ISSN 0510-3517

WHEAT INFORMATION SERVICE

No.65

October, 1987

Wheat Information Service

Kihara Institute for Biological Research

Yokohama, Japan

Contents

I. Research Notes

Chromosome numbers of supernumerary spikelet lines of bread wheat (*Triticum aestivum* L.)

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The term supernumerary spikelets includes the occurrence of both extra spikelets on the rachis as well as extra spikelets on an extended rachilla (branched ear) in a wheat ear (PENNELL & HALLORAN 1984) and the degree of expression of this character is considerably influenced by environment (SWAMINATHAN *et al.* 1966, PENNELL & HALLORAN 1984). SINGH and JOSHI (1983) reported that plants with branched ears arising from a wheat-rye cross were trisomics with 43 chromosomes. This condition appeared to be the basis of continued segregation in advanced generations for ear branching in their lines. SINGH and JOSHI (1983) have hypothesized that the super-numerary spikelet character is due to increased dosage of the genes controlling ear morphology brought about by tri- and tetrasomy in their lines. In contrast, KORIĆ (1973, 1978) and PENNELL and HALLORAN (1983) reported the presence of two and one to two genes, respectively, controlling this character. SWAMINATHAN *et al.* (1966) reported that the branched-ear character in a mutant of cv. N.P. 797 was due to a chromosomal deletion. In view of these conflicting reports on the genetic basis of the supernumerary spikelet character it was decided to study the chromosome numbers of six supernumerary spikelet lines of hexaploid wheat which were used in studies by PENNELL (1983) and PENNELL and HALLORAN (1983, 1984).

Materials and Methods

Seeds of the six supernumerary spikelet lines of bread wheat (AUS15910, AUS15915, AUS15916, AUS15157, AUS17335, AUS17336, see Table 1 for origin and pedigree) obtained from the Australian Winter Cereals Collection, Tamworth, N.S.W., were germinated on moist filter paper in petri dishes. Root tips were collected from each seedling whose identity was maintained. The seedlings were grown in a glasshouse under normal daylength during the spring of 1985 using 15cm diameter pots cantaining a potting mix. The root tips collected as above were treated with 10^{-3} M colchicine for four hours after which they were incubated in 1% acetocarmine for 48 hrs at room temperature. The root tips were squashed in 1% acetocarmine.

Results and Discussion

Except for AUS15157, which appeared to be tetraploid (all the plants studied had 2n=28 chromosomes), most of the plants in the lines studied were hexaploids (2n=42) (Table 1). Most of the hexaploid plants of the lines AUS15910, AUS15915 and AUS15916 produced supernumerary spikelets. The progeny of supernumerary spikelet plants of AUS15910 possessing 42 chromosomes have bred true for this character in subsequent glasshouse plantings. The head type of the plants of AUS17335 and AUS17336 could not be satisfactorily verified due to their very high vernalization and long photoperiod requirement (six weeks of vernalization at 4°C and 18 hr photoperiod were tried with partial success in inducing heading). However, in experiments of PENNELL and HALLORAN (1984) these lines planted outdoors during the normal growing season displayed the supernumerary spikelet character consistently. Both these lines were isolated for branched-ear character from bread wheat and differ from normal wheats in two genes (KORIĆ 1973, 1978).

Table 1. Chromosome numbers of five supernumerary spikelet bread wheat lines

Line	Origin and pedigree	Super-numerary spikelet 2n = 42	Normal 2n = 42	Super-numerary spikelet 2n = 41	Super-numerary spikelet 2n = 43	Total
AUS15910	M * Restoracao x Noreste 66 + H176 - 68A - 2B - 1Y from CYMMIT, bred by R. Rodriguez	26	4			30
AUS15915	Ram Hari E771 from CYMMIT, bred by S. Rajaram	27		2	2	31
AUS15916	Ram Hari E771 from CYMMIT, bred by S. Rajaram	21	9	2		32
* AUS17335	Mutant line 5 2663/74 White, awnless bred by S. Korić, Zagreb, Yugoslavia	31			1	32
* AUS17336	Mutant line 6 1646 2520/74 White, awnless bred by S. Korić, Zagreb, Yugoslavia	31			3	34

* Head type of these lines could not be assessed.

All plants of AUS15157 had 2n = 28 chromosomes and produced supernumerary spikelet ears.

There were some 43 and 41 chromosome plants in some lines (Table 1). These could be taken to be due to spontaneous variation in chromosome numbers which has been well documented for wheat (e.g. WORLAND 1981). The hexaploid plants which produced normal heads could be considered to have arisen from contamination either by cross pollination or accidental seed mixing.

The above results and those of PENNELL and HALLORAN (1983) suggest that the genetic nature of the supernumerary spikelet character in the above lines is most likely different from that reported by SINGH and JOSHI(1983). Further cytogenetic studies of the supernumerary spikelet character to identify the chromosomal location of the genes controlling its expression, are in progress.

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Transfer of D genome from common wheat to *durum* wheat

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One of the most important events in wheat evolution was the transition of genome constitution from a tetraploid level to hexaploid one by addition of wild *Aegilops tauschii* (Coss.) Schmal. genome to cultivated *Triticum dicoccum* (Schrank.) Schuebl. (MCFADDEN & SEARS 1946). The consequence of such a transition has been studied at various points and provided evidence for drawing a general outline of the origin and evolution of common wheat. These investigations were mainly carried out when using natural wheats and their relatives. However, there are many details left that cannot be clarified in experiments with only these wheat forms. It is necessary to develop some particular genetic material. Thus, for detailed study of D genome of common wheat those forms are needed, which differences can be converged to differences of their D genomes. This report concerns developing these particular forms.

The objective was to substitute A and B genomes of common wheat (AABBDD, 2n = 42) by the similar genomes of *durum* wheat (AABB, 2n = 28) while retaining D genome inchanged. This substitution was realized with a series of 5-6 backcrosses of the hybrids between the two species (AABBD, 2n = 35) to *durum* wheat as a recurrent parent. Spring cultivar *Triticum aestivum* L. var. *ferrugineum* (Alef) Mansf. "Kalyansona" and winter cultivar *T. aestivum* L. var. lutescens (Alef) Mansf. "Kavkaz" were used as a D genome donor. The recipient for them was a winter line *Triticum durum* Desf. var. *muticitalicum* Dorof. & A. Filat. "MI". Pentaploid hybrids, which contained 14 bivalents, belonging to A and B genomes and 7 univalents coming from D genome, were backcrossed as female parents to MI. Random distribution of 7 univalents to eggs bring about segregation of the backcross progenies for chromosome number from 28 to 35. As only 35-chromosome plants contain a complete complement of unpaired D genome chromosomes they were selected for the production of the successive generation.

Unfortunately, while carring out this procedure, the share of pentaploid plants in backcross progenies proved to be insufficient (1.2% for Kalyansona and 0.7% for Kavkaz) for continuous backcrossing. The attemps to take advantage of a possible increase in the share at the expense of the preferential functioning more viable 21-chromosome male gametes from pentaploid when pollinating the tetraploid parent with its pollen was not a success because the seeds from such a cross were shrunken and produced no healthy seedlings. Therefore, begining from the first backcross for Kavkaz and the second one for Kalyansona to enlarge the number of plants carring a complete set of D genome chromosomes, the transition to each following backcross was realized after selfing 35-chromosome plants from the previous backcross and selecting 35-42-chromosome plants. It was found that the share of such plants markedly decreased in the progenies of the second and the successive backcross pentaploids in comparison with the first one (see table). Without a doubt this drop was caused by the substitution of ineffective in retaining D genome

chromosomes of *durum* wheat gene/genes for effective common wheat alleles.

The hexaploids recovered in F_2 populations derived from the fifth backcross pentaploids for Kavkaz and the sixth backcross pentaploids for Kalyansona (let designate them by MI^5KV and MI^6KS respectively) were considered to be very close to MI genotype regarding to their AABB component. Supporting evidence to this there were the results obtained when comparing MI with tetraploids recovered in the same F_2 populations as the hexaploids done. No differences were found on morphological characters. Electrophoretic patterns of gliadins in MI and the recovered tetraploids were identical.

Table 1. Percentage of 35-42-chromosome plants in selfs of pentaploids of successive backcrosses

D genome source	B_1F_2	B_2F_2	B_3F_2	B_4F_2	B_5F_2	B_6F_2
Kavkaz	62,5	30,4	18,2	12,0	20,7	
Kalyansona	34,3	22,0	24,5	20,4	15,7	13,7

Synthetic hexaploids represent vigorous full-fertile forms (see figure), which are attributed to variety group Semirigidum A. Filat and Dorof. of *Triticum aestivum* L. subsp. *hadropyrum* (Flaks.) Tzvel. MI^5KV belongs to var. *magnificum* and MI^6KS - var. *turanicum* according to the classification by DOROFEEV *et al.* (1979). Chromosome pairing in both of them is similar to that corresponding sources of D genome.

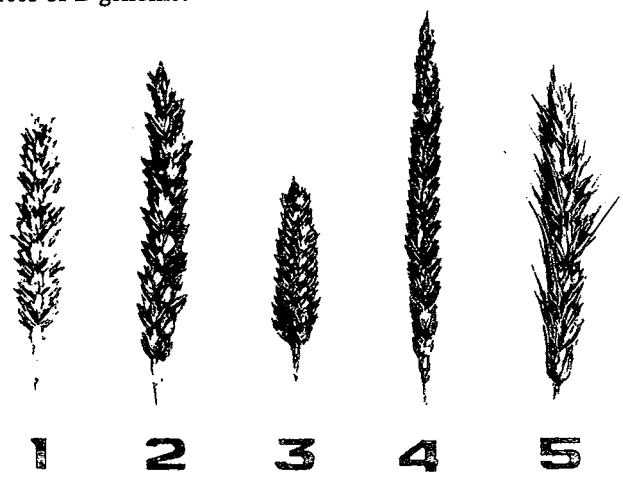

Fig. 1. Spikes from natural and synthetic wheats: 1) cv. Kavkaz, 2) MI^5KV, 3) MI, 4) MI^6KS, 5) cv. Kalyansona

Comparison of the synthetic hexaploids with tetraploid MI showed that D genome from both sources increased top internode diameter, length, width and weight of grain and decreased spikelet number per ear and undeveloped spikelet number. Some characters in the hexaploids such as plant height, top internode length, heading time and others deviated from those in MI in plus or minus derections dipending on the sources of D genome.

These new hexaploids may provide a new approach to the problem concerning a genetic composition of wheat genomes. They enable us to study durum wheat with monosomic analysis as exactly as it is done in common wheat and identify those genetic changes in common wheat D genome which presumably have taken place within it since incorporation into the complex wheat genome.

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The meiotic analysis and morphological characters of the hybrid *Triticum durum* Desf. var. *hordeiforme* Körn. × *Aegilops speltoides* Tausch

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It has long been known that *Aegilops* and other close relatives of wheat are resistant to various wheat diseases of which most important are rusts (*Puccinia* spp.). Therefore, in spite of various limitations such as difficulty in crossing, and low fertility, they have been maintaining the importance as gene sources in resistance breeding programs for a long time (HIRATSUKA 1955, SEARS 1956, DYCK & KERBER 1970, DVORAK 1977, DVORAK & KNOTT 1980).

In this research, some morphological characters, meiotic configurations and level of resistance to stripe rust (*Puccinia striiformis* West.) of F_1 hybrid of *T. durum* var. *hordeiforme* × *Ae. speltoides* were studied.

