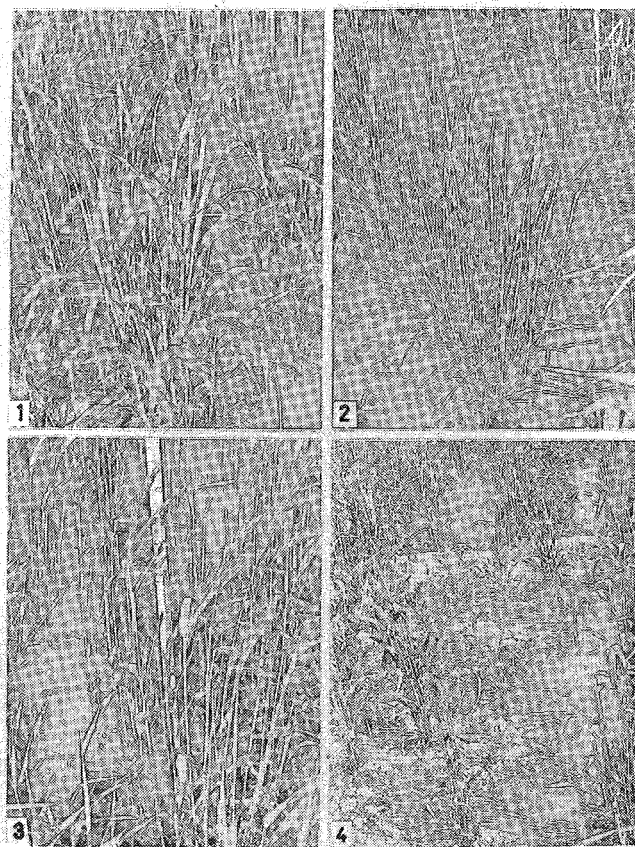


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# WHEAT INFORMATION SERVICE



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## I. Research Notes

### Allelic variation at the crossability loci in wheat (*Triticum aestivum*)

L.A. SITCH<sup>(1)</sup> and J.W. SNAPE

PLANT BREEDING INSTITUTE,  
CAMBRIDGE, U.K.

The crossability of hexaploid wheat (*Triticum aestivum*) with rye (*Secale cereale*) has been shown to be controlled by three loci, designated *Kr*<sub>1</sub>, *Kr*<sub>2</sub> (LEIN 1943) and *Kr*<sub>3</sub> (KROWLOW 1970), located on chromosomes 5B, 5A (RILEY & CHAPMAN 1967) and 5D (KROWLOW 1970) respectively. LEIN (1943) demonstrated that the dominant alleles at the *Kr*<sub>1</sub> and *Kr*<sub>2</sub> loci reduced crossability, with *Kr*<sub>1</sub> having a greater effect than *Kr*<sub>2</sub>. A high positive correlation between the crossability of wheat with rye and *Hordeum bulbosum* has also been demonstrated (FALK & KASHA 1981, SITCH *et al.* 1985, SNAPE *et al.* 1979) and genetic studies involving comparisons of the crossability of the Chinese Spring (Hope) single chromosome substitution lines (SNAPE *et al.* 1979) and of recombinant lines for the *Kr*<sub>1</sub> locus, with rye and *H. bulbosum* (SITCH *et al.* 1985) confirm that the *Kr* loci control the crossability of wheat with both pollen parents.

An examination of the *H. bulbosum* and the rye crossability of the single chromosome substitution lines of the non-crossable varieties, Hope, Atlas 66 and Cheyenne into Chinese Spring, for all the homoeologous group 5 chromosomes by FALK & KASHA (1983) indicated that there may be multiple alleles for reduced crossability on chromosomes 5A and 5B. However, no evidence was found for variation at the *Kr*<sub>3</sub> locus on chromosome 5D of these varieties. The only significant evidence of a third crossability gene was obtained by FEDAK & JUI (1982), in pollinations of barley (*Hordeum vulgare*) cv. Betzes with the Chinese Spring (Hope) substitution lines.

This paper describes an investigation designed to ascertain whether there is any evidence of multiple allelism at the *Kr* loci of the non-crossable varieties Hope and Capelle-Desprez and to determine whether different *Kr*<sub>3</sub> alleles exist in these varieties from that in Chinese Spring, from a study of the *H. bulbosum* crossability of the group 5 substitution lines of these varieties into Chinese Spring.

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(1) Address: International Maize and Wheat Improvement Centre (CIMMYT), Londres 40, Apdo. Postal 6-641, Deleg. Cuauhtemoc, 06600 Mexico, D.F., MEXICO.

## Materials and Methods

The single chromosome substitution lines of the group 5 homoeologous chromosomes of the varieties Hope and Cappelle-Desprez into Chinese Spring were produced by Professor E.R. Sears, University of Missouri, Columbia, Missouri, U.S.A. and by Dr. C.N. Law and Mr. A.J. Worland, Plant Breeding Institute, Cambridge, England respectively. SNAPE *et al.* (1979) demonstrated that these two donor varieties are non-crossable with tetraploid *H. bulbosum*. All *H. bulbosum* pollinations were made using the tetraploid *H. bulbosum* clone PB168, originally obtained from Dr. D.B.H. Sparrow, from the Turkey collection CPI 18968, entry number 73/3.

The chromosome 5D substitution lines were vernalized for two weeks, at 4°C with an 8-hour daylength, to promote flowering because both donor varieties possess winter alleles at the *Vrn<sub>3</sub>* locus on chromosome 5D controlling vernalization requirement (LAW *et al.* 1976). The *H. bulbosum* clones were vernalized under identical conditions for 8 weeks to promote flowering, and grown, together with the wheat genotypes, in an unheated glasshouse during the summer.

All crossing procedures were carried out as described SITCH *et al.* (1985) on 12 spikes per genotype. The percent seed set was established for each spike individually and then averaged over contributing spikes. The statistical analysis was carried out using data transformed to angles.

## Results

The table of means of Chinese Spring and the six substitution lines and the analysis of variance for seed setting ability are shown in Tables 1 and 2 respectively. The seven genotypes differed significantly in seed setting ability. The seed set obtained on the 5A and the 5B chromosome substitution lines of Hope and Cappelle-Desprez was significantly lower than that obtained on Chinese Spring. The crossability of the 5D substitution lines, however, was not significantly different from Chinese Spring. This implies either that Hope and Cappelle-Desprez possess an allele of small effect at the third crossability locus, *Kr<sub>3</sub>*, on chromosome 5D or that, in these varieties, this locus is represented by an allele equivalent to that of Chinese Spring.

The variation in crossability of the six substitution lines was partitioned into the main effects of the three chromosomes, of the two varieties and the interaction between these two main effects, Table 2.

The overall crossability of chromosomes 5A, 5B and 5D differed significantly, the 5D chromosome substitution lines having the highest crossability and the 5B chromosome substitution lines the lowest. The variation between chromosomes was further partitioned to allow a comparison between chromosome 5B and the remaining chromosomes, and between chromosomes 5A and 5D. This indicated that a large proportion of the variation in the overall crossability was attributable to the severe reduction in percent seed set caused by *Kr<sub>1</sub>* on chromosome 5B. However, the allele *Kr<sub>2</sub>*, on chromosome 5A, also contributed towards this variation since the overall crossability of the 5A substitution lines was significantly lower than that of the 5D substitution lines.

An overall comparison of the crossability of the substitution lines derived from Hope and from Cappelle-Desprez showed that the mean of the group 5 chromosome substitutions did not

Table 1. The mean *H. bulbosum* crossability of the Chinese Spring (Hope) and the Chinese Spring (Cappelle-Desprez) homoeologous group 5 single chromosome substitution lines and of Chinese Spring

	Variety		Chromosome Mean
	Hope	Cappelle-Desprez	
Chromosome 5A	15.3 *(i)	6.6 ***	10.9
5B	2.5 ***	7.3 ***(ii)	4.9
5D	29.9 NS	19.2 NS	24.5
Variety Mean	15.9	11.0	
Chinese Spring	23.0		

- (i) Significant differences from Chinese Spring, as determined from transformed percentage data.  
(ii) Cappelle-Desprez contains the 5BS-7BS/5BL-7BL translocation and consequently this substitution line is for the 5BL-7BL chromosome.

Significance levels: NS = not significant, \*  $p = 0.05-0.01$ , \*\*\*  $p < 0.001$ .

Table 2. The analysis of variance of *H. bulbosum* crossability (per cent seed set, transformed to angles) of the Chinese Spring (Hope) and the Chinese Spring (Cappelle-Desprez) homoeologous group 5 single chromosome substitution lines

Item	df	MS	VR
Between lines (including Chinese Spring)	6	1024.23	17.433 ***
Between lines (excluding Chinese Spring)	5	1043.26	17.758 ***
between chromosomes	2	2077.34	35.359 ***
5B v remainder	1	2537.27	43.188 ***
5A v 5D	1	1617.40	27.530 ***
between varieties	1	147.01	2.502 NS
chromosome . variety interaction	2	457.30	7.784 ***
5B v remainder	1	904.18	15.390 ***
5A v 5D	1	10.43	0.177 NS
Within lines	77	58.75	

Significance levels: NS = not significant, \*\*\*  $p < 0.001$ .

differ significantly. However, the significance of the interaction implies allelic variation between the homoeologous chromosomes of Hope and Cappelle-Desprez. A partitioning of this variation into a comparison between chromosome 5B and the remaining chromosomes, and between chromosomes 5A and 5D, revealed that the allelic variation between Hope and Cappelle-Desprez was attributable to allelic differences at both the  $Kr_1$  and  $Kr_2$  loci. The  $Kr_1$  allele on chromosome 5B of Hope was significantly ( $p < 0.05$ ) more potent than that of Cappelle-Desprez in suppressing crossability. In contrast, the  $Kr_2$  allele from Hope was significantly ( $p < 0.05$ ) less effective than that from Cappelle-Desprez.

### Discussion

This investigation indicates that allelic variation probably exists at the  $Kr_1$  and  $Kr_2$  loci of the non-crossable varieties, Hope and Cappelle-Desprez. The similar study of FALK & KASHA (1983) using the group 5 chromosome substitution lines of Hope, Atlas 66 and Cheyenne into Chinese Spring also showed that the chromosomes carrying crossability genes differed in potency depending on the donor variety (FALK & KASHA 1983). Although other modifier genes on the substituted chromosome could have led to variation in the expression of the  $Kr$  genes, FALK & KASHA (1983) interpreted the results as possible evidence for the existence of a multiple allelic series at the  $Kr$  loci and this is also suggested by the data described here.

One method of overcoming the incompatibility caused by the crossability genes is to back-cross the recessive crossability gene,  $kr_1$ , from a crossable variety such as Chinese Spring, into the non-crossable variety (SNAPE & SIMPSON 1980). If this technique is to be used, it is important to ascertain the degree of allelic variation at the crossability loci of the recipient variety. In the case of Cappelle-Desprez, for example, the dominant alleles  $Kr_1$  and  $Kr_2$  are equally effective and consequently the substitution of  $kr_1$  of Chinese Spring into Cappelle-Desprez would make Cappelle-Desprez crossable, but only at a very low level.

