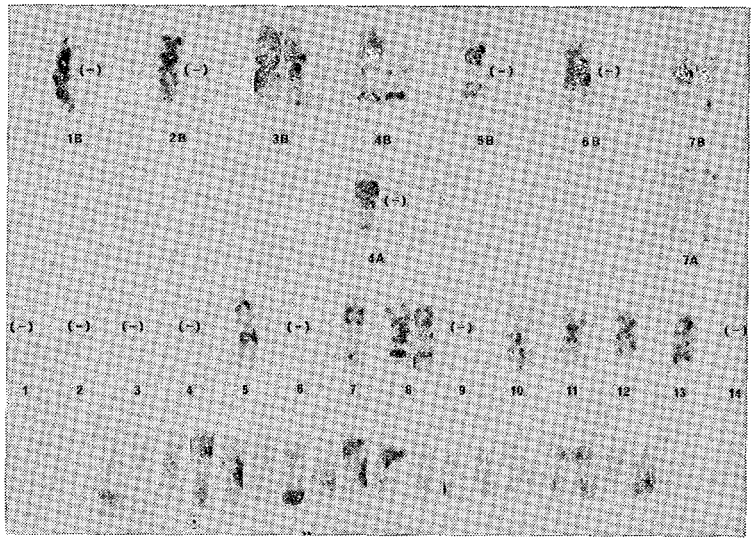
ISSN 0510-3517

WHEAT INFORMATION SERVICE



No. 55 September, 1982

Wheat Information Service
Kihara Institute for Biological Research
Yokohama, Japan

Contents

No. 54

WIS

September, 1982

I. Research Notes

Gene flow between the F_1 amphidiploid (*Aegilops sharonensis* × *Triticum monococcum*) and *Triticum turgidum dicoccoides* — Further evidence for *Aegilops sharonensis* as the putative donor of the B genome of wheat

U. KUSHNIR and G.M. HALLORAN

School of Agriculture and Forestry, University of Melbourne
Parkville, Victoria, 3052, Australia

Evidence from studies of cytoplasmic compatibility, chromosome pairing, plant morphology and karyomophology (KUSHNIR & HALLORAN 1982a) and from quantitative studies of developmental characters (KUSHNIR & HALLORAN 1982b) have recently been advanced for *Ae. sharonensis* as the putative donor of the B genome of wheat. The production of a fertile F_2 plant from the hybrid *T. turgidum dicoccoides* × F_1 amphidiploid (*Ae. sharonensis* × *T. monococcum*) reported in this paper is further support for *Ae. sharonensis* as the B genome donor of wheat.

Material and Methods

The amphidiploid used for this study was produced from the hybrid between a line of *Ae. sharonensis* line from an undisturbed habitat on the coastal plain in Israel and *T. monococcum* from Turkey. The amphidiploid was produced by the application of 0.05% colchicine solution to the hybrid seedlings. The line of *Triticum turgidum dicoccoides* used in this study was collected from the Upper Galilee of Israel. The hybrid between *T. turgidum dicoccoides* and the F_1 amphidiploid *Ae. sharonensis* × *T. monococcum* was planted in 15 cm diameter pots containing potting mix (1 part washed sand; 1 part perlite; 1 part Derrimut red brown loam by volume). It was grown in a glasshouse maintained 15–20°C in natural daylight over the winter period at Brumley Plant Sciences Research Centre, Mt. Derrimut, Victoria. The somatic chromosome number of the F_1 hybrid was determined from root tips of the germinating seed, which had been placed in colchicine (10^{-3}m) for 4 h and stained in 1%

acetocarmine for 48 h. For the meiotic studies spikes were collected and fixed in Carnoy's solution for 48 h, stored in 70 percent alcohol and stained in 1 percent acetocarmine. Pollen fertility was determined by dissecting mature anthers soaked in 2% acetocarmine. Grains were considered normal when they were rounded and deeply stained, and a sample of 1000 grains was examined. Seed fertility was determined by examination of two lower florets in the spikelet. A floret was considered fertile if it had a well-developed kernel. In the semi-sterile hybrid plant, seed set was determined by examination of all available spikes. In the more fertile F_2 plant a sample of 3000 florets (150 spikelets) was examined.