Materials and Methods

Widely grown *durum* wheat variety Çakmak 79 (*T. durum* var. *hordeiforme*, 2n = 28), which was susceptible to stripe rust, and *Ae. speltoides* (2n = 14), which was resistant to stripe rust, were used as parents. Parents and F_1 hybrid were tested at both seedling and adult-plant stage by a mixture of spores which was consisted of prevalent races of stripe rust.

Growing of parents, emasculation and pollination were made under field conditions with the techniques given by ÖZGEN (1983a).

The obtained seeds from the crosses were germinated under laboratory conditions. Chromosome number was observed in root-tip mitosis using the Feulgen squash method. During the winter all seedlings were grown in the greenhouse and then transplanted to the field in early spring.

Immature spikes of the F_1 hybrid were fixed in 1:3 asetic acid-alchol for 24 hours. Fixed spikes were stored in 70 per cent alchol at 0-4°C. Pollen mother cells (PMC's) were stained with acetocarmine. Chromosome pairing was analyzed in the PMC's at metaphase I. Slides were sistematically scanned and pairing configurations recorded.

Rachis toughness, spike density, feature of lower internodes and growth habit were studied as morphological characters.

Results and Discussion

In crossing program, 404 florets from 17 spikes of *T. durum* var. *hordeiforme* were pollinated by *Ae. speltoides* and 62 seeds were obtained. Chromosome numbers were determined by examining root-tip mitosis and eventually hybrids were found to be triploid (2n=21) (Fig. 1). As it is known, due to genomal incompatibility between endosperm and embryo, and mitosis abnormalities in embryo reduce the germination ability of the seeds which are obtained from interspesific

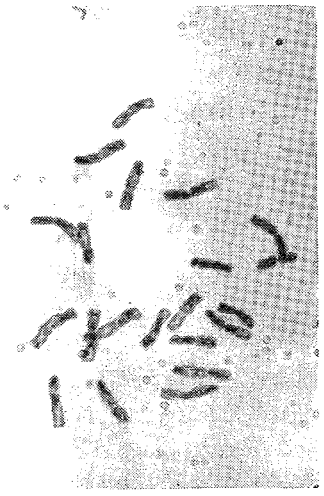

Fig. 1. Mitotic metaphase in a triploid hybrid between *T. durum* var. *hordeiforme* × *Ae. speltoides* (× 500)

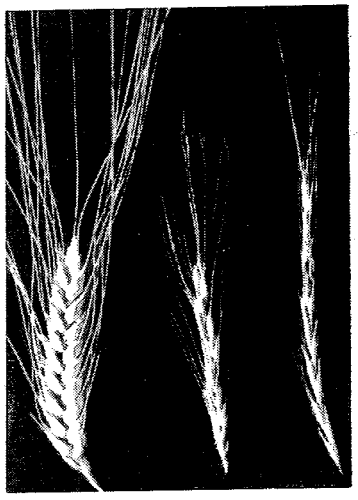

Fig. 2. Spikes of *T. durum* var. *hordeiforme*, F_1 triploid hybrid and *Ae. speltoides* (from left to right)

crosses (LILIENFELD 1951, KIHARA & YAMASHITA 1956, STEBBINS 1958). Therefore, only 21 of the 62 hybrid seeds were germinated under laboratory conditions. The seedlings were transplanted to the field and 12 F_1 plants with spike were obtained.

Table 1. Some characters of *T. durum* var. *hordeiforme* × *Ae. speltoides* F_1 hybrids and their parents

	Rachis	Spike density[1)]	Lower internodes with/without (angle, knee)	Growth habit	Resistance to stripe rust[2)]
T. durum	Tough	26.13 ± 0.47	Without	Erect	S
Ae. speltoides	Weak	12.56 ± 0.28	With	Semierect	R
F_1	Weak	18.21 ± 0.21	With	Semierect	R

1) No. of spikelets/10 cm.

2) S: Susceptible, R: Resistant.

Table 2. The mean and range of meiotic configurations in the F_1 hybrids *T. durum* var. *hordeiforme* x *Ae. speltoides*

I	II Rod	II Ring	II Total	III	IV	Number of cell
14.55 9–21	2.86 0–6	0.29 0–2	3.15 0–6	0.07 0–1	0.02 0–1	42

Table 3. Meiotic configuration of F_1 PMC's at the first metaphase (%)

PMC's	$^0_{II}$	$^1_{II}$	$^2_{II}$	$^3_{II}$	$^4_{II}$	$^5_{II}$	$^6_{II}$
%	9.5	2.5	16.5	33.5	21.5	12.0	4.5

In F_1 plants, spike density was intermediate while rachis toughness, lower internode shape and growth habit were dominant. KAGAWA (1927), KIHARA (1958), DOSBA & CAUDERON (1972) were also obtained similar results from various wheat-*Aegilops* hybrids. The characteristics of the parents and F_1 hybrids are shown in Table 1. The ears of the hybrid plants looked like mostly *Ae. speltoides* in compare with the other parent (Fig. 2).

All F_1 plants were tested against stripe rust and found as resistant. It was conclude that resistance was dominant.

Like other wheat-*Aegilops* hybrids (ÖZGEN 1983b, 1984, 1985), these F_1 plants also had non dehiscent anther. It has been known that differences in number and structures of chromosomes of parents may be cause of sterility (KIHARA & YAMASHITA 1956). On the other hand, there are also some genes which cause sterility by affecting meiosis or its resulting gametes in the interspesific hybrids (STEBBINS 1958). Thus, only 8 seeds were obtained from 487 spikes of 12 F_1 plants. According to this result, back-crossing is necessary to obtain off-springs from *T. durum* var. *hordeiforms* x *Ae. speltoides* hybrid.

Meiotic configuration and chromosome pairing of F_1 hybrids are given Table 2 and 3. These show that the number of bivalents varied between zero and six, and most of them were of rod type, but there also were some ring types (Fig. 3). Furthermore, a few trivalents and quadrivalents were seen. The percentage of cells with no bivalents was as low as 9.5 per cent. Chromosome pairing in the F_1 hybrids of *T. durum* var. *hordeiforme* x *Ae. speltoides* were found to be higher than for *T. durum* var. *hordeiforme* x *Ae. umbellulata*'s F_1 hybrids (ÖZGEN 1983b). From the result, thus, it can be inferred that *Ae. speltoides* is more suitable than *Ae. umbellulata* in order to transfer gene to *T. durum* var. *hordeiforme*.

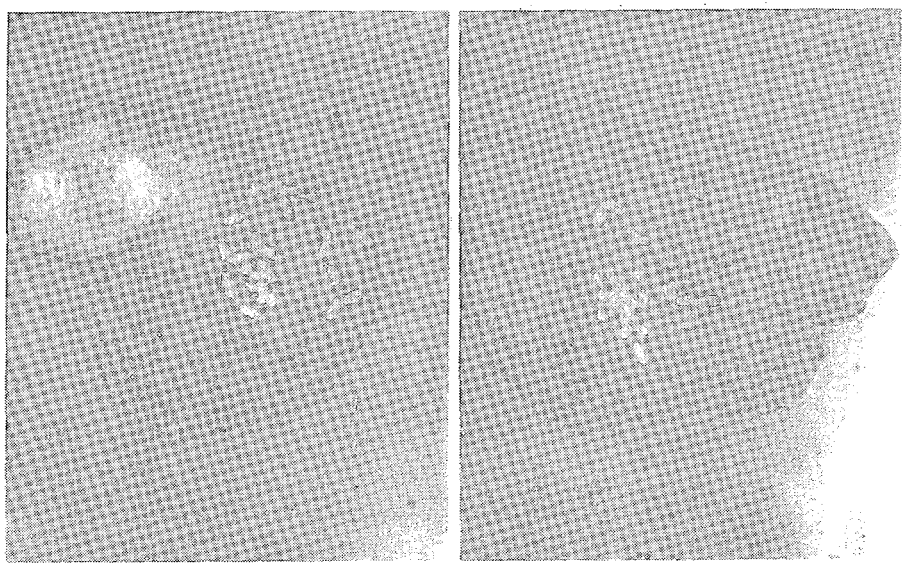

Fig. 3 Metaphase I chromosome associations in F_1 hybrids between *T. durum* var. *hordeiforme* × *Ae. speltoides*
Left: 9I + 6II, Right: 11I + 5II (× 670) .

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Estimation of heterosis in wheat populations derived from intercultivaral hybridization

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With the realization of the possibility of producing hybrid seed on a large scale considerable emphasis has been given to the exploitation of heterosis in self-pollinated crops (BEHL 1985) and has been the object of considerable study as a means of increasing productivity of wheat (*Triticum aestivum* L.). It is now well established that heterosis does occur with proper combination of parents and is the result of allelic or non-allelic interaction of genes under the influence of a particular environment.

Although the reports on yield heterosis in bread wheat are available (BEHL 1985, AL-SAHEAL & GAMIL 1981, UDDIN & JOARDER 1986) but the data for superiority over commercial check are scarce. Hence the present study was initiated to elucidate the nature and magnitude of heterosis over better parent and commercial check in wheat populations derived from intercultivaral hybridization.

Materials and Methods

Seeds of four cultivars (Pak-70, Sonalika, Pak-81 and T.J.-83) selected on the basis of diversity for their various economic traits alongwith F_1 seeds of their crosses were grown during winter 1985-86 in a randomized complete block design with three replications at the Botanical Garden, Department of Plant Breeding and Genetics, Sind Agriculture University, Tandojam, Pakistan. The sub-plots had 3.5m long five rows. The seeds were planted at commercial sowing density, *i.e.*, at distance of 15 cm plant to plant and 30 cm row to row. Standard cultural practices were followed throughout the growing season. Eight pre- and post harvest characters were recorded on 20 random plants in each entry (Table 1). Heterobeltiosis and "Commercial heterosis", *i.e.*, heterosis over regional check (Pak-70) were calculated for each character separately.

Results and Discussion

Deviation from mid parent values signifies the expression of heterosis, but in our study the main aim was to define heterosis in terms of net economic gain. So the evaluation was carried out in comparison with better parent and the commercial check Pak-70.

Mean performance of the parents and their F_2 hybrids is presented in Table 1. Heterosis for days to flowering and days to maturity was low and negative. This is expected as heterosis for these traits have mostly been reported for either photoinsensitive or qualitatively photosensitive

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Table 1. Average performance of parents, F_2 hybrids and percent heterosis over better parent and regional commercial check (Pak-70) in bread wheat

Characters	Parental mean	Hybrid mean	Average heterosis %	Percent heterosis over BP	Percent heterosis over Comm. Check
Days to flowering	80.71**	73.99**	-8.32	-11.20*	-13.03*
Days to maturity	146.20**	140.68**	-3.77	- 4.66	- 5.66
Plant height	87.23**	97.24**	11.47*	9.70*	14.73*
Spikes per plant	18.88**	23.14**	22.56**	16.16**	14.77*
Spike length	9.50*	11.27*	18.71**	18.27**	20.76**
Spikelets/spike	17.11**	19.88**	16.20**	9.12*	8.16
Grains per spike	48.69**	64.14**	31.73**	22.18**	25.64**
Yield per plant	42.42**	64.65**	52.40**	44.18**	38.80**

*, ** Significant at P = 0.05 and P = 0.01 level of probability respectively.

crops (BANGA & LABANA 1984). Wheat on the other hand, is quantitatively photosensitive crop which flowers when the total photoperiodic requirements are met. All the hybrids flowered and matured earlier than their parents. Hybrid Sonalika x Pak-70 matured 9.53 days earlier than their better parent (Table 2). It appeared that due to interaction of genes and partial dominance, the hybrids matured earlier.