From this study, the third  $Kr$  allele,  $Kr_3$ , of both Hope and Cappelle-Desprez appeared to be incapable of significantly reducing the crossability of Chinese Spring. In other studies, Chinese Spring (Hope 5D) showed a slight but again statistically non-significant reduction in seed setting ability, relative to Chinese Spring, in pollinations with rye (RILEY & CHAPMAN 1967) and *H. bulbosum* (SNAPE *et al.* 1979).

The absolute values of the crossability of the substitution lines for Hope chromosomes 5A, 5B and 5D with *H. bulbosum* vary between the studies made by FALK & KASHA (1983), by SNAPE *et al.* (1979) and that described here. The highest seed set values were obtained by FALK and KASHA (1983) of 28, 4 and 50% for the three substitution lines respectively. The results obtained here were slightly lower; being 15.3, 2.5 and 29.9% seed set respectively. The lowest levels of seed set were obtained by SNAPE *et al.* (1979), of 4.9, 0.0 and 9.8%. These differences may reflect differences in the presence or absence of post-pollination applications of gibberellic acid (GA) or other environmental influences. In both the present investigation and in that of FALK & KASHA (1983) post-pollination GA applications were made one day after pollination

and for three consecutive days after pollination respectively. The higher seed sets obtained by FALK & KASHA (1983) may reflect the greater number of GA applications. The lower seed sets obtained by SNAPE *et al.* (1979) may result from the lack of a post-pollination GA application, since previous investigations have shown that the application of GA has a stimulatory effect on pollen tube growth (LARTER & CHAUBEY 1965), the frequency of fertilization (SITCH & SNAPE 1986) and seed set (SITCH 1984).

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### Hybrid necrosis in bread wheat. III.

R.P. SINGH, I. SINGH and R.K. CHOWDHURY

Department of Plant Breeding,  
Haryana Agricultural University, Hisar-125004, India

Hybrid necrosis is the pre-mature gradual death of leaves and leaf sheaths in certain crosses of wheat and is the major barrier in combining desirable traits into hybrid combinations. Based on the earlier studies, two complementary genes, namely,  $Ne_1$  and  $Ne_2$  when brought together in hybrid combination, either in homo- or heterozygous form, cause necrosis (HERMSEN 1963). The degree of necrosis in  $F_1$  plants varies depending on the multiple alleles ( $s$ ,  $m$  and  $w$ ) of these two genes ( $Ne_1$  and  $Ne_2$ ). HERMSEN (1963) has given 0 - 9 grades of necrosis in hybrids ( $F_1$ ) depending on different combinations of the three alleles of  $Ne_1$  and  $Ne_2$  genes as:

- 0 - 3 Weak necrosis (Hybrids produce normal seeds)
- 3 - 6 Moderate necrosis (Hybrids produce pre-mature seeds)
- 6 - 9 Severe (No seed obtained from hybrids)

Indian varieties have been reported to be generally having  $Ne_1$  gene, while Mexican varieties are supposed to have  $Ne_2$  genes (GILL *et al.* 1969, ANAND *et al.* 1969, CHOWDHURY 1981, 1983). Because of these reasons, many times it becomes cumbersome to combine desirable traits of Indian varieties with that of Mexican, if the genotypes in combination have  $Ne_1$  and  $Ne_2$  genes, respectively. This problem has already been experienced in case of variety C306, which is one of the top drought tolerant varieties and has good quality grains. Since it carries  $Ne_1$  gene, therefore, many of its crosses with Mexican wheat varieties fail, when the other parent has  $Ne_2$  gene, though some way-outs have been suggested to overcome the necrosis in  $F_1$  generations of such crosses (DHALIWAL *et al.* 1986).

While breeding of high yielding and drought/rust resistant varieties, we at Haryana Agricultural University are attempting a number of crosses in bread wheat every year and screening their hybrid generations. While doing so, we came across many of the crosses showing necrotic behaviour in  $F_1$  generation. We have already published two lists of such crosses (CHOWDHURY 1981, 1983). Here we have compiled the third list of bread wheat crosses showing necrosis. Depending on the gene combination we have sorted-out wheat genotypes having  $Ne_1$  or  $Ne_2$  genes. Other varieties have also been listed which have given indication of non-carrier of either  $Ne_1$  or  $Ne_2$  or both (Table 1). The data on morphological features like plant height and number of leaves (green as well as dry) per tiller of some of the necrotic  $F_1$  hybrids have been given in Table 2.

The observations made on these necrotic  $F_1$  hybrids showed that the yellowing of leaves started at 2 - 3 leaf stage and most of the hybrids died at the 5 - 6 leaf stage without producing ear, showing the characteristic of severe necrosis of grade 7 as described by HERMSEN (1963).



Table 1. List of carrier/non-carrier of necrotic gene in bread wheat

$Ne_1$ carrier	$Ne_2$ carrier	Non-carrier of $Ne_1$	Non-carrier of $Ne_2$	Non carrier of $Ne_1$ and $Ne_2$
C306	cm 58803		HS 33	HS 90
GP104	cm 59376	K 227 - 1	HS 43	HS 74
GP106	cm 66675	K 227 - 7	NT 574	NT 5439
WH157	WH 331	WL 1562	WH 129	HT 1011
AP105	P 48 B	Hindi 62		HD 2281
	Raj 939	Kharchia-65	DL 172	
	CBS 102			
	PC 89			
	UP 262			
	WL 410			
	IWP 72			
	CBS 289			
	Kalyansona			

It is well established that Indian variety C306 carries  $Ne_1$  gene. Therefore, the varieties like IWP72, WH331, UP262, P48B, Raj 939, CBS289, Cm 58803, Cm 59376, Cm 66675, CBS102, PC89, WL410, Kalyansona, which have produced necrotic hybrids with C306, carry  $Ne_2$  gene. Similarly, the variety GP104 which did give normal plants with C306 but showed necrosis with above listed varieties, must have  $Ne_1$  gene. Other varieties like GP106, WH157 and AP105 also gave indication of having  $Ne_1$  gene in their genotypic back-ground. The crosses involving WH331 showed less necrosis, indicating that this variety may be having  $m$  or  $w$  alleles of  $Ne_2$  but it needs further confirmation. There were varieties like WH157, IWP72 and WL410 which were earlier reported to be non-carrier of necrotic genes, have now been identified having  $Ne_1$  (WH157) and  $Ne_2$  (WL410 and IWP72) genes. These information will be of importance to the wheat breeders/geneticists in their hybridization programme.

Table 2. Morphological characteristics of some of the F<sub>1</sub> hybrids showing necrotic behaviour :  
in bread wheat

Cross	Necrotic behaviour	Plant height(cm)	No. of leaves/tiller		
			Green	Dry	Total
CBS 102 x C 306	Severe	12.67	1	4	5
x WH331	Normal	36.67	5	0	5
x WL410	Normal	32.00	4	1	5
x TWP72	Normal	29.33	5	0	5
GP 104 x C 306	Normal	63.00	5	1	6
x WH331	Weak	45.00	1	5	6
x WL410	Severe	35.00	1	4	5
x TWP72	Severe	40.00	1	4	5
C 306 x TWP72	Severe	58.00	1	4	5
x WH331	Weak	46.00	0	5	5
x UP262	Severe	—	1	4	5
x P 48B	Severe	—	0	5	5
x Raj939	Severe	45.00	1	4	5
x CBS289	Severe	30.00	1	5	6
WH 157 x WH331	Weak	76.00	2	4	6
cm 58803 x C306	Severe	10.00	0	5	5
cm 59376 x C306	Severe	8.00	1	5	6
cm 66675 x C306	Severe	24.00	0	5	5
Raj 939 x C306	Severe	45.00	0	5	5

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## Variation in growth, flowering, and seed set under high temperatures in *Aegilops* species

B. EHDAIE and J.G. WAINES

Department of Botany and Plant Sciences, University of California,  
Riverside, CA 92521, USA

Drought and heat are major environmental factors that reduce rainfed wheat production in semiarid regions. While there has been considerable effort to understand and improve drought resistance in wheat, relatively little effort has been made to increase knowledge about heat resistance (MARSHALL 1982). Consequently, there has been little improvement of resistance to heat stress.

The effect of temperature on wheat was studied under controlled conditions (FRIEND 1966, BAGGA & RAWSON 1977). In these studies, only a few bread wheat genotypes (*Triticum aestivum* L.) were tested. The existence of heritable variation for heat resistance during early stages of growth was reported in bread wheats and *durum* wheats (*T. durum*) (SISODIA *et al.* 1978, KANANI & JADON 1985). Reports of the effect of high temperatures on wild relatives of wheat are limited. This preliminary experiment was undertaken to study the responses of different accessions of the D genome (*Aegilops squarrosa* L.) and the B genome (Sitopsis group of *Aegilops*) to high temperatures in the field during early stages of growth as well as during reproductive stages.

### Materials and Methods

A total of 389 plants belonging to *Ae. squarrosa* (15 accessions), *Ae. speltoides* ssp. *speltoides* (13 accessions), *Ae. speltoides* ssp. *ligustica* (5 accessions), *Ae. bicornis* (11 accessions), *Ae. longissima* (12 accessions), *Ae. sharonensis* (7 accessions), and *Ae. searsii* (10 accessions) from the University of California, Riverside, germplasm collection along with 5 tetraploid and 5 hexaploid wheat genotypes were grown in the field during Summer 1987. The tetraploid genotypes, Mexicali, Nos. 18, 62, 82, and 94, and the hexaploid genotypes, Anza, Yecora Roja, Sholeh, and Nos. 14 and 69, involved Mexican semidwarf Californian cultivars and landraces from southwestern Iran. Seed were sown in flats in the greenhouse on June 16, and seedlings were transplanted in the field on July 22. Each accession had 4 to 10 plants. Plants were irrigated frequently to prevent moisture stress. The number of plants which survived during early stages of growth was recorded for each species and subjected to  $\chi^2$  analyses to compare the survival rates, i.e., the number of plants that survived to total number of plants, of different species under heat stress. The number of plants that flowered and produced seed was also recorded. Agronomic characteristics of the promising heat-resistant accessions were measured.

## Results and Discussion

Monthly mean minimum and maximum temperatures along with ranges during the study period are shown in Table 1. The average temperatures were well above the optimum temperatures for vegetative and reproductive growth, as shown by accelerated developmental phases of the tetraploid and hexaploid genotypes. For example, Mexicali, Anza, and Yecora Roja, commercial day-length insensitive wheat cultivars in California, reached the flowering stage 51 days, 51 days, and 41 days after seeding, respectively. All tetraploid and hexaploid genotypes flowered and produced seed.

Table 1. Monthly mean minimum and maximum temperatures (°C) and ranges during study at Moreno Field Station, Riverside, CA, 1987

Month	Minimum		Maximum	
	Mean (°C)	Range (°C)	Mean (°C)	Range (°C)
July	12.0	7.5 - 15.9	32.6	25.0 - 39.2
August	13.6	11.1 - 16.8	35.1	27.0 - 40.1
September	12.4	8.4 - 18.4	33.4	25.1 - 39.8
October	12.2	7.0 - 15.9	28.3	17.6 - 37.3

Numbers of dead and live plants and the survival rate for each *Aegilops* species are presented in Table 2. The  $\chi^2$  test for equality of survival rates was highly significant ( $\chi^2 = 27.552$ ,  $P < 0.001$ ), indicating large differences among the species for heat resistance during early stages of growth. However, when *Ae. squarrosa* and *Ae. speltoides* ssp. *ligustica* accessions were excluded from the  $\chi^2$  analysis, the  $\chi^2$  value was insignificant ( $\chi^2 = 6.394$ ,  $0.10 < P < 0.25$ ), which indicates similarity of survival rates of the remaining *Aegilops* species. The survival rates of *Ae. squarrosa* and *Ae. speltoides* ssp. *ligustica* were the same, but higher than those of other groups (Table 2).