Results and Discussion

The hybrid between *T. turgidum* and the F_1 amphidiploid (*Ae. sharonensis* × *T. monococcum*) exhibited very low seed fertility of 0.03% and only one viable seed was obtained out of 75 bagged heads. This seed was germinated and its somatic chromosome number was found to be 2n=29. Since the meiotic chromosome pairing of the hybrid was found to be irregular (KUSHNIR & HALLORAN 1982a) with a mean of 8.11 bivalents per cell and with maximum of 12 bivalents per cell, only rare chromosome segregation close to normal gametic chromosome number of the tetraploid hybrid would be expected to lead to the production of functional gametes and development of viable seed. In these conditions

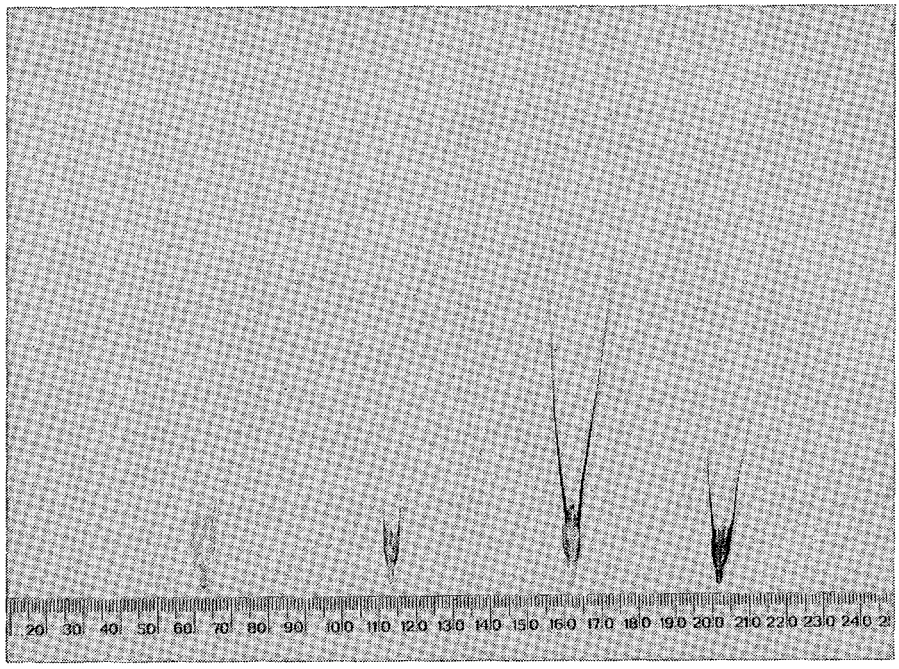


Fig. 1. Spikelet morphology (from left to right) of *T. turgidum dicoccoides* (large cereal type). The amphidiploid (*Ae. sharonensis* × *T. monococcum*), the F_1 and F_2 plants from the cross *T. turgidum dicoccoidies* × (*Ae. sharonensis* × *T. monococcum*).

Table 1. Chromosome pairing at first metaphase of meiosis in a F_2 plant of the hybrid between *T. turgidum dicoccoides* and the F_1 amphidiploid *Ae. sharonensis* × *T. monococcum* ($A^aA^mB^aB^{sh}$)

No. of cells examined	Univalents	Bivalents			Quadivalents
		Ring	Rod	Total	
104	2.00±0.13* (1-7)	10.62±0.13 (7-14)	2.86±0.14 (0-6)	13.48±0.06 (11-14)	0.01 (0-1)

* Figures are means±standard error and range

the appearance of the extra chromosome in the F_2 progeny is not surprising. This F_2 plant grew vigourously with a phenotype intermediate between its parents with spikelets of intermediate size and with the dominant blackish coloration from the F_1 amphidiploid parent (Fig. 1). It was examined cytologically (Table 1) and at first metaphase of meiosis it exhibited a mean bivalent frequency of 13.48 per cell. The mean frequency of 2 univalents per cell and range of 1–7 was caused mainly by the additional chromosome and, to lesser extent, by some partial asynapsis in the chromosome set of the tetraploid hybrid. The frequency of quadivalents was very low with only 0.01 per cell. *T. urartu* is considered by SEARS (1981) to be a variety of *T. monococcum* and hence the likely donor of the A genome of wheat. When it is crossed with hexaploid common wheat, chromosome 4A is the only chromosome which fails to pair with a chromosome from the diploid species (CHAPMAN *et al.* 1976; DVORAK 1976). It is therefore, assumed that the additional chromosome in the F_2 plant which appeared as a uinivalent in all pollen mother cells in this study is either chromosome 4A of the *T. turgidum dicoccoides* parent or chromosome 4Am from *T. monococcum* of the F_2 amphidiploid. This is the subject of a present study and will be reported elsewhere. The F_2 plant was of much higher fertility than the F_1 plant; pollen fertility was high (92%) and seed fertility was 54%. The seed was well-developed and viable. The production of such seed in the hybrid between *T. turgidum dicoccoides* and the F_1 amphidiploid (*Ae. sharonensis* × *T. monococcum*) is evidence for the possibility for gene flow between the genome of *Ae. sharonensis* and the B genome of wheat. Although this event would probably have been rare in nature it may have been of evolutionary significance.