The heterosis (Table 1) for plant height, spikes per plant, spike length and grains per spike is of common occurrence in wheat (AL-SAHEAL & GAMIL 1981, BEHL 1985). It is concluded that the increased height and spike length of hybrids over parents may be due to the interaction of complementary growth genes. Deviation of hybrids from mid parent values suggests dominance due to positive dominant genes, whereas deviation of crosses from better parent values indicate over dominance due to positive dominant genes.

Among the traits studied maximum heterosis manifested was for yield per plant (Table 1). The hybrid advantage for yield per plant varied from 38.80 to 44.18 percent over commercial check and better parent respectively. Highest heterobeltiosis values for yield per plant was recorded by cross combination Pak-70 x Sonalika. All the hybrids on an average out yielded their parents. An explanation of yield heterosis encompasses the contribution of its various physiological components. A close persual of Table 1 indicate that yield heterosis was mainly due to heterosis for grains per spike ranging from 22.18 to 25.64 percent and spike length 18.27 to 20.70 percent for better parent and commercial check respectively. It may be mentioned that the contribution of grains per spike to grain yield per plant was comparatively higher than the spike length in yield heterosis of both better parent and the commercial check. Number of reports highlight the positive contribution of these traits to yield heterosis (BAILEY *et al.* 1980, GIRIRAZ & GOUD 1981, BITZER *et al.* 1982, UDDIN & JOARDER 1986).

Heterosis for four F_2 hybrids alongwith their component characters is presented in Table 2.

Table 2. Component heterosis values over better parent (upper values) and over commercial check Pak-70 (values in brackets) for four F_2 heterotic crosses of bread wheat

Crosses	Days to flowering	Days to maturity	Plant height	Spike length	Spikelets per spike	Grains per spike	Spikes/ plant	Yield/ plant
Pak-70 x Sonalika	-12.88**	- 9.53	10.55*	4.06	3.08	24.75**	19.53**	32.80**
	(-11.75)	(- 7.65)	(10.88)	(5.06)	(2.08)	(21.95)**	(20.30)**	(30.10)**
Pak-81 x T.J.-83	- 4.00	- 5.75	5.86	5.11	0.65	14.05*	12.43*	25.75**
	(- 6.00)	(- 4.75)	(5.10)	(5.00)	(0.68)	(15.05)*	(12.40)*	(20.80)**
Sonalika x Pak-70	-11.70*	- 9.11	11.73*	4.87	1.08	25.00**	19.08**	23.75**
	(-11.00)*	(- 8.90)	(10.73)*	(4.50)	(1.00)	(24.10)**	(18.09)**	(21.90)**
T.J.-83 x Pak-81	- 4.58	- 4.12	6.26	5.59	0.99	14.61*	13.05*	25.75**
	(- 4.25)	(- 3.85)	(6.75)	(5.25)	(0.88)	(13.95)*	(12.95)*	(26.75)**

*, ** Significant at P = 0.05 and P = 0.01 level of probability respectively.

Although the components of heterosis were specific for each cross, yield heterosis in general is largely due to heterosis in yield components. The best hybrid in our study gave as much as 44.18 percent more yield than the regional check Pak-70. This, coupled with other reports of substantial yield heterosis, presents an encouraging picture for exploiting heterosis by producing F_2 hybrids in bread wheat.

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A comparative study of three selection procedures in bread wheat

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Several selection procedures (pedigree selection, bulk population breeding, single seed descent, mechanical mass selection, etc.) have been proposed for improving self-fertilized crops. However, only a few of these procedures have been used extensively in wheat. The knowledge about the relative efficiency of the different methods may greatly help the plant breeder in choosing a better method to be adopted in a particular crop. The information available on this aspect is little and controversial. Keeping these points in mind, an attempt has been made to compare the efficiency of pedigree selection, bulk breeding and single seed descent (SSD) methods in a three-way wheat cross.

Materials and Methods

The F_2 generation of a three-way wheat cross (WH157 x T460-P-1200-5) was grown in two lots *i.e.* space planting and at commercial seed rate in 1982-83 at the research farm of Haryana Agricultural University, Hisar. The population grown for exercising pedigree selection was space planted. Ten per cent plants were visually selected on the basis of plant type, good tillering, ear characteristics and disease resistance from F_2 generation and were grown as F_3 progeny rows during 1983-84 crop season. Subsequently, superior plants were selected from F_3 progeny rows and grown as F_4 progeny rows during 1884-85 and finally 35 single plants were selected from the chosen progeny rows in F_4 generation and grown as F_5 progeny rows during 1985-86. Under bulk method, a random sample of seed was taken from F_2 bulk plot grown during 1982-83 and advanced to F_3 bulk during 1983-84. Subsequently, random sample of seed was taken from F_3 bulk and grown as F_4 bulk plots in space planting during 1984-85. Finally, a random sample of 35 plants was selected from space planted F_4 bulk and grown as F_5 progeny rows during 1985-86. In SSD procedure, one seed was taken from each healthy plant from F_2 generation grown for pedigree selection during 1982-83. Seeds collected in this way were bulked to constitute F_3 SSD, which was grown during 1983-84. Again, single seeds were collected from individual plants of F_3 SSD population and grown as F_4 SSD in space planting during 1984-85. Finally, a random sample of 35 plants was taken from space planted F_4 SSD population and grown as F_5 progeny rows during 1985-86. In this way, one hundred and five progenies (35 from each of the three selection procedures) were grown in a randomized block design with three replications in single row plots of 3m length having row to row distance of 23 cm and plant to plant distance of 10 cm during 1985-86. The data were recorded on five randomly selected competitive plants from each progeny rows per replication for days to heading, plant height, effective number of tillers, number of grains per spike, 1000-grain weight and grain yield per plant. The efficacy of the three selection procedures was compared on the basis of mean performance

(top 25 lines), range, phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance. All statistical parameters were computed using standard statistical procedures. The expected genetic advance at 5 per cent level of selection intensity was computed using standard procedures as suggested by Johnson, ROBINSON & COMSTOCK (1955).

Results and Discussion

The range, mean, phenotypic coefficient of variation, genotypic coefficient of variation, per cent heritability in broad sense and expected genetic advance as per cent of mean of F_5 progenies following three selections method in a three-way wheat cross for six metric traits are presented in Table 1. The range of distribution in SSD progenies was, in general, higher than the progenies developed through pedigree selection for almost all the traits, while bulk selection showed lower range of distribution for almost all the traits. The mean values of F_5 progenies produced by pedigree selection and SSD methods were significantly better in comparison to the F_5 progenies produced by bulk method. However, no significant differences existed between the mean values of F_5 progenies developed through pedigree selection and SSD methods. Hence these two procedures sppeared to be equally effective methods of handling the segregating generations of this wheat cross. It can also be suggested that SSD method may be used as an alternative to pedigree selection when it is not feasible for a breeder to handle large populations owing to the limited resources available. Several previous workers (KNOTT & KUMAR 1975, TEE & QUALSET 1975, WRIGHT & THOMAS 1976) also observed that the SSD procedure was often superior or was at least equally efficient to pedigree and bulk methods of selection in wheat. However, SNEEP (1977) pointed out that SSD method is affected by genetic drift and as a consequence many genotypes are lost.

As regards the phenotypic and genotypic coefficients of variation, the pedigree selection gave slighly high values than SSD method. The lowest values of phenotypic and genotypic coefficients of variation were recorded for bulk selection. This might be due to strong inter-genotypic competition within the population. As there were large differences between phenotypic and genotypic coefficients of variation for tiller number, grain number and grain yield per plant, so these three characters were more influenced by the environment.

It can be seen from Table 1 that the heritability values for plant height and days to heading were relatively higher. On the other hand, these values for grain yield and tillers per plant were smaller indicating that these two characters were more influenced by environment. The values of heritability and genetic advance (as per cent of mean) calculated in SSD procedure were higher than those in pedigree selection for all the traits except for grain yield where slightly higher genetic advance was obtained in pedigree selection than in SSD procedure. Bulk selection showed lower values of heritability and expected genetic advance for almost all the traits. In majority of cases, there was association between high heritability and higher genetic advance but in few cases like days to heading and plant height, there was no association between high heritability and high genetic advance. This was due to high or low amount of phenotypic standard deviation. Hence, on the basis of results of the present study, it can be suggested that both the pedigree selection and single-seed-descent method are effective in handling the segregating generations of this wheat cross.

Table 1. Range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), per cent heritability in broad sense (h^2) and expected genetic advance as per cent of mean (GA) of F_5 progenies following three selections methods in wheat for six metric traits

Method	Parameter	Days to heading	Plant height (cm)	Tillers/ plant	Grains/ plant	1000-grain weight (g)	Grain yield/ plant (g)
Pedigree selection	Range	77.3–91.8	94.4–116.7	8.3–23.6	44.1–68.4	40.3–16.6	15.3–29.6
	Mean	81.8	108.0	14.8	58.5	53.8	24.7
	PCV	7.8	9.8	21.8	16.2	10.3	20.3
	GCV	6.9	7.2	14.3	12.7	9.4	11.8
	h^2	87.4	84.6	56.9	79.7	69.4	66.3
	GA	14.7	15.8	19.2	16.3	12.7	19.4
Single seed descent	Range	75.6–94.7	95.2–122.8	9.3–26.7	39.3–76.8	38.4–57.7	11.3–26.6
	Mean	83.4	114.5	13.5	56.9	49.8	22.8
	PCV	8.2	10.1	19.7	17.4	9.7	18.4
	GCV	7.4	8.6	12.3	11.6	8.2	12.7
	h^2	81.5	79.3	59.6	82.5	71.3	73.8
	GA	15.4	18.6	21.7	18.8	12.9	18.8
Bulk method	Range	79.3–104.9	98.3–126.1	9.2–20.4	42.6–60.3	41.4–52.6	12.6–22.6
	Mean	89.9	122.6	10.9	52.2	44.7	17.6
	PCV	6.2	7.4	17.6	12.4	9.6	14.9
	GCV	5.1	6.1	11.4	9.6	7.3	6.8
	h^2	80.7	81.4	52.3	76.6	67.9	65.3
	GA	9.5	11.2	16.4	13.9	8.6	14.5
C.D. at 5%		4.13	6.98	2.53	3.87	4.72	4.64

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Wheat cultivation under saline irrigations

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Wheat (*Triticum aestivum* Linn. emend. Thell) is one of the most important cereal crop of the world, grown in wide range of climatic zone and mostly in irrigated conditions, to nourish the mankind. In the arid and semi-arid areas, saline ground water is a common feature, irrigation with saline water to fulfil the evaporation demand throughout the growth period of crops resulted in soil salinization in the root zone caused deterimental affect on growth and yield potential of the crops. BERNSTEIN (1964), BHUMBLA *et al.* (1964), KANWAR & KANWAR (1969), TRIPAAHI & PAL (1979) have reported the reduction in yield of wheat with high saline irrigations. Compared to grain yield, the crop growth and yield attributes were found to vary with tolerance/sensitivity for salinity. Therefore, it will be of vital interest for scientist trying to overcome the salinity menace, to predict the wheat crop growth, development and yield potential with varying salinity of irrigation water on the basis of long term experimentation.