The responses of different species to heat stress in the latter stages of growth were quite different. None of the plants belonging to *Ae. squarrosa*, *Ae. speltoides* ssp. *speltoides*, or *Ae. sharonensis* which survived heat stress during early stages of growth produced heads. This could be due to their vernalization requirements, or to their susceptibility to heat during reproductive stages. Of 20 *Ae. speltoides* ssp. *ligustica* plants and of 49 *Ae. bicornis* plants that survived only 8 and 1 plants, respectively, produced heads, but none set seeds. In contrast, all plants from two accessions of *Ae. longissima*, G1414 and G1415, and six accessions of *Ae. searsii*, G1416, G1417, G1418, G1419, G3069, and G3528, produced seed-bearing heads, indicating their resistance to heat during both vegetative and reproductive stages. The mean number of days from seeding to flowering and the mean of some yield-related traits for these promising accessions are pre-

sented in Table 3. Considerable variation was observed for different traits among these heat-resistant accessions.

Table 2. Number of dead and live plants and survival rate for each species under heat stress

Species	Number of plants			Survival* rate
	Dead	Alive	Total	
<i>Ae. squarrosa</i>	5	68	73	0.93
<i>Ae. speltoides</i> spp. <i>ligustica</i>	1	28	29	0.97
<i>Ae. speltoides</i> spp. <i>speltoides</i>	20	45	65	0.69
<i>Ae. sharonensis</i>	14	25	39	0.64
<i>Ae. bicornis</i>	18	50	68	0.74
<i>Ae. longissima</i>	17	48	65	0.74
<i>Ae. searsii</i>	7	43	50	0.86

\* Calculated as ratio of live plants to total plants for each species.

Table 3. Mean number of days to flowering (DF), heads/plant (H/P), seeds/plant (S/P), and seed yield/plant (Y/P) of heat-resistant *Aegilops* accessions

Accession	Species	Origin	DF (no.)	H/P (no.)	S/P (no.)	Y/P (g)
G1414	<i>Ae. longissima</i>	Jordan	70	9.6	78.4	1.44
G1415	"	"	98	14.5	58.4	1.12
G1416	<i>Ae. searsii</i>	Syria	86	10.7	56.0	1.00
G1417	"	"	86	28.0	47.2	0.96
G1418	"	"	101	30.4	126.6	1.76
G1419	"	"	101	30.8	147.6	1.62
G3069	"	Israel	86	32.4	234.0	3.80
G3528	"	"	93	28.5	128.6	1.36

MIDMORE *et al.* (1984) reported that yield reduction in wheat in hot environments is due to the acceleration of all plant developmental phases. FISCHER & MAURER (1976) reported that yield reduction in semidwarf wheats under high temperatures was associated with reduced number of heads per plant and seeds per head. SISODIA *et al.* (1978) classified bread and *durum* wheats into desirable and undesirable groups when grown under high temperatures. Genotypes which either flowered too early (< 45 days), too late (> 120 days), or never flowered were considered undesirable. In the present study, days to flowering for the heat-resistant *Aegilops* acces-

sions ranged from 70 to 101 days (Table 3). These accessions also produced a large number of seed-bearing heads, although the late tillers produced heads with only a few seeds or no seeds. Plants of *Ae. searsii* G3069 were an exception; they tillered profusely over a short period, and the tillers produced heads with several seeds.

These heat-resistant *Aegilops* accessions could be used to study the inheritance of resistance to heat and to investigate the mechanisms involved in heat resistance.

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## **Effect of salt stress on germination and seedling growth of wheat cultivars.**

S.M. ALAM, A.R. AZMI and S.M. NAQVI

Atomic Energy Agricultural Research Centre,  
Tando Jam, Sind, Pakistan

Soil salinity is one of the most important problems in the arid and semi-arid zones causing significant decreases in soil productivity. The accumulation of salt in irrigated soils reduced the germination, growth and eventually the crop yield. Soil salinity both decreases and delays germination in wheat, barley and triticale (BISHNOI & PANCHOLY 1980) and differences in salt tolerance of various cultivars have been reported (JANA *et al.* 1980, MAAS & HOFFMAN 1977). In the present investigation, an attempt was made to determine the effect of different concentrations of NaCl and Na<sub>2</sub>SO<sub>4</sub> mixed together on germination and seedling growth of wheat genotypes to identify their salt tolerant and salt sensitive behaviours.

### **Materials and Methods**

A laboratory experiment was conducted to ascertain genotypic response of 9 wheat genotypes to salinity during germination and seedling growth. One hundred seeds of each of these genotype were subjected to different concentrations of NaCl and Na<sub>2</sub>SO<sub>4</sub> (0.00, 0.2, 0.4, 0.6, 0.8 and 1.0%) and were allowed to germinate in darkness on filter paper in petri dishes soaked in a solution of the respective salt concentration for 120 hours at 26°C. A completely randomized design with four replication was used in this experiment. Ten plants from each treatment and the control were measured for shoot and root length to the nearest millimeter. The total number of seeds germinated were also counted. The data were tabulated and presented in Table 1-3.

### **Results and Discussion**

#### **i) Germination.**

It is obvious that each increment of 0.2% salinity concentration significantly reduces. The germination percentage of all the genotypes. It is assumed that in addition to toxic effects of certain ions, higher concentration of salt reduces the water potential in the medium which hinders water absorption by germinating seeds and thus reduces germination (MAAS & NIEMAN 1978). The genotype LU-26-S had shown significantly higher salt tolerance (87.8%) than all other genotype at the highest salinity level 1.0%. The most salt sensitive genotype was Sonalika with 53.2 percent germination. The differential genotypic response to salinity at germination stage has also been reported (HELAL & MENGEL 1981, JANA *et al.* 1980).

Table 1. Effect of salt concentrations on germination percentage of wheat genotypes

Genotypes	Concentration per cent						Mean
	0.0	0.2	0.4	0.6	0.8	1.0	
P-89	100	80 (80.00)	70 (70.00)	70 (70.00)	50 (50.00)	43 (43.00)	68.33
C-591	98	87 (88.78)	75 (76.53)	68 (69.39)	59 (60.20)	55 (56.12)	73.66
Sind-81	95	83 (87.37)	75 (78.95)	70 (73.68)	60 (63.16)	50 (52.63)	72.16
Pavon	100	97 (97.00)	85 (85.00)	68 (68.00)	63 (63.00)	42 (42.00)	75.83
LU-26-S	100	98 (98.00)	95 (95.00)	90 (68.00)	80 (80.00)	64 (64.00)	87.83
Sind-83	100	90 (90.00)	80 (80.00)	70 (70.00)	68 (68.00)	60 (60.00)	78.00
Pak-70	97	89 (91.75)	84 (86.60)	77 (79.38)	69 (71.13)	60 (61.86)	79.33
Mehran	80	74 (92.50)	68 (85.00)	60 (75.00)	50 (62.50)	40 (50.00)	62.00
Sonalika	74	65 (87.84)	60 (81.08)	50 (67.57)	40 (54.05)	30 (40.54)	53.17

Figures in parentheses show percentages of control.



Table 2. Effect of salt concentrations on shoot length 120 hrs after emergence (cm)

Genotypes	Concentrations per cent						Mean
	0.0	0.2	0.4	0.6	0.8	1.0	
P-89	3.60	2.89 (80.28)	2.86 (79.44)	2.40 (66.66)	1.29 (49.72)	0.83 (23.05)	2.39
C-591	4.83	3.28 (67.91)	2.77 (57.35)	2.08 (43.06)	1.36 (28.16)	1.08 (22.36)	2.56
Sind-81	4.64	4.02 (86.64)	2.42 (52.16)	1.65 (35.56)	1.47 (31.68)	1.31 (28.23)	2.58
Pavon	5.17	4.54 (87.81)	2.67 (51.64)	2.42 (46.81)	1.29 (24.95)	1.13 (21.86)	2.87
LU-26-S	4.85	4.56 (94.02)	3.59 (74.02)	2.36 (48.66)	1.82 (37.52)	1.41 (18.76)	3.02
Sind-83	4.43	3.86 (87.13)	3.63 (81.94)	3.48 (78.55)	1.17 (26.51)	0.75 (16.93)	2.89
Pak-70	6.61	4.36 (65.96)	3.11 (47.05)	2.09 (31.62)	1.88 (28.44)	1.40 (21.18)	3.24
Mehran	5.26	4.14 (78.71)	3.42 (65.02)	2.14 (40.68)	1.82 (34.60)	1.20 (22.81)	2.99
Sonalika	3.83	3.18 (83.03)	2.73 (71.28)	2.14 (55.87)	1.27 (33.15)	0.69 (17.75)	2.40
Mean	4.80	3.87	3.02	2.31	1.61	1.08	

Figures in parentheses show percentages of control.

Table 3. Effect of salt concentration in root length 120 hrs after emergence (cm)

Genotypes	Concentration per cent						Mean
	0.0	0.2	0.4	0.6	0.8	1.0	
P-89	7.20	6.28 (87.20)	4.73 (65.70)	4.58 (63.61)	3.53 (49.03)	2.15 (29.86)	4.74
C-591	5.89	3.60 (61.12)	2.89 (49.07)	2.59 (43.97)	2.10 (35.65)	1.31 (22.24)	3.063
Sind-81	5.25	4.16 (79.24)	3.43 (65.33)	3.06 (58.29)	2.33 (44.38)	1.70 (32.38)	3.321
Pavon	9.79	6.21 (63.43)	4.82 (49.23)	3.89 (39.73)	3.06 (31.26)	2.57 (26.25)	5.056
LU-26-S	7.35	7.03 (95.65)	6.34 (86.26)	4.14 (56.33)	3.84 (52.24)	2.27 (30.88)	5.161
Sind-83	6.38	6.34 (99.69)	6.27 (98.28)	4.86 (76.18)	1.84 (28.84)	1.43 (22.41)	4.520
Pak-70	7.27	5.14 (70.70)	3.37 (46.35)	2.73 (37.55)	2.16 (29.71)	1.76 (24.21)	3.740
Mehran	6.20	5.64 (90.97)	4.19 (67.58)	3.10 (50.0)	2.18 (35.16)	1.38 (22.42)	3.783
Sonalika	5.18	4.32 (83.40)	3.12 (60.23)	2.82 (54.44)	2.15 (41.51)	1.07 (20.65)	3.11
Mean	6.72	5.41	4.35	3.53	2.58	1.73	

Figures in parentheses show percentages of control.