Gene flow between any F_1 amphidiploids comprising any other *Aegilops* or *Triticum* species proposed as B genome donors and *T. monococcum* and the present day tetraploid wheat does not appear to be likely as shown for amphidiploids involving *Ae. speltoides* and *Ae. bicornis* (SEARS 1956) for *Ae. longissma* (TANAKA 1956, FELDMAN 1978) and *T. urartu* (DHALIWAL & JOHNSON 1982). TANAKA *et al.* (1978) showed that only after successive growing of the amphidiploid *Ae. speltoides* × *T. monococcum* from the F_1 to the F_{11} generation, the hybrid between the progressive generation and *T. turgidum dicoccum* yielded 2 F_2 viable seed. The F_2 plants were found to have only a low frequency of bivalents (mean of 6.96 per cell) and relatively high frequency of univalents and multivalents leading to poor seed fertility of only 4.1%. The possibility of gene flow between the F_1 amphidiploid (*Ae.*

sharonensis × *T. monococcum*) and the *T. turgidum dicoccoides* found in the present study in addition to the chromosome stability of this amphidploid and its high fertility and high prominents combining ability with *dicoccoides* (small grassy type) (KUSHNIR & HALLORAN 1982a, 1982b) serves as further support for *Ae. sharonensis* as the putative donor of the B genome of wheat.

Literature Cited

CHAPMAN, V., MILLER, T.E. and RILEY, R. 1976. Equivalence of the A genome of bread wheat and that of *Triticum urartu*. Genet. Res. Camb. **27**: 69–76.

DHALIWAL, H.S. and JOHNSON, B.L. 1982. Diploidization and chromosomal pairing affinities in the tetraploid wheats and their putative amphiploid progenitor. Theo. Appl. Genet. (In Press).

DVORAK, J. 1976. The relationship between the genome of *Triticum urartu* and the A and B genomes of *Triticum aestivum*. Can. J. Genet. Cytol. **18**: 371–377.

FELDMAN, M. 1978. New evidence on the origin of the B-genome of wheat. Proc. 5th Int. Wheat Genet. Symp. New Delhi, India, pp. 120–132.

KUSHNIR, U. and HALLORAN, G.M. 1982a. Evidence of *Aegilops sharonensis* Eig as the donor of the B genome of wheat. Genetics. **99**: 495–512.

——— and ——— 1982b. Quantitative studies of the amphidiploid (*Aegilops sharonensis* × *Triticum monococcum*) and the origin of the B genome of wheat. Wheat Inf. Serv. **54**: 12–16.

SEARS, E.R. 1956. The B genome of *Triticum*. Wheat Inform. Serv. **4**: 8–10.

——— 1981. Transfer of alien genetic material to wheat *in* Wheat Science Today and Tomorrow. *Ed.* Evans, L.T., and Peacock, W.J., Cambridge University Press, pp. 75–89.

TANAKA, M. 1956. Chromosome pairing and fertility in the hybrid between the new amphidiploid S^1 S^1-AA and emmer wheat. Wheat Inform. Serv. **3**: 21–22.

———, KAWAHARA, T. and SANO, J. 1978. The origin and the evolution of wild tetraploid wheats. Wheat Inform. Serv. **47**: 7–11.

Unexpected chromosome numbers in backcross I generations of F_1 hybrids between *Triticum aestivum* and related alien genera

D. JEWELL and A. MUJEEB-KAZI

CIMMYT, Apdo. Postal 6-641, Delg. Cuauhtemoc
06600, México D.F.

Self-sterile F_1 hybrids within the *Triticinae* are often partially female fertile. This allows successive generations to be obtained by backcrossing the F_1 hybrid to a common wheat parent with the eventual isolation of individual addition lines of the alien species as described by O'MARA (1940). The reason for the partial female fertility has been assumed to be due to the formation of unreduced female gametes.