Materials and Methods

A field experiment in microplot of 2.5 × 2.5 m size (net plot size 2 × 2 m) was conducted during *rabi* seasons of 1972-73 to 1978-79 consequtively at the Research Farm, Raja Balwant Singh College, Bichpuri, Agra, India. The plots were separated by polythene sheets upto 90 cm depth to prevent lateral movement of water. The annual rainfall in the region is about 600-700 mm of which about 80% is received during July, August, September months. The soil was alluvial, sandy loam (16% clay, 14% silt and 70% sand) in texture with 1.75 cm/hr hydraulic conductivity. The soil initially had EC 3 ds/m, pH 8.6, SAR 15 and ESP 6 at surface (0-15 cm) depth.

Seven salinity levels of irrigation water with EC 0.6 (control), 2, 4, 6, 8, 12 and 16 ds/m were tried in Randomized Block Design with four replications. Artificially synthetic water were prepared from canal water by adding the salts of chlorides of sodium, calcium and magnesium, and sulfates and bicarbonates of sodium keeping the ratio of Na: Mg: Ca as 60:25:15 and $Cl:SO_4:HCO_3$ as 2:1:1 as long as sulfates did not exceed 30 me/l and HCO_3 10 me/l and excess of these ions were substituted by chloride ion. The composition of these irrigation water are as per composition of the ground water of this locality. Under the Pearl Millet- Wheat crop rotation for consequitive 7 years on the same field, wheat (HD 1593) was sown in November and harvested in April in respective years. The crop was fertilized with the dose 120 kg/h/N and 60 kg/ha/P_2O_5. Irrigation was adjusted at 6 cm CPE with 1.0 ratio of CPE/depth of irrigation. In all 4-5 irrigations were provided each year for wheat cultivation. The details of rainfall and water table depth are presented in Table 1.

Table 1. Rainfall and depth of water table in different years

Particulars	Years						
	1972–73	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79
Total rainfall (mm)	293	650	512	640	750	1044	895
Rainfall during kharif (mm)	272	558	388	504	653	958	816
Rainfall during cropping period (mm)	51	17	101	29	53	68	114
Water table depth during cropping period (m)	–	–	3.3–4.8	4.9–5.4	3.9–4.4	1.2–2.1	1.3–2.2

Results and Discussion

The saline irrigation resulted in soil salinization and under wheat crop production the salinity build up (EC_e) has been recorded about 1 to 1.5 times to that of irrigation water (EC_{iw}). This increased EC_e ultimately increased the osmotic potential, resulted mainly reduced water intake by crop mainly besides specific ion effect. Plants make adjustment when faced unfavourable conditions upto certain limit beyond that depressed plant growth resulted.

The data pertaining to effect of varying saline irrigations on wheat crop growth and yield for 7 years of experimentation are presented in Table 2 and 3. The germination performance, which is directly related to soil moisture content, of seed revealed that it decreased progressively with salinity of water, however, the magnitude of reduction was more with high salinity. From EC 6 to 8 it decreased about 1.2% with each unit of EC and from 8 to 16 the reduction per unit EC was about 4%. The correlation between EC_{iw} and germination ($r = -0.61$) was also found significant with regression equation as $Y = -1.8X + 65.62$.

The crop growth judged by plant height and number of tillers revealed that both these characters declined with salinity but only beyond EC 8 ds/m. The EC 12 declined crop growth about 10% while at EC 16 it was about 30%. The correlation between EC_{iw} vs plant height ($r = -0.36$) and number of tillers ($r = -0.37$) were also found significant. The respective regression equation are $Y = -1.25X + 87.5$ and $Y = -1.08X + 69.4$.

The yield contributing characters viz. ear length, number of grain per ear and 1000 grain weight were also studied and it has been observed that upto EC 12 ds/m ear length was not found affected and EC 16 caused only 3.6% reduction. Similarly, number of grain per ear was not found to be affected upto EC 8 and at EC 12 & 16 it declined only by about 5%. 1000 grain weight was started to decline from EC 2 onwards progressively but with very low degree (Table 2). The correlation between EC_{iw} and these yield attributes was rated non-significant (Table 3).

Table 2. Effect of saline irrigation on growth and yield of wheat crop

Treatments (EC – ds/m)	Germination/metre	Number of tillers per metre	Plant height (cm)	Ear length (cm)	Number of grains/ear	1000 grain weight (gm)	Drymatter yield (g/ha)	Grain yield (g/ha)
EC 0.6 (control)	60.6 (100)	65.0 (100)	81.7 (100)	8.4 (100)	40.4 (100)	34.4 (100)	95.4 (100)	40.4 (100)
EC – 2	60.1 (99.2)	65.5 (100.8)	82.9 (101.5)	8.5 (101.2)	41.7 (103.2)	34.0 (98.8)	95.8 (100.4)	40.9 (101.2)
EC – 4	62.7 (103.5)	67.8 (104.3)	82.5 (101.0)	8.6 (102.4)	43.2 (106.9)	32.5 (94.5)	95.8 (100.4)	39.5 (97.8)
EC – 6	55.2 (91.1)	65.7 (101.1)	82.2 (100.6)	8.5 (101.2)	41.0 (101.5)	32.5 (94.5)	97.0 (101.7)	39.3 (97.8)
EC – 8	53.7 (88.6)	65.8 (101.2)	82.0 (100.4)	8.8 (104.8)	40.8 (101.0)	31.0 (90.1)	96.3 (101.1)	39.3 (97.8)
EC – 12	43.3 (71.5)	57.8 (98.9)	73.6 (90.1)	8.5 (101.2)	38.4 (95.1)	30.6 (89.0)	78.6 (82.4)	31.8 (78.7)
EC – 16	34.8 (57.4)	44.7 (68.8)	54.9 (67.3)	8.1 (96.4)	38.7 (95.8)	28.8 (83.7)	63.6 (66.7)	25.4 (62.9)

( ) data in parenthes indicate percentage over control as 100.

Table 3. Correlation between salinity of irrigation water and crop characters

Characteristics		'r' value	Regression equation
EC_{iw}	vs. Germination	–0.61*	Y = –1.82 X + 65.62
	vs. No. of tillers	–0.37*	Y = –1.08 X + 69.40
	vs. Plant height	–0.36*	Y = –1.25 X + 87.51
	vs. Ear length	–0.09	– –
	vs. No. of grains per ear	0.186	– –
	vs. 1000 grain weight	–0.27	– –
	vs. Drymatter	–0.42*	Y = –2.09 X + 103.02
	vs. Grain yield	–0.50*	Y = –1.01 X + 43.49

* Significant at 5% level.

Table 4. Correlation studies between grain yield and different crop characters

Characteristics		'r' value	Regression equation
Grain yield	vs. Germination	0.70*	Y = 3.60 X – 153.92
	vs. No. of tillers	0.76*	Y = 0.53 X + 4.31
	vs. No. of effective tillers	0.16	– –
	vs. Plant height	0.52*	Y = 0.50 X – 2.97
	vs. Ear length	0.07	– –
	vs. No. of grains per ear	0.02	– –
	vs. 1000 grain weight	0.11	– –
	vs. Dry-matter yield	0.95*	Y = 0.38 X + 2.83

* Significant at 5% level.

The crop yield under saline irrigation was found to decline with salinity of irrigation water. The drymatter yield declined only at EC 12 ds/m and above. At EC 12 and 16 the drymatter yield declined by 18 and 33% respectively. The reduction in grain yield started with EC 4 onwards but upto EC 8 the percentage was only 2.7. With EC 12 and 16 the grain yield lowered by 21 and 37% respectively. Reduction in grain yield per unit EC of water from EC 8 to 16 was about 4%. Almost similar reduction in wheat yield was reported by POONIA *et al.* (1974) and TRIPATHI & PAL (1979). Mildly saline water (EC 2 to 5 ds/m) have shown the improvement in grain and dry-matter yield (TRIPATHI *et al.*, 1971). The EC_{iw} has been found to be significantly correlated with grain yield (r = –0.72) and dry-matter yield (r = –0.5) with respective regression equation as Y = –1.0X + 43.49 and Y = –2.0X + 103.02.

Further, the relationship of different plant characters with grain yield under saline irrigation were also assessed and presented in Fig. 1 and Table 4. The figure show that germination trend very closely related with grain yield while plant height and number of tillers also showed the

trend similar to yield. The 1000 grain weight data also rallid to some extent only. The ear length and number of grain per ear had shown no resemblance with grain yield pattern. The correlation studies (Table 4) also showed that only germination, number of tillers and plant height were found to be significant.

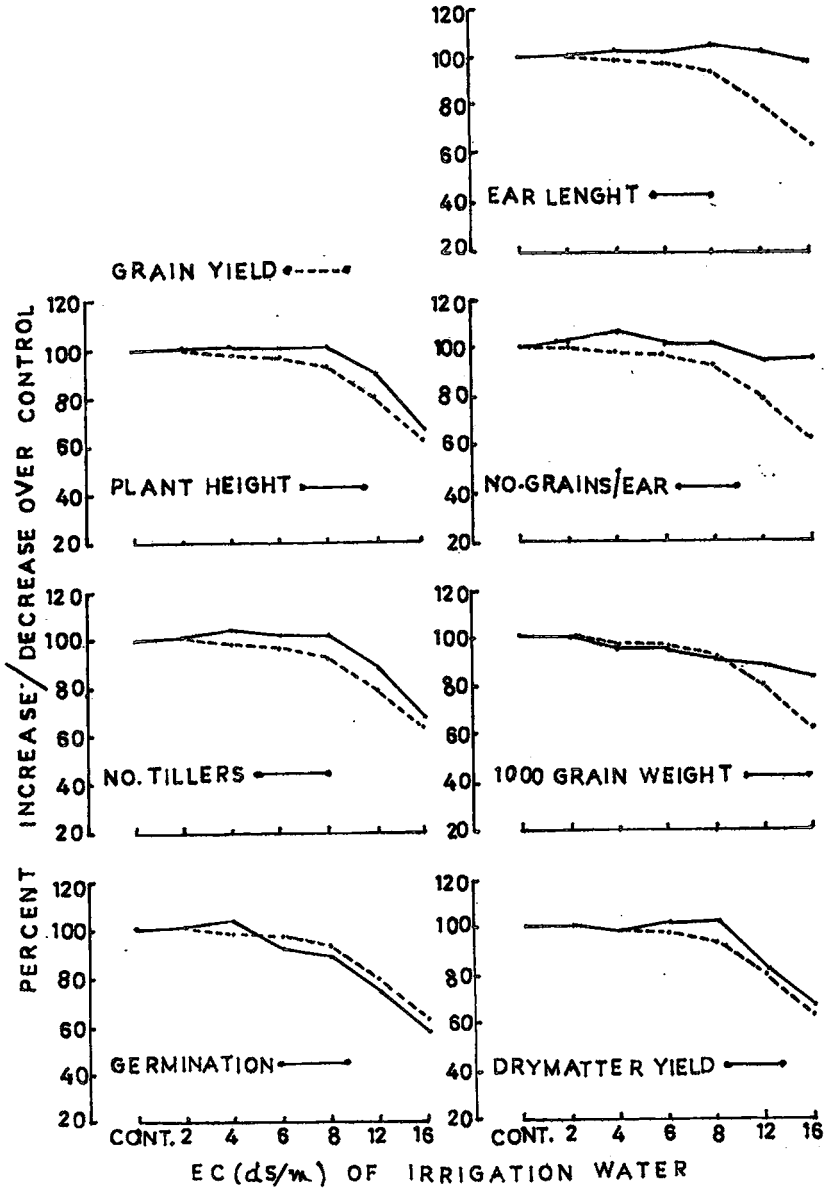

Fig. 1. Grain yield in relation to different plant characters of wheat under saline water irrigations (7 years average)

Thus it may be inferred that in light textured soils and semi-arid climatic conditions, wheat can be grown upto EC 8 ds/m comparable to control (canal water). The saline irrigation at EC 12 and 16 ds/m reduced wheat yield by 21 and 37 per cent over control and also significantly correlated ($r = -0.42$). The reduction in yield mainly caused by poor germination, tillering, stunted growth and to some extent by low 1000 grain weight.