## ii) Seedlings growth.

Sodium chloride and sodium sulphate salinization has a definite effect on shoot and root length (Tables 2 and 3). Increasing salinity levels from 0.2 to 1.0% significantly decreases shoot and root growth of all the genotypes. At higher concentrations (0.8 to 1.0%) shoot and root growth is considerably retarded. It was also observed that the degree of reduction increased proportionally with the increasing concentration of salt. Inhibition of plant growth by salinity is due to the inhibitory effect of ions. As a result of this inhibition carbohydrates and nitrogenous substances are not fully utilized (STROGONOV 1962). Another reason for reduced shoot and root development may be due to toxic effects of the salts used as well as unbalanced nutrient uptake by the seedlings. Osmotic effects may also contribute to low growth rates under saline conditions (EPSTEIN 1977). Generally the genotype Sind-81 seemed to be the most tolerant during shoot and root growth at the highest salinity level (1.0%), while the genotypes Sind-83, Sonalika and LU-26-S were proved to be the most salt-sensitive at the maximum salinity level. At the highest salinity (1.0%) the average shoot and root length is reduced by almost 51% of the control. The degree of decrease was higher in the case of shoot length which indicates that salinity inhibits shoot growth more than the root growth (STROGONOV 1962) and this could be due to the reduction in physiological availability of water with increases in solute suction. Genotypic response to shoot and root growth at different salinity levels are obvious and one genetically controlled (EPSTEIN & NORYLIN 1977).

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## Screening of wheat germplasm for Mn deficiency stress tolerance

N.P. KAUR, P.N. TAKKAR and A.K. GUPTA

Punjab Agricultural University,  
Ludhiana, India

In coarse textured soils of Punjab under rice rotation, the deficiency of available manganese has been increasing at an alarming rate. This problem can be tackled either through amending the soil with Mn-bearing fertilizer or by selecting and/or breeding Mn-efficient varieties. The prohibitory fertilizer costs have forced us to look for nutrient efficient genotypes of crops that will grow and produce economic yields with minimal fertilizer inputs. Mn efficiency of oats S171 (VOSE & GREFFITHS 1961), Thatcher Wheat (NYBORG 1970) and Indian wheat varieties, HD 2009, C 306 and triticale TL 419 (KAUR & TAKKAR 1987) have been reported. The following study reveals beginning of a detailed screening programme for available wheat germplasm in the country for Mn efficiency factors.

Soil culture technique was used for screening of wheat germplasm tolerant to Mn stress condition. Mn deficient soil (0 - 15 cm top layer) was collected and was air-dried, ground and thoroughly homogenized. Half kg soil was mixed with urea,  $\text{KH}_2\text{PO}_4$  and  $\text{ZnSO}_4$  to supply 120 mg N, 60 mg  $\text{P}_2\text{O}_5$  and 5 mg Zn/kg soil and placed in plastic containers. The physico-chemical characteristics of the soil were: loamy sand, pH 9.1, organic matter 0.37%, EH 0.2, Olson's P 7.5 kg/ha, available K 368 kg/ha, DTPA-extractable Mn 1.6 mg/kg, Zn 3.0 mg/kg, Fe 8 mg/kg and Cu 0.7 mg/kg soil.

One hundred wheat genotypes, 50 each of *Triticum aestivum* and *T. durum*, differing in morphological, genetic and yield characters were sown, five seedling in each remained at 12 days, with 3 pot replicates in a randomized block design. The appearance of deficiency symptoms was recorded on alternate days. Dry weight of seedlings was recorded after 70 days stage.

### Results and Discussion

On the basis of number of leaves affected and degree of deficiency symptoms, the genotypes were grouped into different ratings of efficiency, viz. Mn-efficient, slightly less efficient, medium efficient, inefficient and highly inefficient (Table 1). Seventeen *aestivum* and 25 *durum* genotypes developed very severe Mn deficiency symptoms: 19 *aestivum* and 15 *durum* exhibited severe symptoms (rated highly inefficient- and inefficient respectively). Seven *aestivum* and one *durum* produced moderate and a similar number mild deficiency symptoms (rated moderately less efficient and slightly less efficient respectively). One *aestivum* (Nadodores 63) and two *durum* genotypes viz. ED 2398 and E 2153 did not show any visible deficiency symptoms even up to 70 days of growth and were rated Mn-efficient. Among the *aestivum*, Chinese spring Lr 9 CS and

Table 1. Rating of genotypes for susceptibility to Mn deficiency

	Mn inefficient	Moderately less efficient	Slightly less efficient	Mn-efficient
<i>T. aestivum</i>	CPAN 1285, 1983, 1418; WL 711, WG 138, WG 147, NI 5439, NN 60, NP 846, HD 1982, TZ PP, E 6360, Frontana (I), Frontana (C), Carazinho, Axminster (I), Axminster (C), Tobar 66, Tanori 71, Theu, Kalyan Sona	Chirja, WL 1562, E 6840, Preludes, Thatcher lines	CPAN 1235, Spica, Thatcher, Chinese Spring Lr 9 CS, CS with alien genes (Lines 2518, 2519, 2956)	Nadodores-63
<i>T. durum</i>	NI 146, NP 400, 404; ND 63-36 ND 64-202, ND 64-210, D60-114, D 62-51, DT 183, 182, ND 59-121, ND 62-21, ND 363 (675-427), ND 64-33, ND 64-167, D 14497-B-5M-9Y, D 63-2, ED 3009, ED 1598B, DT 183, TD 19 Wakooma, Wakooma, RAJ 911 Malvika, HD 4502, MACS 825, BARC 78-2-10, Gaza, Andes 56, Hercules, Line AW 3673, Sr 12 Bot Sr 12 T 77, Spelmar, Ward, Wells, TD 15 H 44 x Marquis, TD2-Renfrew, Flamingo's, CPAN 1778, II-11491-A-9Y-5M-3R-1N, 18888-1M-3Y-5M-2Y, II-19005-6M-5Y-3M-1Y-1C	E 3109	RL 3661	ED 2398 A E 2153

Table 2. Genotype showing early appearance of symptom

Days			
0 - 20		20 - 30	
Severe	Moderate	Severe	Moderate
CPAN 1283, 1418, NN 60, Frontana (I), Frontana (C), Axminister (I), Carazinho, MAC 825, NI 146, ND 59-121, DT 183, 182, NP 404, 400, HD 1982, ED 3009, 1598 B TD 15H44 x Marquis, TZ PP, BARC 78-2-10	Girja, Thatcher, Sonalika	Axminister(C), Andes 56, CPAN 1285, Tobari 66, Thatcher, Manitou, D 63-2, D 62-51, ND 64-210, ND 64-210, ND 64-167, ND 62-21, ND 363 (675-427), NI 5439, E 6360, I 8888-1N-3Y-5M-2Y, II 19005-6M-5Y-3M-1Y-1C	E 6840, Prelude
Days			
30-40		40-50	
Severe	Moderate	Severe	Moderage
WL 711 WH 147 D 14497-B-5N-9Y	WL 1562	UP 262, Malvi local, ND 63-33, Wells, TD 19 Wakooma, Spelmar, ND 63-36, ND 64-202, Wakooma	None
Days			
50-60			
Severe	Mild		
None	CPAN 1235, Speca, Thatcher, Chinese Spring with alien genes (three lines), RL 3661		

those with allian genes (lines 2518, 2519, 2956), Spica and a Thatcher (Acc. 1408) showed only slight susceptibility. Similarly the *durum* RL 3661 showed mild symptoms of Mn deficiency. On the other hand 25 *aestivum* (including popularly cultivated WL 711) and 41 *durum* were highly Mn-inefficient (Table 1). The rest had moderate deficiency symptoms.

The degree of Mn-inefficiency (susceptibility) did not relate to the time of appearance of symptoms. In some genotypes, very severe symptoms appeared as late as 40 – 50 days while in others as early as 20 days from the date of planting (Table 2). The deficiency symptoms in most of the genotypes started on the 3rd leaf from below except in highly inefficient ones. The delay in appearance of symptoms may be related to Mn content of grain resulting from variation in sources and capacity to accumulate Mn in the grain.

The genotypic efficiency was, however, not related to plant height and number of leaves per plant but was negatively related to number of tillers. The significance of the findings lies in the suggestion that the parents which are susceptible to Mn deficiency should be excluded from the breeding programmes although they may have other desirable characters viz. disease resistance etc. Studies are in progress to determine the mode of inheritance of Mn-deficiency tolerance with respect to number of genes and dominance.

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## Induced genetic variability in some dwarf wheat mutants

C.S. KALIA, M.P. SINGH and C. RAJLAKSHMY

Division of Genetics, Indian Agricultural Research Institute,  
New Delhi-110012, India

Wheat is one of the most important cereal crops in which dwarfing genes have considerably contributed for higher yields in the last two decades. Therefore, in this context induction of dwarf mutants in high yielding tall varieties have great practical importance. The stiff straw mutants have been recorded in many wheat varieties after physical and chemical mutagenesis (SINGH *et al.* 1985). Short coleoptile in dwarf and semidwarf varieties are primarily responsible for the poor seedling emergence under dryland farming condition. In the course of present investigations, efforts were made to evaluate the dwarf mutants with better yield potentials and to ascertain the relative range of coleoptile length for further selection.

### Material and Methods

The hexaploid wheat variety NP 880 (6x) was subjected to varied chemical mutagens, consisting of three distinct groups of Aziridines, Nitroso compounds and Esters. The chemical mutagens used were Metapa (0.4% and 0.2%), Thiotepa (0.2% and 0.01%), MNG (0.1% & 0.05%), MMS (0.1% & 0.05%) and EMS (0.1% & 0.05%) in direct and sequential treatments. M1 was raised and bagged to ensure 100% self pollination. Each single plant was harvested and progenies were raised to select the M2 variant plants. Dwarfs were selected from tall NP 880 and their performance was studied in M3 and M4 generations. The yield contributing traits, spike length, spikelet number and seeds per spike were separately recorded for primary and secondary spikes.

