genetic advance (GA) for yield traits under timely and late sown conditions in bread wheat

Genetic parameter	No. of ear bearing tillers		Spike length		Grains per spike		Grain yield per spike		Grain yield per plant	
	timely sown	late sown	timely sown	late sown	timely sown	late sown	timely sown	late sown	timely sown	late sown
D	2.46**	11.44**	1.63**	1.12**	81.29**	106.11**	0.16**	0.09**	22.0**	7.77**
H	4.93**	7.34**	1.32**	1.45**	55.36**	132.53**	0.05**	0.10**	22.93**	16.09**
$(H/D)^{0.5}$	1.41	0.80	0.89	1.23	0.82	1.11	0.55	1.05	1.02	1.43
h^2	47.22	15.97	65.73	55.04	74.25	61.37	83.77	61.64	64.28	46.88
GA (% of mean)	24.97	15.33	30.93	22.98	43.09	48.09	40.96	31.48	49.23	33.42

*Significant at $P = 0.05$. **Significant at $P = 0.01$.

The mean squares due to interaction of sums and differences with environments were significant for all the attributes (Table 3). This suggests that additive and dominance gene effects were equally sensitive to change in environment for all the character. Similar results were reported earlier in wheat [3, 8]. The interaction between i type epistasis and environment was highly significant for all the characters except grain yield per spike, whereas interactions of i and l type epistasis with environments were significant for all the characters. This indicated that j and l type epistasis was more sensitive to change in environment than i type epistasis. Similar results were reported in barley [9], upland cotton [10], and wheat [1, 8, 12].

The presence of epistasis for all the characters under both environments indicates that epistasis played an important role in the control of plant characters and thus this component of genetic variation should not be ignored while deciding breeding plants. The detection

Table 3. Analysis of variance (MSS) for genotype-environment interaction of triple test cross families for yield traits of breadwheat under timely and late sown condition

Source	d.f.	No. of productive tillers	Spike length	Grains per spike	Yield per spike	Grain per plant
Sums	17	21.42	6.80	150.81	0.96	33.51
Sums x environments	17	20.15**	6.95**	170.21**	0.82**	31.39**
Replications within environments x sums	68	3.03**	0.65**	21.51**	0.06	5.61**
Within families	648	0.36	0.31	0.60	0.59	0.007
Differences	17	7.35	2.82	135.67	0.07	21.62
Differences x environments	17	7.03**	2.51**	120.08**	0.10**	20.00**
Replications within environments x differences	68	1.96	0.71	11.44	0.03	5.20
Within families	432	0.45	0.34	0.56	0.007	0.69
i type epistasis	1	4.38	8.21	280.77	0.95	99.12
i type epistasis x environments	1	10.49**	13.21**	560.10**	0.17	161.34**
Replications within environments x i type epistasis	4	17.33**	3.45**	40.51**	0.04	16.34**
i and l type epistasis	17	10.60	1.01	115.74	0.11	18.10
j and l type epistasis x environments	17	12.31**	1.97**	101.34**	1.00**	25.10**
Replications x environments x j and l type epistasis	68	8.44**	1.1**	51.36**	0.11	10.08**
Within families	648	0.36	0.31	0.60	0.69	0.007

*Significant at p = 0.01.

and estimation of epistasis would also enable breeder to determine the genetic causes of heterosis with greater reliability. Using the TTC model, epistasis has been reported to be significant component of genetic variance for different traits in wheat [3, 7, 13]. Further, partitioning of epistasis item into i type (additive x additive) and j and l type (additive x additive and dominance x dominance) revealed that i type interaction was present for all the characters except for number of ear bearing tillers, spike length and peduncle length under late sown conditions and weight of grains per spike under timely sown conditions. However, j and l types of epistasis were more pronounced than i type of epistasis in both the environments for all the characters. Greater importance of j and l type epistasis than i component was reported earlier [3, 14, 15]. On the contrary, Nanda et al. [7] reported i type epistasis to be more important than j and l type epistasis, and Singh [16] recorded equal importance of these two subcomponents.