The expected chromosome number in the first backcross generation (BC_1), based on the premise of unreduced eggs being the only functional gametes, has not been uniformly achieved.

MUJEEB-KAZI & BERNARD (1982) found a variation in chromosome numbers in BC_1 progenies involving *Agropyron, Triticum aestivum, T. turgidum* and *Elymus* species hybrids, as did PIENAAR for *T. aestivum*/*A. distichum* (1980).

An explanation has been offered for only some of these unexpected chromosome numbers. For example, apomixis (MUJEEB-KAZI 1981), chromosome elimination of the alien genome, and spontaneous doubling have been used to explain unexpected numbers of exact multiples of the expected. The derivation of the many other observed chromosome numbers has not been explained, possibly due to complexities involved in determining chromosome identification.

GERLACH (1977) demonstrated that 9 of the 21 wheat chromosomes could be identified using the N-banding technique. JEWELL (1979) confirmed the N-banding of wheat chromosomes and demonstrated that all 14 chromosomes of *Aegilops variabilis* also exhibited unique N-banding patterns which enabled them to be identified and differentiated from wheat chromosomes. The hybrid of *T. aestivum* cv. Chinese Spring and the tetraploid *Ae. variabilis* usually exhibits 35 univalents at metaphase 1 and there is less than 1 chiasmata per cell (DRISCOLL & QUINN, 1968). These plants are self-sterile. Therefore, the BC_1 plants should provide excellent material for chromosome analysis.

The technique used for N-banding analysis is described in detail by JEWELL (1981). However, for ongoing studies at CIMMYT, due to high altitude (above 2,225 m), it was necessary to adjust the technique because the normally used temperature of the acid buffer ($92°\pm1°C$) is not obtainable. At $87°C\pm1°C$ it requires 46 to 50 minutes in 1M NaH_2PO_4 buffer to produce good bands. However, the chromosome morphology is adversely affected

The research on the backross plants of Chinese Spring by *Aegilops variabilis* was undertaken while the senior author was at the Waite Agricultural Research Institute, University of Adelaide, Australia. Reprints may be requested from A. Mujeeb-Kazi.

by this length of treatment. Hence, it was more satisfactory to use 2M NaH_2PO_4 buffer for 25–28 minutes at 87 ± 1°C. Apart from this, the technique was the same as previously described (JEWELL 1981).

Table 1. Chromosome numbers observed in 20 BC_1 plants of (*Triticum aestivum* cv. Chinese Spring/*Aegilops variabilis*)//*T. aestivum* cv. Chinese Spring.

Chromosome No.	39	40	43	46	47	50	53	54	56	59	63
No. of plants	1	1	1	1	1	1	2	4	6	1	1