### Results and Discussion

The macromutants which were identified and separately harvested in M2 were sown as single plant progeny in M3 for checking their breeding behaviour and subsequently true breeding families were evaluated with check in M4. Most of the dwarfs were associated with pleiotropic effects pertaining to variable maturity, alteration in spike length and considerable changes in coleoptile length. The data which has emerged from different dwarf mutants of varied height have been summarised in Table 1. It was interesting to note that most of the dwarf mutants were recorded in EMS treatment (T14-EMS 0.1%). In the dwarf mutant lines, plant height ranged from 74 to 107, whereas in the control the height was 135 cms. In the mutant selection T14/P3-1, the two yield contributing traits-tiller number and spike length were enhanced. The positive change was reflected in the reduction in coleoptile and internode lengths. Relative performance of different dwarf mutants indicate considerable variability in height, tiller number, spike length,



Table 1. Performance of different dwarfs in M<sub>4</sub>

Treatment	Plant No.	Height	Tillers	Spike length		Spikelet No.		Seed/spike		Coleoptile length	Internode length						
				Primary	Secondary	Primary	Secondary	Primary	Secondary		I	II	III	IV	V	VI	VII
T <sub>1</sub> Cont.	1	135.40 ±2.00	10.80 ±1.8	11.25 ±0.31	11.25 ±0.27	17.20 ±0.44	10.0 ±0.44	45.7 ±3.34	43.3 ±3.34	7.52	40.32 ±3.40	36.23 ±5.66	16.82 ±2.23	13.23 ±1.33	8.26 ±2.38	5.72 ±2.00	3.8 ±2.8
T <sub>5</sub> Triosepa 0.01%	P <sub>15-1</sub>	92.2 ±5.43	8.50 ±2.23	9.85 ±1.13	9.40 ±0.88	16.1 ±1.91	16.0 ±1.41	38.30 ±6.82	35.2 ±7.39	4.27	41.56 ±3.38	17.78 ±1.40	13.21 ±1.55	12.15 ±1.76	9.49 ±2.45	2.19 ±2.53	
T <sub>14</sub>	P <sub>3-1</sub>	103.97 ±9.90	13.20 ±3.37	11.59 ±2.07	10.88 ±1.61	18.80 ±3.00	17.90 ±2.42	44.20 ±6.88	41.9 ±9.36	2.45	40.21 ±3.54	15.04 ±2.00	12.05 ±1.50	10.43 ±1.39	8.49 ±1.43	4.29 ±2.69	0.54 ±1.66
EMS 0.1%	P <sub>3-7</sub>	100.60 ±9.09	6.15 ±2.43	11.42 ±1.30	10.70 ±1.45	20.0 ±2.60	19.30 ±2.18	40.15 ±7.92	46.95 ±10.53	5.95	36.59 ±2.46	16.57 ±1.87	13.97 ±2.23	11.57 ±1.22	10.09 ±1.23	6.29 ±1.39	0.88 ±1.26
	P <sub>3-9</sub>	107.71 ±5.87	10.80 ±3.10	10.83 ±1.88	10.76 ±1.34	17.90 ±3.13	16.95 ±2.61	35.5 ±6.82	30.55 ±5.57	3.65	31.68 ±4.97	11.18 ±1.90	8.81 ±1.02	7.46 ±0.84	6.34 ±0.82	3.96 ±1.56	
	P <sub>1-11</sub>	81.50 ±5.94	9.25 ±3.55	12.36 ±2.15	12.13 ±3.75	21.13 ±3.12	18.94 ±3.19	44.25 ±10.59	36.81 ±11.21	1.32	43.89 ±13.70	17.89 ±3.45	12.20 ±1.70	9.51 ±1.43	7.37 ±2.07	3.18 ±2.92	0.50 ±1.03
	P <sub>1-12</sub>	100.61 ±8.49	7.95 ±3.10	11.20 ±1.63	10.58 ±2.47	23.83 ±6.75	23.90 ±5.61	36.45 ±11.18	29.45 ±9.43	2.04	39.98 ±14.89	17.06 ±7.66	12.21 ±4.98	9.45 ±3.93	6.85 ±3.00	2.82 ±4.64	
	P <sub>1-14</sub>	95.13 ±3.65	6.76 ±3.58	8.85 ±3.51	8.23 ±3.27	16.21 ±6.15	15.00 ±5.77	40.76 ±16.64	33.18 ±15.16	6.78	37.72 ±4.04	17.51 ±3.70	11.70 ±2.52	9.41 ±1.91	5.60 ±2.05	1.34 ±1.40	
	P <sub>3-16</sub>	92.69 ±11.71	7.95 ±2.76	9.18 ±1.37	8.80 ±1.30	15.40 ±2.62	13.80 ±5.48	36.00 ±6.52	28.60 ±5.00	5.21	32.56 ±2.40	14.13 ±1.90	9.05 ±1.08	6.58 ±1.49	4.75 ±2.38	0.32 ±0.95	
	P <sub>3-17</sub>	74.74 ±4.91	7.35 ±5.86	8.76 ±0.80	8.96 ±1.05	15.76 ±1.20	16.06 ±2.36	37.76 ±5.37	39.59 ±5.43	2.21	34.22 ±4.55	17.33 ±1.66	10.82 ±1.03	8.55 ±0.64	4.70 ±1.04	0.25	
15 EMS 0.05%	P <sub>1-1</sub>	85.60 ±7.40	4.80 ±1.03	10.96 ±0.70	9.85 ±0.99	17.40 ±0.88	16.20 ±1.32	25.60 ±14.61	27.90 ±18.93	1.94	38.15 ±4.39	15.95 ±1.92	12.30 ±1.65	9.94 ±3.14	6.22 ±3.17	0.69 ±1.26	
	P <sub>1-2</sub>	90.40 ±8.80	6.60 ±2.68	7.49 ±0.89	7.27 ±0.96	11.05 ±1.63	10.55 ±2.70	21.65 ±5.66	22.10 ±6.17	1.75	34.02 ±4.23	16.43 ±1.94	11.36 ±1.40	9.19 ±1.71	5.64 ±1.15	1.15	
	P <sub>1-4</sub>	87.60 ±7.70	8.75 ±3.71	8.87 ±1.14	8.55 ±1.35	14.10 ±1.55	13.50 ±1.50	33.30 ±7.63	30.70 ±5.46	2.72	40.98 ±3.44	17.98 ±1.48	13.34 ±1.63	9.05 ±3.78	4.44 ±2.15	0.31 ±0.73	
	P <sub>1-15</sub>	94.95 ±7.33	12.37 ±3.53	7.63 ±1.14	7.33 ±1.24	12.79 ±1.90	12.26 ±2.28	31.89 ±7.47	36.71 ±9.02	3.92							

\* Mean of three replications

seeds per spike and single plant yield (Table 1).

Plant height is a quantitative character affected considerably by aneuploid conditions which have made it cumbersome to determine the number of dwarfing genes or the type of gene action. There are three major recessive semidwarfing genes *Rht 1* and *Rht 2* (ALLAN *et al.* 1968, FICK & QUALSET 1973). These genes were identified to be located on chromosome 4A and 4D (GALE *et al.* 1975). On the other hand a variety 'Tom Thumb' has a semidwarf gene *Rht 3* located on 4A (MORRIS *et al.* 1975). A dominant gene of dwarfism designated as '*Al-bian 1*' is reported to be located on chromosome 4D (IZUMI *et al.* 1981). In the course of present investigation, a number of dwarf plants with height range of 74 to 107 cms. were obtained in NP 880. Cytological observations of these dwarf mutant lines in M4 did not indicate any visible chromosomal abnormality. It is possible that the major dwarfing gene (GALE *et al.* 1975) located on chromosome 4A and 4D were altered due to chemical treatments, along with some of the other minor genes or modifiers, thereby giving expression to variable type of dwarfing mutants. It is interesting that wherever, the height was reduced upto 100 cms, the 7th internode (basal) was conspicuous by its absence. In this category, evident reduction in all the internodes was recorded, but the first internode showed expression to its full extent. When the height was further reduced, the reduction was noticeable in all the internodes. It is possible that separate genes or minor genes governing the length of each internode are affected. This assumption finds further support from our experimental data obtained in tetraploid wheat HD 4502 with the same set of treatments, where tall mutants showed increase in length, primarily confined to first internode (unpublished).

NP 880, the tall wheat variety has bold grains with lusture, so the main objective in the mutagenic studies was to induce dwarfing which may be lodging resistant with same lusture and chapati making, quality. Although the lodging resistance and culm length reduction are not always associated but the selected mutant lines have shown that reduction in height which was primarily linked with change in first and second internode length showed lodging resistance in different yield trials under field conditions.

Short coleoptile in dwarf and semidwarf varieties are primarily associated with poor seedling emergence under dryland farming, hence high yielding dwarf wheat varieties have not been properly exploited in the rainfed areas (SHARMA *et al.* 1982). Present studies pertaining to different dwarf mutants have indicated not only the wide range of variability for culm length, but also considerable range of variability in coleoptile length (1.5 - 6.8 cms), thereby demonstrating the scope for further selection to combine short culm with somewhat long coleoptile.

FICK & QUALSET (1976) reported that culm length was closely correlated with coleoptile length and seedling emergence. They suggested that the genetic mechanism that governed culm length also influenced coleoptile length, but the relative effects of the genes showing dominant or epistatic effect appear to be different. KONZAK *et al.* (1969) observed that short culm length was associated with long coleoptile in a mutant of wheat variety, thus ruling out the possibility of pleiotropy between these two traits. SCARASCIA MUGNOZZA & PORCEDU (1973) also

have indicated the possibility of developing variety with short culm and long coleoptile. AGRAWAL *et al.* (1977) screened hundred wheat varieties and found some triple dwarf varieties with longer coleoptile and good seedling vigour. Dwarf wheat lines having long coleoptile and peduncle were identified in the segregating progenies (SHARMA *et al.* 1982). If more mutation studies could be undertaken in this direction, there is definite possibility that we might alter the genetic mechanism, that jointly influences the culm and coleoptile length.

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## Mutants for leaf character in hexaploid triticales

V.R.K. REDDY and P.K. GUPTA

Department of Agricultural Botany, Institute of Advanced Studies,  
Meerut University,  
Meerut, India

Triticale ( $\times$  *Triticosecale* Wittmack), a well known amphiploid, is the product hybridization between species of genera *Triticum* and *Secale*. Triticales, relatively have a unstable genomic condition, therefore, through induced mutagenesis, the genetic architecture of triticales can be tailored to develop new and better types. It is also true that high ploidy of triticales provide an opportunity to get large spectrum and high frequency of both micro and macro-mutations. To date very few reports are available on induced mutations in triticales breeding. In our study (REDDY 1985) a large number of morphological mutants were obtained, in this communication mutants based on leaf characters were described.

### Materials and Methods

Four hexaploid triticales varieties, Beagle, Coorong, TL 419, and Welsh were used in the present study. One physical mutagen, gamma rays (100 Gy, 200 Gy, 300 Gy) and are chemical mutagen, Ethyl methane sulphonate (0.5% - 8 hr, 12 hr, 16 hr) were employed for induced mutations 100 seeds were taken for each treatment. All individual  $M_1$  spikes were used to raise spike to row progenies in  $M_2$  generation visual morphological observations were used to isolate different mutants based on leaf characters. Segregation and breeding behaviour was studies in  $M_3$  using plant progenies obtained from  $M_2$  generation.

### Results and Discussion

The characteristics of the mutants isolated in the present studies are as follows:

- (i) **Needle leaves** – mutant plants are characterised by the leaves modified into needle like structures, either partially or fully; mutant plants are identifiable 45 days after germination (Fig. 1).
- (ii) **Narrow leaves** – the width of the leaves is reduced (1 - 1.5 cm) relatively to control (3.5 - 5.5 cm); leaves are erect (Fig. 2).
- (iii) **Leaf tip plant** – the leaves of the mutant plants are characterised by round apex, as against acute apex in control. These plants are 10 - 20 cm shorter than control/heterozygotes (Fig. 3).
- (iv) **Waxless leaves** – the mutant plant leaves are olive green colour (light green), smooth surface (due to absence of waxy coating) and slightly coiled; plants are dwarf (Fig. 4).