Acknowledgement

The authors are very much thankful to I.C.A.R., New Delhi for financial assistance; Principal, Raja Balwant Singh College, Agra for providing necessary facilities and to the staff who made this ivestigation a success.

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Changes in ribonucleases and protein content after powdery mildew inoculation on different genotypes of wheat

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Wheat, which is one of the most important cereals, is affected by various fungal diseases. Powdery mildew (*Erysiphe graminis* f.sp. *tritici*) is an obligate fungal pathogen. Infection on higher plants by the pathogen is accompanied by major changes in the metabolism of the host. Changes in soluble protein content takes place during pathogenesis (De WITT *et al.*, 1980) and new proteins. are also synthesized (GIANINAZZI *et al.*, 1980). Role of ribonucleases in disease resistance has been reported by ROHRINGER *et al.* 1961, RANDLES 1968, and SUTTON & SHAW 1982. In vew of this, role of proteins and ribonucleases were studied during pathogenesis in different lines of wheat carrying powdery mildew resistant genes and susceptible cultivars.

Materials and Methods

Material consisted of 14 genotypes with different powdery mildew (Pm) resistant genes in donor parents (P) and crossed with Chancellor variety in hybrid combination (H) along-with susceptible cvs Chancellor, Lal bahadur, Agra local and Kharchia local.

Plants were raised in glass house under controlled conditions. After 100 days of germination one set of pots were inoculated with Pm pathogen with the procedure given by ARYA (1962) with little modifications. One set of pots were kept free from disease *i.e.*, healthy uninoculated. Protein estimation and enzymatic studies were conducted on inoculated and healthy genotypes after 10th, 15th and 20th day of inoculation on 100 day old plants.

The extract was prepared by homogenising 2g of sample material in prechilled mortar and pestle. The homogenate was centrifuged at 12,000g for 20 min at 0°C. Soluble proteins were estimated by dye binding method of BRADFORD (1976) and ribonuclease I (RNase I) and combined ribonuclease II and nuclease I (RNase II + Nu I) activities were determined by the procedure of SODEK & WRIGHT (1969) with some minor modifications. The spectrophotometric readings were converted to standard units as described by WILSON (1975) and the specific activity was calculated from these units.

Results and Discussion

Total soluble protein content in resistant and susceptible genotypes and in both inoculated and healthy plants showed no marked difference at the 10th day stage. At 15th day stage, protein content was generally less in the inoculated and healthy genotypes of resistant plants in relation to

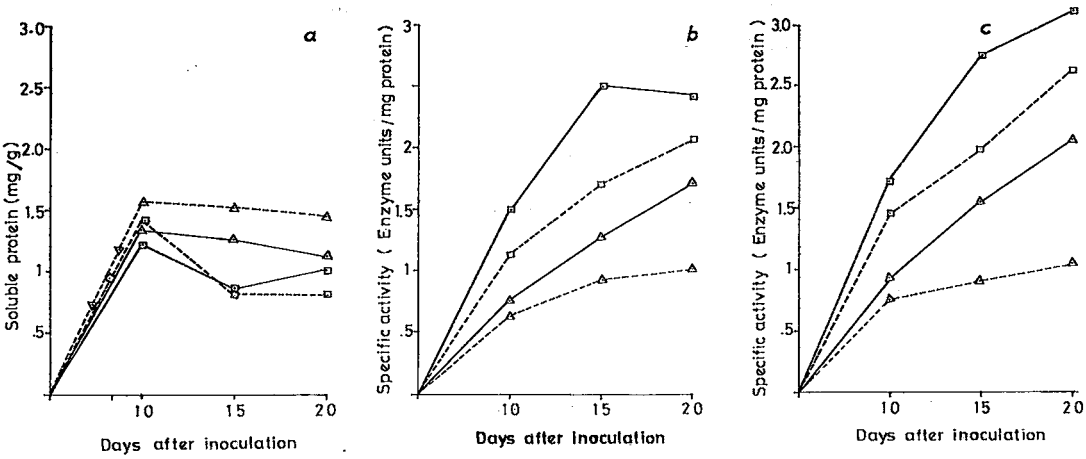

Fig. 1. Changes in soluble protein content (a), and specific activities of ribonuclease I (b) and combined ribonuclease II + nuclease (c) at different days after inoculation with powdery mildew on wheat genotypes. In figures: —□— inoculated resistant, —△— . inoculated susceptible, ---□--- healthy resistant, - - - △- -healthy susceptible.

susceptible genotypes. There was little increase or decrease at the 20th day stage. However, the soluble protein in resistant genotypes was lower as compared to susceptible genotypes (Fig. 1a). JOHNSON *et al.* (1968) also did not observe any variation between healthy and inoculated leaves infected with *Erysiphe graminis* f.sp. *hordei* and in wheat leaves infected with *Puccinia recondita.*

RNase I activity showed a gradual increase in resistant and susceptible plants and also in healthy and inoculated plants from 10th day to 20th day stage. There was almost 2 to 3 fold increase in activity in respective categories. RNase I specific activity was generally high in inoculated plants as compared to healthy plants at different leaf stages (Fig. 1b). ROHRINGER *et al.* (1961) observed similar increase in wheat leaves infected with rust. CHAKRAVORTY & SCOTT (1979) reported changes in catalytic properties and substrate preference of the enzyme in barley leaves inoculated with *E. graminis* f.sp. *hordei.* Two fold increase in activity was observed at the 15th day stage in inoculated plants over healthy plants. Specific activity was found to be low in case of susceptible genotypes as compared to resistant genotypes at three different leaf stages. However, FRIC (1975) observed an increase in activity in susceptible lines of barley upon infection by *E. graminis* as compared to resistant lines. In the present study, probably the resistance mechanism exhibited by the host may be due to a high amount of ribonuclease activity as observed in the case of peroxidase (SEEVERS *et al.* 1971).

The specific activity of RNase II + Nu I in inoculated plants showed a gradual increase from the 10th day to the 20th day stage which was almost two fold. In healthy resistant plants also there was 2 fold increase in activity except for susceptible genotypes where there was no substantial increase (Fig. 1c). The activity was more in inoculated plants compared to healthy plants at different stages. The activity was high and almost 2 times for resistant genotypes in both healthy and inoculated plants as compared to susceptible genotypes. The combined RNase II + Nu I specific activity was more as compared to RNase I at different stages of seed germination. SODEK & WRIGHT (1969) observed more of RNase II + Nu I activity in wheat leaves following detachment.

Acknowledgement

Financial assistance received from the University is gratefully acknowledged.

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Effect of salt stress on germination, growth and nutrient composition of *Aegilops* and *Triticum*

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Salinization of soils and water poses a significant threat to many agricultural crops, particularly in arid and semi-arid regions of the world. (BLACK 1968, KRAMER 1983, PAL *et al.* 1984, RABIE *et al.* 1985). Soils in these areas are poorly leached due to the absence of significant rainfall. As more land is brought into crops production through water development, the salinity problem expands. They either already contain high soil concentrations of Na^+ and other potentially toxic anions like Cl^-, SO_4^{2-}, CO_3^{2-} and HCO_3^-, or are going to accumulate these ions due to the combined effects of irrigation practices and high evaporative demand. Poor soil drainage combined with improper irrigation practices contribute significantly to the increasing salinization of the soil (BOHN *et al.* 1979). Rather than being leached, soluble salts accumulate and attain levels which is inhibitory to crop growth. This situation is aggravated by the increasing burden of salts carried in irrigation water. The problem of salinity has been very widely studied and the results obtained have indicated that while, a number of species respond favourably to different levels of salinity, others are adversely affected. To exploit these regions which are otherwise suitable for cereals production, new cultivars/species are required which are capable of overcoming the deleterious effects imposed by saline conditions.

The salt tolerance of crops has gernerally been expressed as the yield decreased expected for a given level of soluble salts in the root medium as compared with yield under nonsaline conditions (MAAS & HOFFMAN, 1977). There are several factors which influence salt tolerance in plants. The most important among these are species, temperature, salt composition, the growth stage of plant, salinity level, environmental variables, soil fertility and cultivars. Under conditions of high salinity, stunted growth, nutrient imbalance and deep bluish green foliage of plants followed by low production are common observations. Thus under saline water cultivation, it is best to grow tolerant crops and their varieties, as most of them, by virtue of their low moisture requirement and higher osmotic pressure, have better tolerance to the conditions.

The effect of salinity on the chemical composition of plants and nutrient uptake has also been reported differently. A number of investigators (BALBA 1961, EL-SHOURBAGY & MISSAK 1975, SHIMOSE 1968), demonstrated that nutrient uptake by certain plant species is curtailed by salinization. On the other hand, under certain experimental condition, salinization results in promotion rather than an inhibition of nutrient uptake (ASANA & KALE 1965, MAAS *et al.* 1972). Little is known about the investigation of salt tolerance potential of *Aegilops* and *Triticum* species on the absorption of mineral nutrients. The study of *Aegilops* and *Triticum* species with the ability to germinate, emerge and grow rapidly and reliably from salt-afflicted soils

has not been widely investigated. The first exposure of the crop to salinity stress would occur at the germination stage and would likely proceed under high surface soil salinities than would be the case for later growth stages. (BERNSTEIN & HAYWARD 1958). In the present investigation, an attempt was made to study the effect of different concentrations of NaCl and Na_2SO_4 applied together on germination and elemental content by *Aegilops* and *Triticum* species gwon in Tando Jam, Sind and to identify salt tolerant and salt sensitive *Aegilops* and *Triticum* species.

Materials and Methods

Preliminary screening was carried out by testing the germination of three wild species *Aegilops bicornis* (V_1), *Aegilops ovata* (V_2), *Aegilops tauschii* (V_3) and *Triticum dicoccum* (V_4) and *Triticum monococcum* (V_5), provided by Plant Genetics Division, AEARC, Tando Jam, Sind.

(i) Germination trials:

This experiment sought only to determine the best qualified candidate for soil salinity pot studies and further experimentation. Ten healthy seeds of three *Aegilops* and two *Triticum* species were sown on whatman filter paper No. 41 placed in petri dishes and uniformly moistened by submerging them in solution containing equal weights of NaCl and Na_2SO_4 to produce water salinity levels of 0.0, 0.2, 0.4 and 0.6%. The petri dishes were placed in a dark growth room for the purpose of germination at a temperature of 25°C in a randomized experimental design with four replicates. The germination counts were taken after 120 hrs. Seeds which produced a combined radicle and hypocotyl length of 2 mm were considered germinated. Germination results in the salinities solution are reported as a percent of germination in the control solution for each species. After counting the number of seeds germinated, the shoot length of seedlings was also measured.