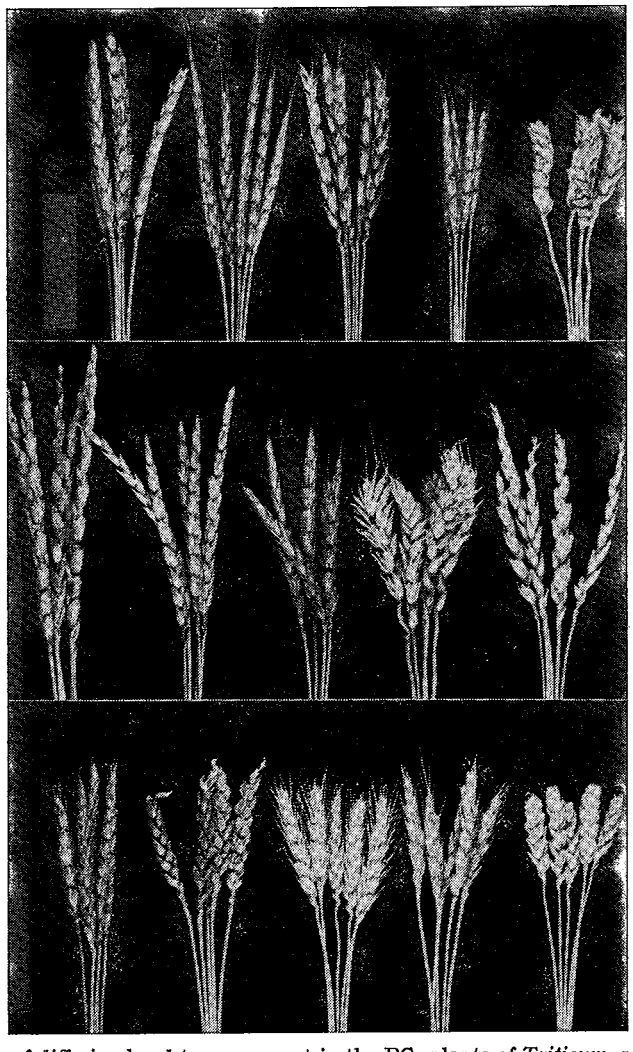


Fig. 1. A selection of differing head types present in the BC_1 plants of *Triticum aestivum* cv. Chinese Spring/*Aegilops variabilis*/ /*T. aestivum* cv. Chinese Spring. Each of the 15 examples of head type were from different BC_1 plants. The first five examples of head type were all taken from BC_1 plants containing the expected chromosome number of 56.

The F_1 of Chinese Spring and *Ae. variabilis* has 35 chromosomes (21 from wheat and 14 from *Ae. variabilis*). Therefore, the expected number in the BC_1 plants derived using pollen from Chinese Spring would be 56 (35 from the unreduced female gamete and 21 wheat chromosomes from the pollen parent). Twenty BC_1 seeds were randomly chosen for chromosome analysis using N-banding, and a range of chromosome number was observed between 39 and 63 (Table 1).

The aim of the analysis was to use N-banding to determine whether there were changes in the chromosome numbers of wheat, or *Ae. variabilis*, or changes in both chromosome complements in the BC_1 plants. Further, MUJEEB-KAZI (1981) has postulated that the meiosis of the F_1 plants must be slightly irregular in order to give rise to the unexpected numbers. The authors explored the possibility that partially reduced eggs may function producing BC_1 progeny of varied chromosome number.

N-banding analysis of the Chinese Spring/*Ae. variabilis* F_1 backcrossed to Chinese Spring demonstrated the following points:

i) At least 1 representative of the N-banded wheat chromosomes was always present.
ii) Some triplication of N-banded wheat chromosomes and some duplication of *Ae. variabilis* chromosomes were observed.
iii) The loss or duplication of chromosomes appeared to be random.
iv) The 56 chromosome plants did not have the expected 18 banded wheat chromosomes and 14 *Ae. variabilis* chromosomes, and their spike/morphology was different (Fig. 1).

The presence of one representative of each of the N-banded wheat chromosomes is expected from the pollen parent, and was observed. Thus, it would appear that partially reduced F_1 female gametes are indeed functional. The partially reduced gametes are assumed to result from random movement of univalents to the poles at anaphase 1 which is the normal occurrence when chromosomes do not have a homologue with which to pair. Further, the duplication of *Ae. variabilis* chromosomes and the triplication of wheat chromosomes are presumed to have arisen by division of the chromosome(s) involved at metaphase 1, followed by movement of both chromatids to the same pole.

Fig. 2 shows the N-banded karyotype of a 39-chromosome BC_1 plant of Chinese Spring/*Ae. variabilis*//Chinese Spring. If, as proposed above, the pollen contributes 21 chromosomes (9 banded and 12 unbanded), (the authors infer that) the functional female gamete had 18 chromosomes. Due to N-banding analysis, these 18 chromosomes can be grouped as follows: 4 of the expected 9 N-banded wheat chromosomes, 7 of the 14 *Ae. variabilis* chromosomes (one of which is duplicated, thus totaling 8 chromosomes) and, by inference, 6 of the 12 unbanded wheat chromosomes. The 6 unbanded wheat chromosomes may, of course, include duplicates. The results indicate that no one genome present in the F_1 is being preferentially excluded from the female gamete. To the best of our knowledge, these findings offer an explanation of unexpected numbers by assuming that some partially reduced gametes, formed by random movement of univalents to poles of anaphase 1, are functional, this being enhanced by the polyploid nature of the material.