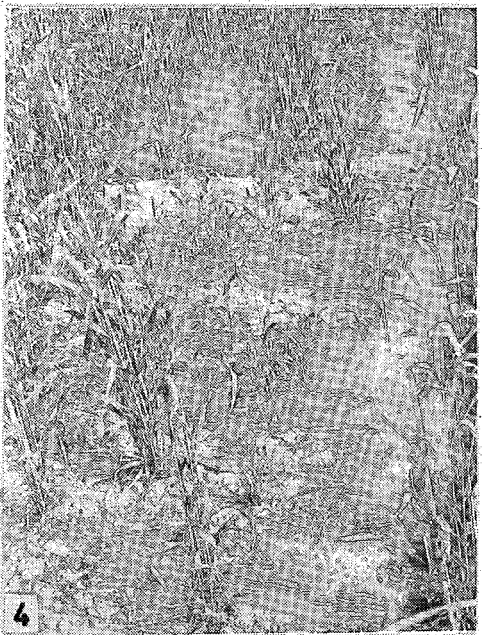
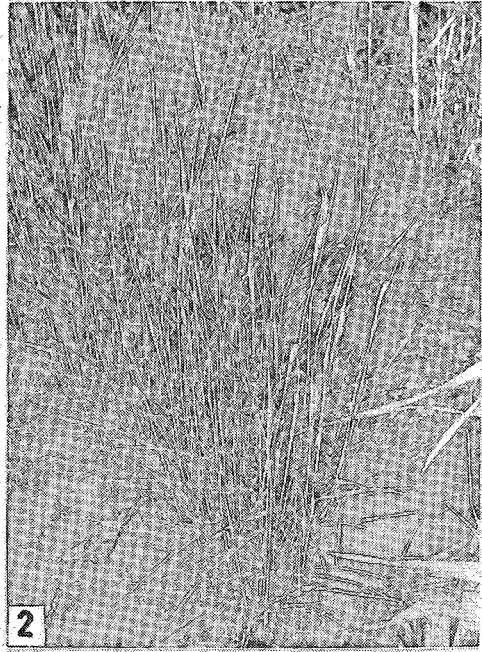
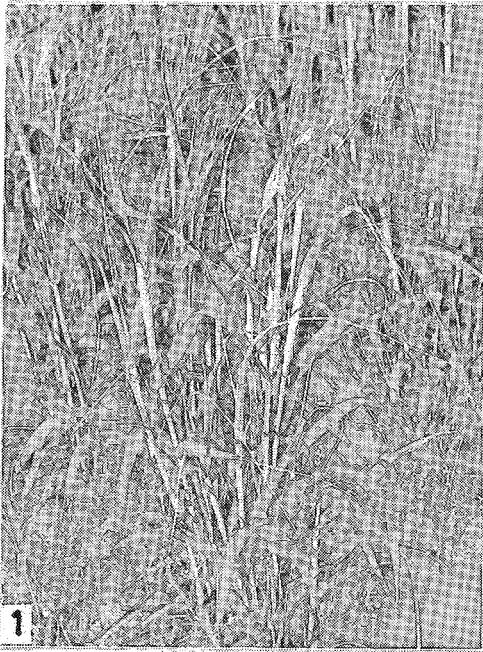


Fig. 1 Needle leaves mutant in triticale Welsh  
Fig. 2 Narrow leaves mutant in triticale Coorong  
Fig. 3 Leaf tip blunt mutant in triticale Beagle  
Fig. 4 Waxless leaves mutant in triticale TL 419

- (v) **Twisting of flag leaf** – the flag leaves of mutant plants at maturity were spirally coiled, the leaf sheath being malformed.
- (vi) **White striped leaves** – the mutant plant leaves characterised by the presence of irregular white patches (due to lack of chlorophyll pigment) and plants can be identified at any time from seedling stage to maturity of the plant.

Segregation pattern and breeding behaviour of the mutants were studied in  $M_2$ ,  $M_3$  and later generations. Out of six morphological mutants isolated for leaf character in each of the four hexaploid triticale varieties (Bagle, Coorong, TL 419, Welsh), except twisting of flag leaf the remaining mutants were found to be monogenically controlled with recessive inheritance. The Chi-square test for these five mutants gave a good fit to 3:1 ratio within  $M_2$  and  $M_3$  segregating rows (Probability ranging from 0.7 to 0.9) and a good fit to 1:2:1 ratio among  $M_3$  rows. While the mutant twisting of flag leaf segregated into mutant and normal without any definite pattern suggest that perhaps chromosomal disorders are involved.

High frequency of mutants for leaf character relative to other morphological mutants (GRZESIK 1980, REDDY 1985) indicates that the genes responsible for these characters are more sensitive and readily available for mutagenic action of both gamma rays and EMS. High frequency of these mutants (REDDY 1985) in EMS treatments over gamma rays also supports that EMS causes more point mutations (GAUL 1964).

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## Genetic analysis of some yield parameters in *Triticum aestivum* L.

M.B. KUMBHAR and A.S. LARIK

Department of Plant Breeding and Genetics, Sind Agriculture University,  
Tandojam, Pakistan

Sufficient understanding of the mode of inheritance of quantitative traits is essential to develop an efficient breeding strategy for a crop. Though, individual gene effects are difficult to precisely measure quantitative traits, statistical tools are available to obtain information on such genes as a whole, in terms of heritability of the trait. Thus, knowledge of heritability of a character helps the plant breeder in predicting the behaviour of the succeeding generations and making desirable selection. The higher the heritabilities the simpler the selection process and the greater the response to selection. Estimation of correlation helps in the identification of the components of a complex character such as yield. LARIK *et al.* (1987), UDDIN & JOARDER (1986) and SHAHID MASOOD & CHAUDHRY (1987) have reported useful information on heritability and genetic advance of yield and other agronomic traits of bread wheat. They utilized these parameters for selecting high yielding genotypes of wheat.

The present investigation was undertaken to estimate the magnitude of heritability, genetic advance and correlation in wheat populations derived from intercultivar hybridization.

### Material and Methods

Seeds of four parents (Pak-70, HD-2009, Z.A.-77 and Macozari) along with F<sub>1</sub> seeds of their crosses were grown during winter 1986 - 87 in non-replicated plots at the Agriculture Research Institute, Tandojam, Pakistan. The plots had 5m long 3 rows at a distance of 30 cm with a total of 153 plants per population. Standard cultural practices were followed throughout the growing season. Four yield components were recorded on 50 randomly selected plants in each entry.

Estimation of broad sense heritability and expected genetic advance with a selection intensity of 5% and correlations were computed similar to SOOMRO and LARIK (1981) as under:

$$h^2 = \frac{VF_2 - \sqrt{VP_1 \times VP_2}}{VF_2} \times 100$$

where h = heritability, V = variance, F<sub>2</sub> = second filial generation, P = parent. Genetic advance was calculated as under:

$$GA = (K) (\hat{\sigma}_p) (H)$$

where K = 2.06 selection differential at 5%,  $\hat{\sigma}_p$  = phenotypic standard deviation and H = heritability coefficient.

Table 1. Mean measurements and the estimates of genetic parameters for four yield components in winter wheat parents and their F<sub>2</sub>'s

Parent/cross	Spikes/plant			Spikelets/spike			Grains/spike			Grain yield/plant		
	Mean	h% (b.s)	G.A	Mean	h% (b.s)	G.A	Mean	h% (b.s)	G.A	Mean	h% (b.s)	G.A
HD-2009	7.56	-	-	17.41	-	-	48.36	-	-	8.82	-	-
Pak-70	7.54	-	-	16.28	-	-	44.42	-	-	7.42	-	-
Z.A.-77	6.44	-	-	17.05	-	-	46.22	-	-	7.94	-	-
Macozari	6.85	-	-	16.45	-	-	47.85	-	-	9.08	-	-
HD-2009 x Pak-70	7.81	55.10	4.02	17.25	78.16	8.07	45.11	88.39	14.38	11.00	90.68	12.09
Z.A.-77 x Macozari	9.69	84.99	9.38	18.68	52.07	2.37	50.22	91.02	17.19	18.29	95.85	13.77
Critical difference at 1% level	0.311			0.675			1.101			0.431		



Table 2. Estimates of correlation coefficients (r) between grain yield and other yield components in wheat

Parent/ cross	Spikes/ plant	Spikelets/ spike	Grains/ spike
HD-2009	0.722**	0.767**	0.713**
Pak-70	0.764**	0.481**	0.919**
Z.A.-77	0.984**	0.490**	0.420**
Macozari	0.539**	0.487**	0.505**
HD-2009 × Pak-70	0.826**	0.532**	0.456**
Z.A.-77 × Macozari	0.895**	0.582**	0.486**

\*\* Significant at 1% level of probability.

### Results and Discussion

Mean measurements of the parents and their  $F_2$  crosses for four quantitative traits are given in Table 1. The estimates of broad sense heritability and genetic advance was considerably high for all the characters and the crosses. Transgressive segregations with high heritability (90.68 to 95.85%) coupled with considerable genetic advance (12.09 to 13.77%) for yield per plant for cross HD-2009 × Pak-70 and Z.A.-77 × Macozari indicate additive gene action (SOOMRO & LARIK 1981) and reveal bright chances for selection of high potential segregates in early generation (UDDIN & JOARDER 1986).

$F_2$  crosses displayed transgressive segregation for spikes per plant, spikelets per spike and grains per spike. High heritability (78.16 to 88.39%) coupled with considerable genetic advance of 8.07 to 14.38% in cross HD-2009 × Pak-70 indicate that additive gene effects are important for spikelets per spike and grains per spike respectively. Therefore, these characters could be manipulated effectively through selection in this cross combination and one could expect potential gain in early generation of selection (LARIK *et al.* 1987).

Spikes per plant also displayed a quantitative pattern of inheritance. Transgressive segregates for greater number of spikes per plant accompanied by moderate to high heritability (ranging from 55.10 to 84.99%) in both crosses reveal good chances of selection for high potential segregates (Table 1).

The estimates of correlation coefficients are presented in Table 2. The traits spikes per plant, spikelets per spike and grains per spike exhibited highly significant (r values ranging from +0.420\*\* to +0.984\*\*) positive association with grain yield and among themselves which indicate that selection based on these traits could be more rewarding and will equally improve the grain yield. These results agree with KUMBHAR *et al.* (1983) and LARIK (1979) who reported significant correlation of yield components with grain yield in wheat.

On the basis of correlation analysis and other genetic parameters, the present investigation therefore, suggests that the grains per spike, spikes per plant and spikelets per spike are the important yield components. Therefore, maximum weightage should be given to these traits in a selection programme in accelerating the yield in wheat crop.

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## Heritability estimation by parent progeny regression vis-a-vis standard unit method in four wheat crosses

I.S. PAWAR, R.S. PARODA\* and S. SINGH

Department of Plant Breeding, Haryana Agricultural University,  
Hisar-125004, India

Since the effectiveness of selection depends on the additive portion of genetic variance in relation to total variance, heritability in narrow sense is of great importance to the plant breeder. The parent off-spring regression method proposed by LUSH (1940) is being used as one of the most common methods of determining heritability of metric traits in plant populations. In self-fertilizing crops, some of the routinely used parent-progeny combinations are:  $F_1/F_2$ ,  $F_2/F_3$  and  $F_3/F_4$ . However, as pointed out by SMITH & KINMAN (1965), this method has been frequently misused for estimating heritability in autogams since the previous inbreeding of the parents which can cause an upward bias in heritability estimate is not usually considered. The reliability of heritability estimate thus can be increased by adjusting regression estimate for previous inbreeding of the parents.

FREY & HORNER (1957) suggested a modification in the parent progeny regression procedure for calculating heritability in standard units. This modification was suggested to reduce the scaling effects of genotype  $\times$  environment interaction.