It is thus obvious that besides the additive and dominance genetic components, epistatic effects have also been found to be significant for all the characters studied. Though their relative magnitudes vary for different characters and under different environments. Under such situations, a breeding method which can effectively exploit the three types of gene effects simultaneously would be more appropriate. In order to exploit the different types of gene effects fully, it is suggested that a breeding method which could accumulate the fixable gene effects (additive, additive x additive, and complementary epistasis) and at the same time maintain considerable heterozygosity for exploiting the dominant gene effects for improving the population should be followed. Other types of epistasis (additive x dominance, dominance x dominance etc.) are not fixable by selection under self fertilization, and therefore, may be useful in development of hybrids. Early generation selection combined with random and diallel selective mating system is the appropriate method as proposed by Jenson [17]. Reden and Jensen [18] suggested that outcrossing concurrent with selection could be a breeding tool for naturally inbreeding crops provided the additive component of genetic variation is important. Using recurrent selection in early generations of two barley populations, Parlevleit and Commeren [19] achieved considerable improvement for grain yield.

REFERENCES

1. G. S. Nanda, P. Singh and K. S. Gill. 1983. Estimation of epistasis through triple test cross in wheat. Indian J. Genet., **42**(2): 160–163.

2. S. Singh. 1983. Detection of epistasis in wheat. Thesis Abstr., **9**(1): 71–72.

3. G. Singh, G. S. Nanda and K. S. Gill. 1984. Inheritance of yield and its components in five crosses of spring wheat. Indian J. agric. Sci., **54**(11): 943–949.

4. M. J. Kearsey and J. L. Jinks. 1968. A general method of detecting additive, dominance and epistasis variation for metric traits. I. Heredity, **23**: 409–419.

5. H. Ketata, E. L. Smith, L. H. Edwards and R. W. Mc New. 1976. Detection of epistatic, additive and dominance variation in winter wheat. Crop Sci., **16**: 1–4.

6. J. L. Jinks and J. M. Perkins. 1970. A general method of detection of additive dominance and epistatic component of variation. III. F_2 and backcross populations. Heredity, **25**: 419–423.

7. G. S. Nanda, P. Singh and K. S. Gill. 1982. Epistasis, additive and dominance variation in triple test cross of bread wheat. Theor. Appl. Genet., **62**(1): 49–52.

8. K. Kumar. 1987. Triple Test Cross Analysis for Some Metric Traits in Wheat. M. Sc. (Ag) Thesis. HAU, Hissar.

9. S. Singh. 1979. A study of genotype x environment interaction in three barley triple test crosses. J. agric. Sci. Camb., **92**: 319–321.

10. S. S. Dhillon and T. H. Singh. 1982. Estimates of epistasis in upland cotton. Indian J. Genet., **42**(3); 389–392.

11. S. Singh and M. S. Dahiya. 1984. Detection and estimation of components of genetic variation and genotype x environment interaction in three wheat crosses. J. agric. Sci. Camb., **103**: 543–547.

12. R. P. Singh and S. Singh. 1984. A study of interaction of additive, dominance and epistatic gene effects with micro- and macro-environment in two tomato triple test crosses. J. agric. Sci. Camb., **103**: 53–57.

13. S. Singh. 1981. Single tester triple test cross analysis in spring wheat. Theor. Appl. Genet., **59**: 247–249.

14. I. D. Tripathi and M. Singh. 1983. Triple test cross analysis in three barley populations under saline alkali soils conditions. J. agric. Sci. Camb., **101**: 317–321.

15. S. S. Verma and M. Yunus. 1986. Role of epistasis in the analysis of genetic component of variance in bread wheat. Indian J. agric. Sci., **56**(10): 687–689.

16. S. Singh. 1980. Detection of components of genetic variation and genotype x environment interaction in spring wheat. J. agric. Sci. Camb., **95**: 67–72.

17. N. F. Jensen. 1970. A diallel selective mating system for cereal breeding. Crop Sci., **10**: 629–635.

18. R. J. Redden and N. F. Jensen. 1974. Mass selection and mating system in cereals. Crop Sci., **14**: 345–350.

19. J. E. Parlevleit and A. V. Commeren. 1988. Recurrent selection for grain yield in early generations of two barley populations. Euphytica, **38**: 175–184.