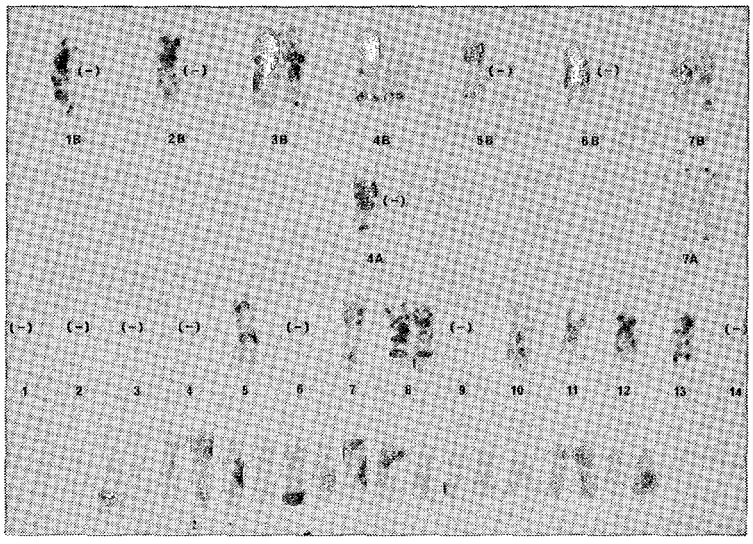


Fig. 2. The N-banded karyotype of a BC_1 plant (*Triticum aestivum* cv. Chinese Spring/*Aegilops variabilis*/ /*T. aestivum* cv. Chinese Spring) containing 39 chromosomes rather than the expected 56 chromosomes.

Some of these BC_1 plants are partially self-fertile and it is envisaged that, through selfing, novel combinations of chromosomes can be obtained; for example, several homoeologous and non-homoeologous substitutions of alien chromosomes in the one plant. These plants may be useful in plant breeding programs.

It has been demonstrated that hexaploid wheat, which is nullisomic for chromosome 5B, will exhibit a considerably increased amount of pairing between homoeologous chromosomes (RILEY & CHAPMAN 1958; SEARS & OKAMOTO 1958). This increase in homoeologous pairing may result from a greater similarity of sites for crossing over and is maximized in hybrids because of the absence of strict homologues (DRISCOLL *et al.* 1979)

Since some of the partially self-fertile BC_1 plants are monosomic for chromosome 5B, selfing of these plants is expected to give rise to plants deficient for chromosome 5B. The plants deficient for chromosome 5B should allow exchange of genetic material between wheat and homoeologous alien chromosomes. Further, it is possible that these plants may give rise to more genetic exchanges between wheat and the alien genera because of the expected higher level of univalency than in some other systems of using modifications of chromosome 5B.

Initial N-banding studies of the chromosomal complement of BC_1 plants of *T. aestivum*/ *A. elongatum*//*T. aestivum*, which exhibit unexpected numbers (RODRIGUEZ & MUJEEB-KAZI, 1981), have also disclosed a similar phenomenon; it appears that these numbers arise from a partially reduced egg cell, pollinated by normal wheat pollen (MUJEEB-KAZI & JEWELL, unpublished). Work is continuing in order to generalize this hypothesis for the *Triticinae*.

Acknowledgements

We are grateful to Professor C.J. Driscoll for his valuable criticism and advice on the manuscript and to Mrs.A. Povich, for editorial contributions.

References

DRISCOLL, E.J., BIELIG, L.M. and DARVEY, N.L. 1979. An analysis of frequencies of chromosome configurations in wheat and wheat hybrids. Genetics **91**: 755–767.

——— and QUINN, C.J. 1968. Wheat-alien hybrids involving a chromosome 5B translocation. Can. J. Genet. Cytol. **10**: 217–220

GERLACH, W.L. 1977. N-banded karyotypes of wheat species. Chromosoma (Berl.) **62**: 49–56.

JEWELL, D.C. 1979. Chromosome banding in *Triticum aestivum* cv. Chinese Spring and *Aegilops variabilis*. Chromosoma (Berl.) **71**: 129–134.

——— 1981. Recognition of two types of positive staining chromosomal material by manipulaiton of critical steps in the N-banding technique. Stain Technology, **56**: 227–234.

MUJEEB-KAZI A. 1981. Apomictic progeny derived from intergeneric *Hordeum-Iriticum* hybrids. Jour, of Hered. **72**: 284–285.

——— and BERNARD, M. 1982. Somatic chromosome variations in backcross 1 progenies from, intergeneric hybrids involving some *Triticeae*. Cereal Res. Communications. **10**: 41–45.

O'MARA, J.G. 1940. Cytogenetic studies of Triticale. I. A method for determining the effects of individual *Secale* chromosomes on *Triticum*. Genetics, **25**, 401–408.