The present study was undertaken to compare heritability estimates obtained through the above mentioned two methods in segregating generations of four wheat crosses.

### Materials and Methods

Visual selections were carried out from large, space planted  $F_2$  and  $F_3$  populations of four wheat crosses, namely, WL 711  $\times$  HD 2122 (cross 1), HD 2122  $\times$  Sonalika (cross 2), WL 711  $\times$  HD 1981 (cross 3) and WG 377  $\times$  HD 1925 (cross 4) during rabi 1982 - 83 and 47 plants were selected from each of these two populations in each cross. The progenies ( $F_3$  and  $F_4$ ) of these plants were grown in a randomized block design with three replications in single row plots of 2.5 m length having row to row distance of 23 cm and plant to plant 10 cm at Haryana Agricultural University research farm during rabi 1983 - 84. Observations were recorded on five randomly selected competitive plants per row per replication from each of the four crosses for number of effective tillers per plant, number of grains per spike, 1000 grain weight (g) and grain yield per plant (g). Heritability (narrow sense) was calculated as per methods suggested by SMITH & KINMAN (1965) and by FREY & HORNER (1957).

\* Present address: Director, National Bureau of Plant Genetic Resources, Pusa Complex, New Delhi-110012.

The expected values of genetic advance were estimated at 5 percent level of selection intensity using standard procedure. Realized genetic gains were also calculated using  $F_2$  and  $F_3$  data only. Finally, the values showing differences between expected and realized genetic gains were calculated to determine the relative reliability of the two methods used to estimate heritability.

### Results and Discussion

The estimates of narrow sense heritability (percent) for four characters calculated through two methods in four wheat crosses are presented in Table 1. There were differences between

Table 1. Heritability (percent) for yield and its component traits computed by parent-progeny regression and standard unit method in four wheat crosses

Trait	Cross	Heritability (percent)			
		$b_1(F_2, F_3)$	$b_2(F_2, F_3)$	$b_1(F_3, F_4)$	$b_2(F_3, F_4)$
Tiller number/plant	C <sub>1</sub>	27.1	38.5	36.2	41.1
	C <sub>2</sub>	34.4	29.4	28.9	34.2
	C <sub>3</sub>	30.2	38.1	39.6	44.4
	C <sub>4</sub>	24.7	36.3	33.4	37.1
Grain numbers/spike	C <sub>1</sub>	37.3	52.1	43.4	46.4
	C <sub>2</sub>	31.2	45.3	38.6	41.2
	C <sub>3</sub>	35.1	48.3	41.2	39.5
	C <sub>4</sub>	40.1	56.4	46.7	47.3
1000 grain weight	C <sub>1</sub>	57.7	59.4	54.1	54.1
	C <sub>2</sub>	54.6	53.5	59.5	57.4
	C <sub>3</sub>	49.2	54.1	61.3	63.1
	C <sub>4</sub>	53.1	58.6	58.7	55.6
Grain yield/plant	C <sub>1</sub>	31.2	46.3	34.3	37.7
	C <sub>2</sub>	25.1	38.5	27.2	29.8
	C <sub>3</sub>	37.4	38.7	33.1	40.3
	C <sub>4</sub>	34.6	51.5	35.4	39.9

C<sub>1</sub> = WL 711 × HD 2122,

C<sub>2</sub> = HD 2122 × Sonalika,

C<sub>3</sub> = WL 711 × HD 1981,

C<sub>4</sub> = WG 377 × HD 1925,

b<sub>1</sub> = Parent-progeny regression,

b<sub>2</sub> = Standard unit method.

the heritability values of three out of total four characters studied (except for 1000 grain weight) in all the four crosses when  $F_2/F_3$  combination was used in the two methods of estimating heritability. In almost all cases showing differences in the heritability values, the standard unit method overestimated heritability as compared to the normal parent progeny regression method. But for 1000 grain weight the two methods gave almost similar estimates of heritability. However, the differences in the heritability values obtained through these two methods in  $F_3/F_4$  combination were smaller as compared to those in  $F_2/F_3$  combination. This might be due to the fact that in  $F_3/F_4$  combination, the phenotypic variance of parents may be almost equal to the phenotypic variance of their progeny.

Table 2. Values showing differences between expected and realized genetic gain (% of mean) using  $F_2$  and  $F_3$  data for yield and its component traits in four wheat crosses

Trait	Cross	Regression method	Standard unit method
Tiller number/plant	C <sub>1</sub>	2.4	4.3
	C <sub>2</sub>	1.7	2.5
	C <sub>3</sub>	1.5	3.0
	C <sub>4</sub>	2.3	3.6
Grain number/spike	C <sub>1</sub>	2.1	3.4
	C <sub>2</sub>	0.6	1.2
	C <sub>3</sub>	1.4	2.8
	C <sub>4</sub>	1.7	2.3
1000-grain weight	C <sub>1</sub>	1.1	2.1
	C <sub>2</sub>	0.9	1.3
	C <sub>3</sub>	0.5	0.8
	C <sub>4</sub>	1.3	2.4
Grain yield/plant	C <sub>1</sub>	3.6	5.4
	C <sub>2</sub>	0.9	2.1
	C <sub>3</sub>	1.8	3.3
	C <sub>4</sub>	5.2	6.7

C<sub>1</sub> = Cross 1 (WL 711 × HD 2122),

C<sub>2</sub> = Cross 2 (HD 2122 × Sonalika),

C<sub>3</sub> = Cross 3 (WL 711 × HD 1981),

C<sub>4</sub> = Cross 4 (WG 377 × HD 1925).

For calculating genetic advance, the heritability values obtained from  $F_2/F_3$  combination were only used. The values showing differences between expected and actual genetic gains for four characters in four wheat crosses are given in Table 2. These values under standard unit method were higher than those obtained through normal parent-progeny regression method, indicating again that the standard unit method overestimated heritability values for grain yield and its component traits in wheat and subsequently overestimated the expected genetic advance from selection.

Hence, one should be careful while calculating heritability or expected genetic advance in early segregating generations and should use only standard procedure for calculating these genetic parameters.

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## Combining ability of latent period and pustule size in wheat

J. SINGH, O.P. LUTHRA and V. CHAWLA

Department of Genetics, Haryana Agricultural University,  
Hisar-125004, India

Slow rusting is a form of resistance which restricts the rate of pathogen development without showing typical hypersensitive response. Slow rusting cultivars can be identified by various ways under controlled conditions. Different slow rusting parameters like latent period, pustule size are taken into account for identifying slow rusting genotypes. (KUHN *et al.* 1978). Information on the combining ability of these parameters is scanty. Therefore, the present investigation was undertaken to estimate combining ability variances and effects of latent period and pustule size in wheat.

### Materials and Method

Eleven genetic stocks viz; WH283, WH291, WH337, WH157, WH331, P1438, P1501, P10015, P1486, P1523 and Agra local were selected for present investigation. Agra local is known to be susceptible cultivar of leaf rust. All possible crosses among the eleven genetic stocks (excluding reciprocals) were attempted. Sixty-six entries (55 F<sub>2</sub> + 11 parents) were grown in plastic pots in the glasshouse. About 25 plants of each of the F<sub>2</sub>'s and parents were inoculated with a mixture of most virulent races of leaf rust at the seedling stage and after inoculation the seedlings were incubated for 48 hours at 20±1°C and 100 percent relative humidity. Observations were made on the 2nd leaf for latent period and pustule size. Latent period was recorded from the 8th day after inoculation. Pustule size was measured on the 18th day of inoculation with the help of a stage and ocular micrometer under low power objective (i.e. 10X) of compound microscope. The size of each pustule was estimated as the product ( $\pi$ ) half width × half length. The analysis of variance for combining ability and effects were calculated according to the method II, model I as proposed by GRIFFING (1956).

### Results and Discussion

The analysis of variance for combining ability revealed that variances due to general and specific combining abilities were significant for latent period and pustule size. Some good general combiners and specific cross combinations along with their *per se* performance for latent period and pustule size are presented in Table 1.

An overall appraisal of general combining ability (*gca*) effects in the present study showed that parent P1438 was the best general combiner for latent period as well as for pustule size. Therefore, this parent could be a good choice in breeding programmes for the improvement

Table 1. Parents and crosses showing good general combining ability for latent period and pustule size in wheat

Sr. no.	Character	General combiner	gca	per se performance	Crosses	scz	per se performance
1.	Latent period	P1438	0.965***	13.60	WH157 x P1486	2.054***	12.26
		WH331	0.893**	10.93	WH283 x P1438	1.823**	13.20
		WH337	0.880**	12.26	P1501 x P1523	1.662**	11.93
		P1501	0.593**	12.33	P1501 x P10015	1.435**	12.86
		P10015	0.318**	7.93	WH337 x P10015	1.427**	13.20
2.	Pustule size	P1438	-0.220**	0.07	P10015 x Agra local	-0.687**	0.493
		P1501	-0.171**	0.12	P10015 x P1523	-0.510**	0.475
		WH291	-0.132**	0.24	WH337 x WH157	-0.431**	0.429
		WH283	-0.119**	0.15	P10015 x P1486	-0.299**	0.589
		WH331	-0.056**	0.30	WH157 x P1438	-0.233**	0.072

\*\* Significant at 1 percent level.



of these characters. The parent WH331 showed a high *gca* effect and had relatively shorter pustule size and considerably longer latent period whereas the susceptible cultivar Agra local showed the poorest *gca* effects for both latent period and pustule size. For latent period, P1501 x P1523 was found to be a good cross combination. One of the parents in this cross was good general combiner for long latent period. This cross can give good segregants for resistance to leaf rust in subsequent generations. The cross combinations WH157 x P1486 and WH283 x P1438 showed significantly high specific combining ability (*sca*) effects for latent period. For pustule size P10015 x Agra local showed the highest *sca* effect followed by P10015 x P1523. These crosses could be expected to give desirable transgressive segregants.

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**Slow rusting mechanism for leaf rust operating in bread wheat varieties (*Triticum aestivum* L.)  
against *Puccinia recondita* f.sp. *tritici* Rob. Ex Desm.**

SHRISHAIL S. NAVI, SRIKANT KULKARNI and R.K. HEGDE

Department of Plant Pathology, University of Agricultural Sciences,  
Dharwad-580005, India

Leaf rust of wheat caused by *Puccinia recondita* f.sp. *tritici* Rob. ex Desm. is one of the dangerous diseases in reducing the yield and quality of the wheat grains. This disease is known to occur in all the wheat growing tracts of the world. In India, the two successive epidemics of leaf rust have been reported during 1971-72 and 1972-73 from North-Western regions causing a loss of 0.8 to 1.0 million tonnes and 1.5 million tonnes respectively (JOSHI *et al.* 1975). The experiments conducted revealed that, the rapid loss of race specific resistance (vertical resistance) to cereal rusts has attracted the attention of plant breeders and plant pathologists to other form of resistance which may be more durable (SINGH 1985). The term slow rusting among others, has been applied to such resistance which allow some disease to develop, may result in reduced selection pressure for preferential development of previously undetected virulent rust strains and accordingly may remain effective longer such forms of resistance may have the effect of slowing down development of an epidemic (ROMING 1957, HOOKER 1967). WILCOXSON (1986) shown that slow rusting vary with environment as well as races of pathogen. Among the different control measures use of slow rusting varieties is also playing an important role against leaf rust of wheat. Hence, an attempt was made to study the slow rusting mechanism in *T. aestivum* (Bread wheat).