(ii) Pot experiment:

To study further the growth and elemental composition of three *Aegilops* and *Triticum* species four healthy seedlings of unfirm height of each specie used for germination test were transferred carefully to earthen pots containing 3.7 kg of alluvial soil (pH 7.8, N 0.075% and O.M. 0.545%) and previously fertilized with 120 kg N/ha, 60 kg P_2O_5/ha and having the same level of four salt concentrations as were used for germination test *i.e.* 0.0, 0.2, 0.4 and 0.6% NaCl and Na_2SO_4 in equal volume. The pots after transplanting the seedlings were kept in a pot house according to a completely randomized design with four replicates. All the normal cultural practices were followed during the growth of the crops. The mean maximum and minimum temperatures of the pot house were 28°C and 20°C. After 8 weeks, one plant from each replicate was harvested, washed with distilled water, blotted dry, dried in an oven at 70°C and weighed. The dried samples were finely ground into a fine powder and assayed for mineral ions determination after wet-digestion with H_2SO_4 and H_2O_2. From the digested sample Na, K, Ca contents were measured by flame photometry. Phosphorus content in the plant was determined by molybdoyellow colour method and total N by modified micro-Kjeldahl method (JACKSON 1958). Iron and Mn were determined colorimetrically using orthophenonthroline and periodate reagents (JACKSON 1958).

Table 1. Effect of salt concentration on germination percentage of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean[1)]
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	85.78	84.10 (98.0)	79.45 (92.6)	66.83 (77.9)	79.04 d
Ageilops ovata (V_2)	98.50	96.40 (97.8)	92.83 (94.2)	89.63 (90.9)	94.34 a
Aegilops tauschii (V_3)	99.25	96.90 (96.81)	91.8 (92.4)	88.18 (88.8)	94.03 a
Triticum dicoccum (V_4)	94.23	94.05 (99.8)	89.15 (94.6)	85.75 (91.0)	90.79 b
Triticum monococcum (V_5)	93.65	93.28 (99.6)	88.9 (94.9)	81.25 (86.7)	89.27 c
Mean	94.28 a	92.95 b	88.43 c	82.33 d	

		V	T	V x T
LSD	0.05	0.88	0.79	1.76
LSD	0.01	1.17	1.05	2.34
	S.E.	0.312	0.279	0.623

(1) Mean values followed by the same letter do not differ significantly at 5% level.
Figures given in parenthesis show percentage of control.

Results and Discussion

Data presented in Table 1 where 3 *Aegilops* and 2 *Triticum* species were screened for their germination test indicate that increasing salinity levels (0.2% to 0.6%) had significantly decreasing effect on germination percent. The specie Aegilops bicornis (V_1) had the lowest germination percentage (77.9%) differing significantly from the other four cultivars. On the average, germination percentage of the remaining four differed slightly from one another (86 to 81.0%). It is assumed that in addition to the toxic effects of certain ions, higher concentration of salts can cause ionic imbalance as well as contribute to osmotic maladjustment, reducing the water potential in the medium which hinders water absorption by germinating seeds and thus reduces germination (MAAS & HOFFMAN 1977). The toxicity of higher concentrations may also be due to Na or SO_4 induced Ca deficiency or to Na or Ca induced K deficiency (BERNSTEIN 1975).

Table 2 summarizes the mean shoot length of the five species. Shoot length of all the species variously decreased by increasing salinity levels. *Triticum monococcum* (V_5) seemed to be the most tolerant one (56.2%) and the *Aegilops bicornis* (V_1) the sensitive one (29.3%) at the highest salinity level, while the percentage decrease at the highest salinity level (0.6%) in the remaining species did not differ much and vary from 41.1% to 49.8%.

Increasing salinity levels (0.2 to 0.6%) significantly decreases leaf dry weight of all the species (Table 3). However, the most tolerant species was *Aegilops tauschii* (V_3) having

Table 2. Effect of salt concentration on coleoptile length 120 hrs. after emergence

Species	Concentration (%)				Mean[1)]
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	3.99	3.58 (89.7)	1.99 (49.8)	1.17 (29.3)	2.68 c
Aegilops ovata (V_2)	4.16	3.21 (77.1)	1.85 (44.4)	1.71 (41.1)	2.73 c
Aegilops tauschii (V_3)	4.55	3.05 (67.0)	2.37 (52.0)	2.23 (49.0)	3.05 b
Triticum dicoccum (V_4)	5.02	3.38 (67.3)	2.41 (48.0)	2.50 (49.8)	3.33 a
Triticum monococcum (V_5)	2.40	1.59 (66.2)	1.42 (59.1)	1.35 (56.2)	1.69 d
Mean [1)]	3.54 a	2.96 b	2.01 c	1.79 d	

	V	T	V x T
LSD 0.05	0.04	0.04	0.08
LSD 0.01	0.06	0.05	0.11
S.E.	0.015	0.0134	0.03

1) Mean values followed by the same letter do not differ significantly at 5% level.
Figures in parenthesis show percentage of control.

84.8% growth at the highest salinity level (0.6%) when compared with control. Similarly the most sensitive one was *Triticum dicoccum* (V_4) having 40.4% reduction at the maximum salinity level. It was also observed that degree of reduction increased proportionally with the increasing concentration of salts. Inhibition of growth by salinity is due to the inhibitory effect of ions. As a result of this inhibition carbo-hydrates and nitrogenous substances are not fully utilized (STROGONOV 1962).

However, salinity also damages the mechanism of control of intracellular orthophosphate (Pi) concentration (Mass and Hoffman, 1977) and could be expected to adversely affect growth.

The decrease in growth of different crops with increasing salinity have been reported (ALAM *et al.* 1986, RABIE *et al.* 1984, PAL *et al.* 1984, VERMA and NEUE, 1984, FAGERIA 1985, BHIVARE and NIMBALKAR 1984). The reduction in dry matter yield under a salt stressed environment is probably due to the osmotic effect which lowers the osmotic potential of the medium, a possibility under arid and semi-arid environs (HOFFMAN & RAWLINS 1971).

Considerable differents in the mineral elements content of leaves of the test plants were induced by the different salinity levels (Table 4-10). Sodium content of all the species was highly significantly increased at increasing salinity levels (Table 4). The increase was almost linear with the increasing salt concentration. LUNIN *et al.*, (1964) with vegetable crops and

Table 3. Effect of salt concentration on leaf dry weight of *Aegilops* and *Triticum*

Secies	Concentration (%)				Mean [1]
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	0.41	0.25 (60.98)	0.25 (60.98)	0.26 (63.41)	0.291 e
Aegilops ovata (V_2)	0.46	0.59 (128.3)	0.34 (73.9)	0.25 (54.3)	0.41 c
Aegilops tauschii (V_3)	0.33	0.41 (124.2)	0.36 (109.1)	0.28 (84.8)	0.34 d
Triticum dicoccum (V_4)	0.89	0.59 (66.3)	0.46 (51.7)	0.36 (40.4)	0.57 a
Triticum monococcum (V_5)	0.72	0.54 (75.0)	0.48 (66.6)	0.39 (54.2)	0.53 b
Mean [1]	0.561 a	0.476 b	0.376 c	0.307 d	

	V	T	V x T
LSD 0.05	0.019	0.017	0.039
LSD 0.01	0.026	0.023	0.051
S.E.	0.0068	0.006	0.014

1) Mean values followed by the same letter do not differ significantly at 5% level.
Figures given in parenthesis show percentage of control.

Table 4. Effect of salt concentration on sodium content of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	0.371	0.422	0.527	0.516	0.457 a
Aegilops ovata (V_2)	0.313	0.410	0.591	0.637	0.488 b
Aegilops tauschii (V_3)	0.331	0.420	0.506	0.614	0.468 c
Triticum dicoccum (V_4)	0.342	0.381	0.392	0.423	0.385 d
Triticum monococcum (V_5)	0.210	0.222	0.324	0.439	0.299 e
Mean	0.313 d	0.371 c	0.468 b	0.572 a	

	V	T	V x T
LSD 0.05	0.004	0.004	0.009
LSD 0.01	0.006	0.005	0.011
S.E.	0.0015	0.0014	0.003

Table 5. Effect of salt concentration on nitrogen content of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	2.48	2.51	2.61	2.70	2.57 a
Aegilops ovata (V_2)	2.38	2.40	2.47	2.55	2.45 b
Aegilops tauschii (V_3)	2.31	2.35	2.37	2.49	2.38 c
Triticum dicoccum (V_4)	2.27	2.35	2.42	2.53	2.39 c
Triticum monococcum (V_5)	2.23	2.32	2.42	2.52	2.37 c
Mean	2.33 d	2.39 c	2.46 b	2.56 a	

	V	T	V x T
LSD 0.05	0.017	0.016	0.035
LSD 0.01	0.023	0.021	0.046
S.E.	0.0061	0.005	0.0123

EL-SHOURBAGY & MISSAK (1975) with three varieties of castor bean reported that sodium increased progressively with saline irrigation. The extent of Na accumulation with saline solution varied among the five test species; the highest was estimated in *Aegilops bicornis* (V_1) which normally contain the highest concentration of sodium.

The total nitrogen content of leaves of all the test soecies was highly significantly increased at all salinity levels (Table 5), and the increase was almost linear with the increasing salinity levels. ALAM *et al.* (1986) reported an increased nitrogen content in three vegetable crops at increasing salinity levels. On the other hand, salinity induced a reduction in the total N content of wheat and radish (HEIKAL 1977). Similarly, HUTTON (1971) with leguminous crops, PAL *et al.* (1984) with barley, BALKI and PODOLE (1982) with rice and MASHHADY *et al.* (1982), with maize reported that salinity resulted in a reduction in total nitrogen content. The phosphorus content in all the test plants increased with increase salinity levels. The highest content of P was recorded in *Aegilops bicronis* (V_1), while in the rest of species, P content was more or less same (Table 1). The reports indicate stimulatory (ALAM *et al.* 1986, MATOH *et al.* 1986, SAMENI *et al.* 1980) as well as inhinitory (AGARWALA *et al.* 1981, STARCK & CZAJKOWSKA 1981) effect on P content.

A reduction in content of K in the tops of *Aegilops* and *Triticum* species at all the levels of NaCl and Na_2SO_4 salinities was noticed (Table 7). However, favourable JOOLKA *et al.* 1977, GORHAM *et al.* 1985, MATOMATSU *et al.* 1982) as well as adverse (HAJRASULIHA 1980, GIRIRAJ *et al.* 1976) effects of salinization on K content in different agricultural crops have been reported. The decrease in K and increase in Na concentration in all *Aegilops* and *Triticum* species with increasing salinity symbolizes the antagonism between Na and K. Among the species, *Aegilops bicornis* (V_1) has greater preference for the uptake of K even under stress condition.