PIENAAR, R. de V. 1980. A fertile amphiploid from the cross *Triticum aestivum* L. em Thell × *Agropyron distichum* (Thumb) Beauv. Wheat Inf. Serv. **51**: 13–14.

RILEY, R. and CHAPMAN, V. 1958. Genetic control of cytological diploid behavior of hexaploid wheat. Nature **182**: 713–715.

RODRIGUEZ, R. and MUJEEB-KAZI, A. 1981. Cytological variations in intergeneric hybrids involving *Agropyron* species, *Secale cereale*, *Triticum turgidum* and *Triticum aestivum*. 73rd Ann. Agr. Meetings, Agronomy Abstracts p. 71.

SEARS, E.R. and OKAMOTO, M. 1958. Intergeneric chromosome relationships in hexaploid wheat (Abstr.) Proc. X Int. Cong. Genet. **2**: 258–259.

A major deletion of part of chromosome 5A of *Triticum aestivum*

T.E. MILLER and S.M. READER

Plant Breeding Institute, Cambridge, England

Many aneuploid types have been established in bread wheat, *Triticum aestivum* (2n=6x=42). In the variety Chinese Spring nullisomics, monosomics, trisomics, tetrasomics, telocentrics, isochromosomes and nullisomic-tetrasomic compensating stocks exist (SEARS 1954; SEARS & SEARS 1978). However, few lines containing chromosomes with deletions of part of an arm have been established or reported despite their potential use for genetic analysis (SEARS 1977; GILL & KIMBER 1974; GIORGI 1978, 1981).

A line containing one complete chromosome 5A and one 5A with a major deletion of part of the long arm has been established in Chinese Spring.

The effects of the deletion were first observed in a disomic addition plant (2n=6x=44) of chromosome 5R of *Secale cereale* cv. Imperial to Chinese Spring. The plant had a hairy neck produced by the *Hp* gene on 5R but also exhibited the speltoid phenotype typical of the reduced dosage of the *Q* gene on 5A. Although not examined cytologically this plant presumably contained a single deletion chromosome as its progeny contained plants with one, two or no very short unequal armed chromosomes which could be recognised in mitotic metaphase preparations (Fig. 1a). Moreover, only those plants with the distinctive chromosome had the speltoid phenotype.

A disomic 5R addition containing a pair of the deletion chromosomes (20″+deletion″+1″5R) was crossed with Chinese Spring euploid and with Chinese Spring double ditelocentric 5A. The euploid cross produced plants that were monosomic 5R but contained a single deletion chromosome (20″+1/deletion″+1′5R). Self pollination of such a hybrid produced a plant lacking 5R but retaining a deletion chromosome (20″+1/deletion″, Fig. 1c), which still exhibited the speltoid phenotype (Fig. 1b).

The double ditelocentric cross gave plants that contained a 5R chromosome, a deletion chromosome and a long and a short telocentric 5A chromosome. At first metaphase of meiosis the 5R and the 5AL chromosomes remained unpaired, whereas the deletion chromosome and the 5AS chromosome formed a bivalent (20″+st/deletion″+1t′+1′5R, Fig. 1d). The *Q* gene is carried on 5AL (SEARS 1952) and the deletion chromosome produces a speltoid phenotype indicating the loss of part of 5AL. This is supported by the morphology of the deletion chromosome and confirmed by the double ditelocentric cross. Further evidence is provided by gel electrophoresis of ß-amylase isozymes. Chromosome 5A carries a gene *β-Amy-A2* at 22 map units from the centromere (GALE, AINSWORTH & BAIRD 1982). Gel electrophoresis of the 5R addition containing a pair of the deletion chromosomes showed that the *β-Amy-A2* gene was missing. The deletion point must therefore be less than 22 units from the centromere.