**Material and Methods**

An experiment on slow rusting mechanism was carried out at Agricultural College Farm, Dharwad, varieties included under the study were DWR-16, DWR-39, HD-2189, NI 5439, HD 2278, Kalyan Sona, Sonalika, Lal Bahadur and CC-464. These varieties were sown separately in each plot (2m × 2m) during rabi season of 1985 - 86 in a randomised block design with three replications. After one and half months of sowing, uredospore suspension was sprayed once in a week. Uresospore inoculum of leaf rust was collected from Regional Wheat Rust Research Station, Mahabaleshwar, IARI Regional Station, Flowerdale, Shimla and IARI Regional Station, Wellington (Tamil Nadu). Disease severity was recorded in each variety for every week (by following the scale given in Fig. 1) and average coefficient of infection was calculated by multiplying the percent infection (severity) by the response value, assigned to each infection type (LOEGERING 1959). So that both the intensity of infection and type of reaction may be combined to study the disease progress in each variety. Further 1000 grain weight and yield data were recorded.

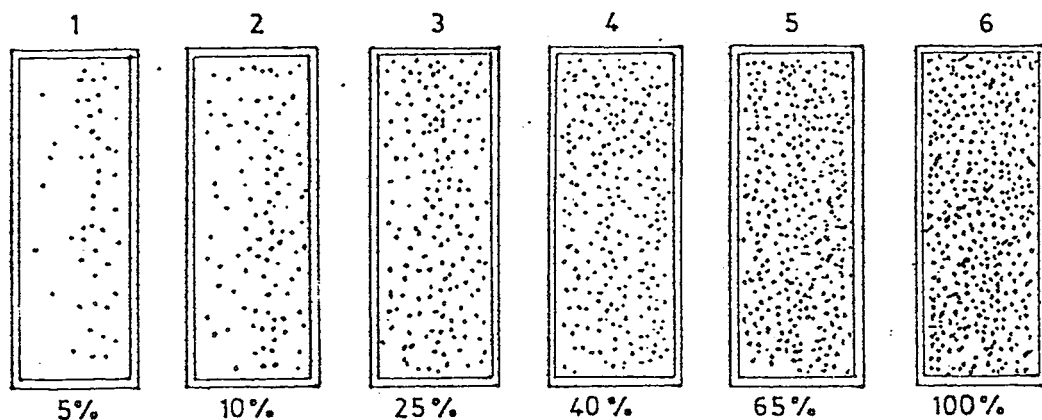


Fig. 1 Modified Cobb's scale for estimating leaf rust

Table 1. Weekly recording of the severity and average coefficients of infection of leaf rust of wheat (*P. recondita* f.sp. *tritici*) on nine varieties of *T. aestivum* under artificial epiphytotic conditions

Varieties	Leaf rust severity with average coefficient of infection							
	14.2.1986		21.2.1986		28.2.1986		7.3.1986	
	a*	b*	a*	b*	a*	b*	a*	b*
DWR-16	10 MS	(2.77)	20 MS	(4.00)	20 S	(8.2)	30 S	(11.88)
DWR-39	0	(0)	0	(0)	Trace	—	5 MR	(1.11)
HD 2189	10 MS	(0.77)	20 MS	(3.88)	30 MS	(4.66)	30 MS	(7.00)
NI 5439	20 MS	(5.00)	40 MS	(15.55)	80 S	(60.88)	100 S	(75.11)
HD 2278	0	(0)	0	(0)	0	(0)	0	(0)
Kalyan Sona	10 S	(4.55)	20 S	(7.66)	60 S	(44.44)	80 S	(46.00)
Sonalika	10 S	(3.77)	40 S	(21.11)	60 S	(23.11)	70 S	(2.55)
Lal Bahadur	20 S	(5.20)	40 S	(21.33)	80 S	(54.22)	100 S	(65.77)
CC-464	0	(0)	0	(0)	5 R	(0.44)	5 MR	(0.88)

a\* — figures indicate terminal severity with type of reaction.

b\* — figures in parenthesis indicate the average coefficient of infection.

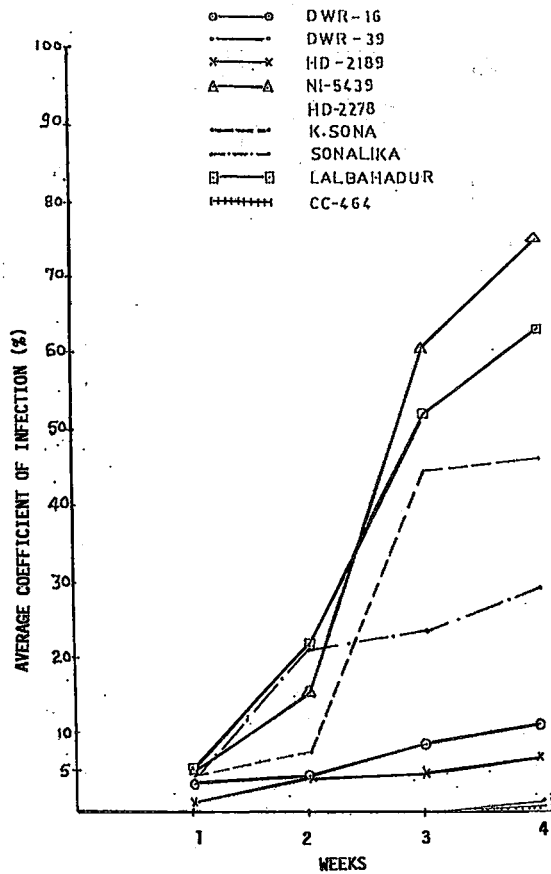


Fig. 2 Weekly severity of leaf rust from 14th February on 9 varieties of *T. aestivum* under artificial epiphytotic conditions

### Results and Discussion

Slow rusting will help in preventing the production of new virulences and thus remain effective longer period of time. With this objective nine varieties of *T. aestivum* were tested for the slow rusting mechanism against leaf rust of wheat under artificial epiphytotic conditions. Severity with type of reaction and average coefficient of infection of leaf rust varied among the varieties studied (Table 1). Varieties CC-464, DWR-39, HD 2189, and DWR-16 have shown slow rate of rust development with the terminal severity 5 MR, 5 MR, 30 MS and 30S respectively (Figure 2). Varieties NI 5439, Lal Bahadur, Kalyan Sona and Sonalika have shown fast rate of rust development with the terminal severity 100S, 100S, 80S and 70S respectively (Figure 1). Thousand grain weight and net plot yield is given in Table 2. Slow rate of rust development may be due to longer

latent period, decrease in size of pustules and production of less number of pustules on leaf surface. Similar type of observation was noticed by OHM & SHANER (1976) in wheat varieties against *P. recondita* f.sp. *tritici*. Yield levels (net plot yield and 1000 grain weight) differed greatly among the varieties used for the study.

The studies indicated that slow rusting promising varieties of wheat could be grown wherever the leaf rust occurs regularly. These varieties do offer the field resistance.

Table 2. Effect of incidence of leaf rust of wheat (*P. recondita* f.sp. *tritici*) on yields of *T. aestivum* (bread wheat)

Varieties	Terminal severity	Average coefficient of infection	1000-grain weight in gm.	Net plot weight in gm.
DWR-16	30 S	11.88	35.68	543.33
DWR-39	5 MR	1.11	31.81	624.04
HD 2189	30 MS	7.00	37.47	686.65
NI 5439	100 S	75.11	36.61	240.00
HD 2278	0	0	39.53	596.59
Kalyan Sona	80 S	46.00	32.12	233.33
Sonalika	70 S	29.77	45.56	303.33
Lal Bahadur	100 S	65.77	39.89	264.09
CC-464	5 MR	0.88	30.88	566.65

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## RD 10—A source of resistance to karnal bunt of wheat

M.K. UPADHYAY and B. SINGH

Division of Genetics,  
Indian Agricultural Research Institute,  
New Delhi, India

With the extensive cultivation of semidwarf wheats in India a hitherto minor disease karnal bunt caused by *Neovossia indica* (Mitra) Mundkar assumed serious proportions. Besides causing yield losses the pathogen imparts fishy odour to the wheat flour and makes it unfit for human consumption. As confirmed sources of genetic resistance to karnal bunt are not yet available (SINGH *et al.* 1986), 30 strains of macaroni wheat were screened against the disease under artificial conditions of infection at Ludhiana during 1986 season. Out of these, eight strains showed immune reaction (no infection) to the disease (UPADHYAY & SINGH 1987). These eight strains were again screened against the disease under artificial infection at Ludhiana and Gurdaspur in 1987. Information on their reaction to karnal bunt, rusts (under multilocational 'hot spot' testing), flowering and thousand grain weight is given below.

Information on disease reactions and other characters

Strain	Karnal bunt infection (%)			Rust reactions			Flowering (days)	1000-gr. weight (gm)
	Ludhiana (1986)	Ludhiana (1987)	Gurdaspur (1987)	Black	Brown	Yellow		
RD 4	0	10.7	0	5S	5R	5S	84	58
RD 10	0	0	0	5S	5S	TS	106	36
RD 11	0	2.3	0	10S	5MS	5S	97	48
RD 15	0	4.6	0	10S	5S	TS	96	60
RD 16	0	9.6	8.0	10S	10S	TS	97	58
RD 19	0	4.1	1.3	20S	10S	0	98	45
RD 24	0	21.8	3.1	20S	20MR	TS	95	45
RD 27	0	12.7	3.7	0	5MR	40S	89	52
WL 711 (Control)	31.9	58.7	33.8	50S	80S	80S	94	35

The data shows that WL 711, the susceptible check variety, showed heavy infection of karnal bunt ranging from 31.9 to 58.7 percent indicating thereby that conditions were favourable for the development of the disease. RD 10 was the only strain showing immune reaction to the disease

at both the locations.

RD 10 is a semidwarf macaroni wheat, medium late in maturity having amber and hard grains. The strain also possesses fair degree of resistance to rusts. Thus RD 10 appears to be an excellent source of genetic resistance to karnal bunt which can be profitably used for incorporation of resistance to the disease into Indian wheat cultivars.

The authors are grateful to Dr. L.B. GOEL, Principal Investigator (Wheat Pathology), I.A.R.I., New Delhi for getting the material screened against karnal bunt.

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## II. Editorial Remarks

### Announcement for Future Issues

WIS No. 70 will be planned for publication in February, 1990. Manuscripts for this issue are most welcome and accepted any time, not later than January 20, 1990.

WIS is open to all contributions regarding methods, materials and stocks, ideas and research results related to genetics, breeding and cytology of *Triticum*, *Aegilops*, *Seeale*, *Haynaldia* and related genera. Manuscripts should be typewritten (double-space) in English and submitted with duplicates. One article should not exceed five printed pages, including two textfigures (smaller than  $7 \times 7 \text{ cm}^2$ ). Lists of stocks are exempted from this page limit. Off-prints are printed by order at cost price, Communications regarding editorial matters should be addressed to:

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*The Managing Editor*



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*Explanation of the Figure on the Cover*

Mutant leaf characters of hexaploid Triticale. See the detail informations described in page 26 ~ 28 of this volume.

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