Calcium content significantly increased progressively in all the species with increasing salinity levels (Table 8). ASANA & KALE (1965) with four varieties of wheat, GEORGE

Table 6. Effect of salt concentration on phosphorus content of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	0.249	0.276	0.338	0.351	0.303 a
Aegilops ovata (V_2)	0.212	0.220	0.220	0.242	0.256 b
Aegilops tauschii (V_3)	0.219	0.240	0.259	0.311	0.256 b
Triticum dicoccum (V_4)	0.189	0.209	0.233	0.273	0.225 d
Triticum monococcum (V_5)	0.200	0.217	0.289	0.323	0.239 c
Mean	0.214 d	0.232 c	0.272 a	0.309 b	

	V	T	V x T
LSD 0.05	0.002	0.0017	0.004
LSD 0.01	0.003	0.0024	0.005
S.E.	0.00070	0.00063	0.0014

Table 7. Effect of salt concentration on potassium content of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	3.89	3.07	2.86	2.71	3.13
Aegilops ovata (V_2)	2.98	2.79	2.73	2.59	2.77
Aegilops tauschii (V_3)	2.77	2.66	2.59	2.50	2.63
Triticum dicoccum (V_4)	2.79	2.65	2.59	2.45	2.62
Triticum monococcum (V_5)	2.79	2.70	2.48	2.39	2.59
Mean	3.042	2.773	2.651	2.526	

	V	T	V x T
LSD 0.05	0.02	0.020	0.04
LSD 0.01	0.03	0.024	0.05
S.E.	0.0072	0.0064	0.0143

(1967) with some cereal crops, VERMA & NEUE (1984) with rice indicated that Ca content appreciably increased with increasing salinity levels. With increasing salinity levels the concentration of iron in all the test plants significantly increased (Table 9). The highest content of iron was recorded in *Aegilops bicornis* (V_1) and lowest in *Aegilops ovata* (V_2). This result confirms the finding of MAAS *et al.* (1972). On the other hand, a decrease in Fe in the tops of NaCl treated tomatoes plant has also been reported (ALAM *et al.* 1986). Mana-

Table 8. Effect of salt concentration on calcium content of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	0.336	0.372	0.376	0.384	0.367 a
Aegilops ovata (V_2)	0.310	0.359	0.365	0.376	0.353 bc
Aegilops tauschii (V_3)	0.292	0.309	0.336	0.402	0.334 cd
Triticum dicoccum (V_4)	0.290	0.306	0.339	0.366	0.325 d
Triticum monococcum (V_5)	0.291	0.313	0.335	0.358	0.324 d
Mean	0.304 c	0.332 b	0.350 b	0.377 a	

	V	T	V x T
LSD 0.05	0.016	0.014	NS
LSD 0.01	0.021	0.019	NS
S.E.	0.0057	0.0051	0.0113

ganese content decreased with increasing salinity levels in all the test plants (Table 10). Similar results have been reported by ALAM *et al.* (1986) with tomato plants.

It would appear that the response of different species to salinity depends on the degree of salt tolerance of these wild species and triticale and the extent of salinization of the growth medium.

Table 9. Effect of salt concentration on iron content of *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	216	241	271	292	255 a
Aegilops ovata (V_2)	188	198	240	279	226 d
Aegilops tauschii (V_3)	209	216	249	264	264 c
Triticum dicoccum (V_4)	210	229	279	291	252 a
Triticum monococcum (V_5)	215	225	254	290	243 b
Mean	208 d	222 b	258 c	281 a	

	V	T	V x T
LSD 0.05	3.67	3.28	7.33
LSD 0.01	4.88	4.36	9.75
S.E.	1.29	1.16	2.59

Table 10. Effect of salt concentration on the manganese content by *Aegilops* and *Triticum*

Species	Concentration (%)				Mean
	0.0	0.2	0.4	0.6	
Aegilops bicornis (V_1)	173	167	161	150	163 d
Aegilops ovata (V_2)	194	184	170	163	178 b
Aegilops tauschii (V_3)	202	195	192	182	193 a
Triticum dicoccum (V_4)	190	180	172	159	175 bc
Triticum monococcum (V_5)	185	178	168	159	162 c
Mean	189 a	181 b	172 c	162 d	

	V	T	V x T
LSD 0.05	2	2	4
LSD 0.01	3	3	6
S.E.	0.784	0.701	1.57

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Photosynthesis in wheat as influenced by leaf position, time of the day and presence of the sink

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Photosynthesis is the major component of biomass production. Photosynthetic potential depends on the area of the leaves and their photosynthetic efficiency over the growing period. Generally the uppermost fully expanded leaves were examined and measurements were made once in a day to characterise the photosynthesis rate of the plant (GIFFORD & EVANS 1981). There are reports however, of variation in photosynthesis rate among different leaves (DANTUMA 1973: HODANOVA 1981). Diurnal changes in photosynthesis rate have been reported in other species (UPMEYER & KOLLER 1973, PALLAS *et al.* 1974, KERR *et al.* 1985). One of the important factors which influences the rate of photosynthesis is the sink capacity (NEALES & INCOLL 1968, GIFFORD & EVANS 1981). In wheat, removal of sink (ear) led to inhibition of flag leaf photosynthesis (KING *et al.* 1967). AUSTIN & EDRICH (1975) however, were unable to confirm the ear removal response. In the present investigation we have examined some of these aspects in an *T. aestivum* wheat cultivar Kalyansona.

Materials and Methods

Wheat (*Triticum aestivum*) cultivar Kalyansona was raised in earthen pots (35 x 40 cm) containing sandy loam soil. Fertilizers were supplied at the rate of 120, 60 and 60 ppm respectively of N, P and K. N was supplied in two split doses, whereas P and K were given only at the time of sowing. Four healthy plants were kept in each pot which formed one replication. There were six replications for every determination at each sampling occasion.

Photosynthesis rate was measured by a battery portable infrared CO_2 analyser (ADC; UK) under saturated light conditions (PARKINSON *et al.* 1980). Parkinson leaf chamber for cereal leaves was used. Rate of photosynthesis was examined in the uppermost fully expanded leaf of main shoot (MS) 23 and 18 days before anthesis, at anthesis and 10 and 20 days after anthesis to examine changes in the rate during ontogeny. The rate of photosynthesis of the leaves at different position in the main shoot was examined at pre-anthesis, anthesis and post anthesis stages. Photosynthesis rate and stomatal diffusive resistance of the uppermost fully expanded leaf/flag leaf of the main shoot was also examined hourly from 10 AM to 4 PM at pre-anthesis, anthesis and post anthesis stages. The stomatal diffusive resistance was measured by a steady state porometer (Li- Cor LI 1600).

In order to examine the effect of sink on photosynthesis rate, ear removal treatments were given. In one of the treatments MS ears were removed as soon as they emerged whereas, in another, ears of both MS and tillers were removed. Photosynthesis rate of the flag leaf of main

shoot of control and de-eared plants was examined 10 and 20 days after anthesis observed in MS of control plants. The dry matter yields were recorded at the time of harvest.

Results

Photosynthesis rate of the uppermost fully expanded leaf showed a decrease from anthesis onwards (Table 1). The leaves at different positions in the MS did not differ significantly in photosynthesis rate 23 days before anthesis (Table 2). At anthesis however, the flag leaf and penultimate leaf had higher rate of photosynthesis and the rate decreased significantly towards lower leaves. At 20 days after anthesis lower leaves senesced and only flag leaf had some activity followed by the penultimate leaf.

The rate of photosynthesis was more during the forenoon and decreased towards the evening at both pre-anthesis and anthesis stages (Table 3). At 20 days after anthesis the net photosynthesis could be detected only in the initial two measurements *i.e.* at 10 and 11 AM. The stomatal diffusive resistance was less in the morning, increased during the mid day period and again decreased towards evening by 4 PM (Table 4).

Table 1. Photosynthesis rate of the leaves in wheat var. Kalyansona

Stage	μ mole CO_2 $m^{-2}s^{-1}$
Anthesis – 23 days	14.85
Anthesis – 18 days	18.27
Anthesis	11.17
Anthesis + 10 days	9.59
Anthesis + 20 days	4.28
C.D. at 5% P	2.44

Table 2. Photosynthesis rate of different leaves in the main shoot of wheat var. Kalyansona

(μ mole CO_2 $m^{-2}s^{-1}$)

Leaf position from the top	Anthesis -23 days	Anthesis	Anthesis +20 days
I	14.85	11.17	4.28
II	15.05	11.69	0.26
III	13.32	9.85	–
IV	13.16	7.90	–
C.D. at 5% P	NS	1.10	0.77

Table 3. Photosynthesis rate of the flag leaf of main shoot of wheat var. Kalyansona at different time of the day

(μ mole CO_2 $m^{-2}s^{-1}$)

Time of the day	Anthesis -18 days	Anthesis	Anthesis +20 days
10 AM	18.27	11.17	4.28
11 AM	17.61	12.04	0.86
12 Noon	16.34	9.50	–
1 PM	11.63	9.39	–
2 PM	9.59	8.07	–
3 PM	7.41	7.44	–
4 PM	7.20	8.21	–
C.D. at 5% P	2.43	2.87	0.61

Table 4. Stomatal diffusion resistance of the flag leaf of main shoot of wheat var. Kalyansona at different time of the day

(S cm^{-1})

Time of the day	Anthesis -18 days	Anthesis	Anthesis +20 days
10 AM	2.12	1.36	2.77
11 AM	2.75	1.01	5.63
12 Noon	3.28	1.75	*
1 PM	4.32	3.03	*
2 PM	3.09	1.98	*
3 PM	3.85	2.48	*
4 PM	2.29	2.25	*
C.D. at 5% P	1.13	0.65	1.13

* not recorded.

The effect of ear removal on rate of photosynthesis of the flag leaf of MS showed no significant difference ten days after anthesis (Table 5). At 20 days the photosynthesis rate was considerably more in treatments where ears were removed. It may be mentioned that flag leaf remained green for a longer period in treated plants. The MS weight and shoot weight of tillers were not significantly affected by removal of MS ears (Table 6). The ear weight of tillers however, was increased by this treatment. There was considerable increase in the shoot weight of tillers when ears of MS and tillers were removed. This appeared to be due to the formation of new tillers during the later stages of development when all the ears were removed.

Table 5. Effect of ear removal on the rate of photosynthesis of the flag leaf of wheat var. Kalyansona

(μ mole CO_2 $m^{-2}s^{-1}$)

Ear removed	Anthesis +10 days	Anthesis +20 days
None	9.59	4.28
MS	8.88	6.78
MS and Tillers	10.00	5.86
C.D. at 5% P	NS	0.48

4 plants/pot.

Table 6. Effect of ear removal on dry matter yield in wheat var. Kalyansona

Ear removed	Main shoot			Tillers			Total dry matter (MS + Tillers) g/pot
	Shoot g/pot	Ear g/pot	Total g/pot	Shoot g/pot	Ear g/pot	Total g/pot	
None	8.08	15.05	23.13	19.12	33.45	52.57	75.70
MS	8.60	–	8.60	19.66	37.10	56.76	65.36
MS and Tillers	8.12	–	8.12	36.80	–	36.80	44.92
C.D. at 5% P	NS	–	1.34	3.56	2.44	4.17	4.83

4 plants/pot.

Discussion

The present study showed diurnal changes in photosynthesis rate and stomatal diffusive resistance in wheat variety Kalyansona. The flag leaf of de-eared plants retained higher rate of photosynthesis in this cultivar.

Diurnal changes in photosynthesis rate have been reported in other species (UPMEYER & KOLLER 1973, PALLAS *et al.* 1974, KERR *et al.* 1985). In peanut the diurnal changes in photosynthesis seemed to be associated with stomatal component (PALLAS *et al.* 1974), but not so in case of soybean (KERR *et al.* 1985). In the present study photosynthesis rate decreased towards evening and this pattern was not parallel with stomatal diffusive resistance. It may be mentioned here that a decline in rate of net CO_2 assimilation with time of illumination in wheat has been reported (AZCON-BIETO 1983). This decline was greatest under conditions of reduced export or higher rates of photosynthesis and was found to be related to the carbohydrate concentration. The decline in photosynthesis rate later in the day in soybean was reported to be associated with leaf carbohydrate level (UPMEYER & KOLLER 1973).

The changes in photosynthesis rate during the ontogeny of the plant are in line with those reported earlier (RAWSON *et al.* 1983, GHILDIYAL & SIROHI 1986). The photosynthesis rate of the leaves at different positions in the main shoot was similar during the pre anthesis stage.

Subsequently, the upper leaves were comparatively more active (Table 2). It has been suggested that during pre-anthesis period there was enough demand for assimilates from all the leaves for the growth and differentiation of root and shoot (YOSHIDA 1972, GIFFORD & EVANS 1981). After ear emergence the ear became the major sink and root growth decreased considerably (ASANA 1968). The possibility of sink demand influencing the pattern of variation in photosynthesis rate among leaves at different positions in the MS may therefore, not be ruled out.

The removal of ears did not result in any significant change in photosynthesis rate of flag leaf when compared at an active grain development stage of control plants. At later stages the flag leaf of de-eared plants retained higher rate of photosynthesis. AUSTIN & EDRICH (1975) also found that ear removal did not affect the rate of photosynthesis of the subtending flag leaf. Their studies showed that a new pattern of translocation was established within 2-3 days of ear removal. Similar explanation may be valid for the present results in the sense that removal of MS ears increased the ear weight of tillers. The removal of ears of MS and tillers caused a remarkable increase in the shoot weight of tillers; suggesting the existence of alternative sink capacity. The roots, which may be the important sink for assimilates in de- eared plants and the weight of the ears at the time of their removal were not included in this study. This might be the reason for less dry weight of de-eared plants. The lower photosynthesis rate of flag leaf in control plants compared to de- eared plants at a later stage could possibly be due to a decrease in requirement of assimilates by the ear in control plants as it was approaching maturity and development of alternative sink capacity in de- eared plants.

Acknowledgement

This research has been financed in part by a grant made by the United States Department of Agriculture under the Cooperative Agricultural Research Program.

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II. Record

The following article should have been included in the record section of WIS No. 63 concerning to the abstract papers presented in The Small Symposium on Genome Reorganization and Developmental Abnormality in Wheat (held at Mishima, Japan). Editorial office would like to express sencere sorry for this mistake to the author and concerned people.

Genome rearrangement caused by a gametocidal chromosome in common wheat

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Previously, I reported that chromosome aberrations frequently occurred in the offspring from a cross between monosomic 4A and an alien chromosome addition line having a gametocidal chromosome derived from *Aegilops longissima* (2n = 14, S^1S^1), homoeologous to wheat group 4 chromosomes (Endo 1985a). In this study the effect of another gametocidal chromosome derived from *Ae. sharonensis* (2n = 14, S^1S^1) on the genome rearrangement in common wheat was studies. This chromosome, belonging to wheat homoeologous group 4, has the same gemetocidal action as the *Ae. longissima* chromosome, but they do not pair well and have different morphologies and N-banding patterns (Endo 1985).

As shown in Table 1, a Chinese Spring line with a disomic substitution of the *Ae. sharonensis* chromosome for chromosome 4A was selfed or crossed with euploid and monosomic 4A lines of Chinese Spring, and the chromosome constitutions of the progenies were studied by C-banding. It may be concluded from the data in the table that chromosome structural changes were induced only when the substitution line was used as the male parent, and that the aberrations occurred in zygotes, not in gametes because no chromosome structural changes were found in the selfed offspring of the substitution line. In a few cases, both of the homologues had deletions in the same cell, which is evidence that the genome rearrangement occurred in both genomes from the male and female parents. Moreover, the absence of chromosome 4A in zygotes seems to be critical for the induction of the chromosome abnormality; Among the offspring from the cross between the monosomic 4A and the substitution line, one or more chromosome structural changes were detected in 29 out of 55 (60%) plants without chromosome 4A, whereas only in four out of 14 (29%) plants with chromosome 4A.

Deletion and translocation were the major chromosome structural changes observed as the result of chromosome breakage. The chromosome arm or arms involved in them were identified by C-banding, being summarized in Table 2 as the frequency of breakage in each chromosome arm. Undoubtedly, a part of the chromosome structural changes must have been overlooked because such chromosomes as 1A, 4D, and 6D and minor structural changes were difficult to be identified

Table 1. Frequencies of plants with expected and aberrant chromosome constitution

Progeny from	No. plants examined	Expected chr. consti.	Aberrant chr. consti.
Chinese Spring × *sharonensis* sub.	47	44	3 (2)*
sharonensis sub. × Chinese Spring	28	25	3 (0)
sharonensis sub. self	68	66	2 (0)
Monosomic 4A × *sharonensis* sub.	69	35	34 (33)
Monosomic 4A × Chinese Spring	49	48	1 (0)

* Numbers in a parentheses indicate the numbers of plants having one or more chromosome structural changes; the other aberrants were aneuploids.

Table 2. Frequencies of chromosome breaks in each arm detected in the offspring of monosomic 4A pollinated with the substitution line

Chromosome	Short arm	Long arm	Chromosome	Short arm	Long arm	Chromosome	Short arm	Long arm
1A	–	–	1B	–	4	1D	1	5
2A	1	5	2B	3	2	2D	2	3
3A	2	3	3B	2	5	3D	1	5
4A	–	–	4B	4	2	4D	–	–
5A	2	1	5B	–	2	5D	1	2
6A	1	–	6B	2	4	6D	–	–
7A	2	5	7B	1	1	7D	–	2
sh	–	1						

Note: Indicates that no chromosome structural change was detected, and sh stands for the *Ae. sharonensis* chromosome.

by C-banding. The breakage in chromosome 4A was not detected mostly due to the absence of chromosome 4A in most of the offspring. Apparently chromosome breakage leading to deletion or translocation can occur in any chromosome arm; it occurred in the *Ae. sharonensis* chromosome itself. It is not known whether there was specific breakpoints or not.

A similar phenomenon is reported in a gametocidal chromosome of *Ae. speltoides* (TSUJIMOTO & TSUNEWAKI 1985). If these gametocidal chromosomes exert the same effect of genome rearrangement in the diploid species as in common wheat, they must have caused genome rearrangement whenever species without the gametocidal chromosome was pollinated with species with it, resulting in karyotype differentiation.

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III. Announcement

Seventh International Wheat Genetics Symposium

July 13th – 19th 1988
Cambridge, UK

International Organizing Committee: M Tanaka (Chairman); M D Gale, S S Maan, O Maystrenko, D Mettin, R de V Pienaar, G T Scarascia Mugnozza, K W Shepherd
Symposium Organizing Committee: Sir Ralph Riley (President); C N Law (Chairman); M D Gale, J W Snape, M D Bennett, J Bingham

The response to the first circular has been most encouraging and more than 500 people have indicated their interest in attending. In this second circular, further details about the Symposium are given but most important are the accompanying registration and booking forms. It is essential that you follow the instructions closely, and return these on or before the dates given so that the organizers can continue with arranging and planning the Symposium.

Location

The Symposium will be held in the Babbage Lecture Theatre in the University of Cambridge and also in the nearby Corn Exchange where the Plenary and Poster Sessions will be presented. Both sites are situated in the centre of Cambridge and are within walking distance of Queens' and King's Colleges, where most participants will be staying.

Wheat genetics and breeding in Cambridge

Cambridge, in East Anglia, is the seat of one of the oldest universities in the British Isles. It has a population of about 100,000 but the population of the immediately surrounding area is over 300,000. Architecturally the most interesting buildings in the city are those belonging to the University which is composed of 32 colleges, the first founded in 1284 and the most recent in 1985. The 'Backs', where historically interesting college buildings back onto the river Cam, often separated from it by immaculately kept lawns and gardens, are one of Cambridge's most attractive features.

The association of Cambridge University with genetics and plant breeding is very strong. William Bateson, the proposer of the term 'genetics', was the first of an illustrious series of Professors of Genetics which included Sir Ronald Fisher. Sir Rowland Biffen, the Professor of

Agriculture in the early part of this century, was one of the earliest research workers to apply genetic principles to wheat breeding. Biffen was also the founder of the Plant Breeding Institute which subsequently achieved a reputation as a centre for wheat breeding and genetics. The Institute site and breeding work has recently been sold to Unilever plc. However, most of the research work in wheat genetics still remains state-funded and forms part of the new Institute of Plant Science Research which, until 1990, will remain in Cambridge. During the Symposium visits to the former Plant Breeding Institute will be made to view demonstration plots of both the public and private groups.

The Scientific Programme

Following the recommendations made at the 6th International Wheat Genetics Symposium the scientific programme will include:

1. Special lectures of 30 minutes duration on selected topics considered to be of special interest to wheat geneticists (one per day after the first day).
2. Invited review papers of 20 minutes duration preceding and during each scientific session.
3. Contributed papers: either given orally (10 minutes) or as posters.
4. Evening workshops on particular topics: gene nomenclature with reference to biochemical and molecular markers: chromosome banding nomenclature: genome designations.

The Symposium will be divided into seven sessions covering the following topics:

Session I	Wheat evolution: species and genome relationships (including the cytoplasm); genetic resources.
Session II	Cytogenetics: transfer and use of alien genetic variation.
Session III	Genetic analysis of qualitative and quantitative characters: gene mapping (including biochemical and molecular markers), uses of marker systems.
Session IV	Molecular biology of wheat genes: *in vitro* culture techniques, transformation studies.
Session V	Genetics of resistance to pathogens and tolerance to environmental stress.
Session VI	Genetics of grain quality.
Session VII	Genetical approaches to breeding: the application of new breeding technologies (including haploids and hybrids).

On the recommendation of the International Organizing Committee there will not be a separate session on triticale as it is felt that this crop is now well covered by independent symposia. However, relevant papers are invited and will be included in appropriate sessions.

CIMMYT Pre-symposium Tour in Turkey

The Turkey/CIMMYT winter wheat programme in Ankara, Turkey, has tentatively offered a tour in the central Anatolian wheat growing areas and research Institutes, as well as of local sights. The cost and precise timing has not yet been fixed but the cost is likely to be reasonable and the tour will last for about four days. The time period will be either one or two weeks prior to the Symposium depending on response.

All arrangements will be handled by CIMMYT and interested parties should contact:

Dr. Bent Skovmand
CIMMYT
P.K. 120
Yenimahalle
Ankara
Turkey

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4. ABSTRACT	31 January 1988	Dr. J.W. Snape
5. PAPER	31 January 1988	T.E. Miller
6. LOCAL PARTICIPANTS	30 April 1988	Secretary of Administrative Committee

IV. Editorial Remarks

Announcement for Future Issues

WIS No. 67 will be planned for publication in September, 1988, Manuscripts for this issue are most welcome and accepted any time, not later than July 31, 1988.

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 × 7 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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Back numbers are available by order at cost price.

Acknowledgement

The cost of the present publication has been defrayed partly by the Grant-in-Aid for Publication of Scientific Research Result from the Ministry of Education, Government of Japan and contributions from Kihara Memorial Yokohama Foundation for Life Science Promotion. We wish to express our sincere thanks to those organizations. We should also like to express our sincere gratitude for favorable comments regarding WIS Nos. 1 ~ 64 and valuable contributions for the present issue. Increased support would be appreciated.

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Explanation of the Figure on the Cover

The symbol mark of the 7th Intern. Wheat Genetics Symposium at Cambrige, July 13 ~19th, 1988. See the detail informations described in pages 45~46 of this volume.

WIS No. 65

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横浜市立大学 木原生物学研究所内
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発行者 田 中 正 武

発行日 昭和 62 年 10 月 1 日

印 刷 株式会社 野 毛 印 刷 社
Tel. (045) 252-2511