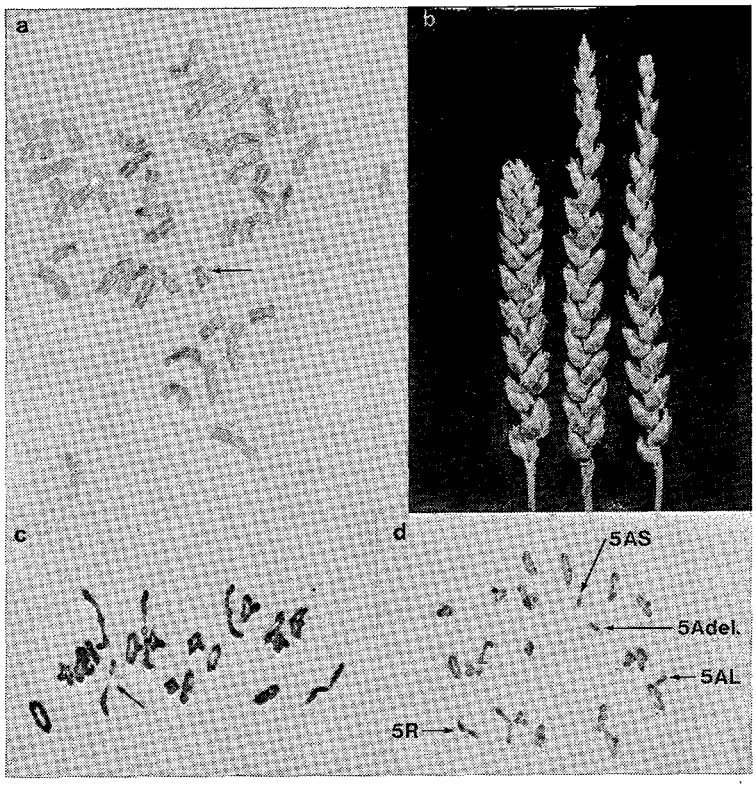


Fig. 1. a) Mitotic metaphase of *T. aestivum* cv. Chinese Spring with one 5A deletion chromosome (arrowed). b) Ears of Chinese Spring euploid, Chinese Spring monosomic 5A and Chinese Spring with one 5A deletion chromosome.
c) First metaphase of meiosis of Chinese Spring showing one complete 5A/deletion 5A bivalent (arrowed).
d) First metaphase of meiosis of the hybrid between addition 5R containing two 5A deletion chromosomes and Chinese Spring double ditelocentric 5A, 20″+st/deletion″+1t′+1′5R.

Self pollination of the Chinese Spring plant with a single deletion chromosome produced a progeny containing 45% of the parental type but failed to produce any disomic deletion plants. Also when crossed as male parent to Chinese Spring euploid no deletion chromosome was found in the progeny. Presumably the loss of the major part of 5AL in male gametes renders them incapable of competing with normal male gametes. However, in the disomic 5R addition containing two 5A deletion chromosomes transmission through the pollen did occur. Apparently the presence of the 5R homoeologue can compensate for the partial deficiency of 5AL. In fact this may be the mechanism which allowed such a major deletion to become established. A large deletion of this type, especially if arising in a male gamete, would in all probability be selectively eliminated.

Two further deletions, although not yet unequivocally identified, have been detected at Cambridge in other addition lines of alien chromosomes to wheat. One is in a 6R

addition of King II rye to Holdfast, and is a deletion in the long arm of one of the wheat satellited chromosomes, probably 6B. The other is in the Chinese Spring – *Hordeum vulgare* addition line C, produced by ISLAM, SHEPHERD & SPARROW (1981). This is the addition line containing the pair of satellited chromosomes which probably belong to homoeologous group 6 and the deletion is in the long arm of a wheat satellited chromosome again probably 6B.

It appears that chromosomes with deletions may survive more readily in alien addition lines where the effects of the resulting deficiency are compensated by the presence of an extra homoeologue. A closer investigation of addition lines using more critical techniques, such as C-banding and *in situ* hybridization of DNA probes, may detect further deletions which are too small to detect by routine cytological screening.

Literature Cited

GALE, M.D., AINSWORTH, C.C. & BAIRD, S. 1982. Allelic variation at β-amylase loci in hexaploid wheat. Proc. 4th Internat. Conf. on Isozymes. (In press).

GILL, B.S. & KIMBER, G. 1974. Giemsa C-banding and the evolution of wheat. Proc. Natl. Acad. Sci. (Wash.) **71**: 4086–4090.

GIORGI, B. 1978. A homoeologous pairing mutant isolated in *Triticum durum* cv. Cappelli. Mutation Breeding Neswletter **11**: 4–5.

———— 1981. A line with a deletion on the long arm of chromosome 6B isolated in *Triticum aestivum* cv. Chinese Spring. Wheat Inform. Serv. **50**: 22–23.

ISLAM, A.K.M.R., SHEPHERD, K.W. & SPARROW, D.H.B. 1981. Isolation and characterization of euplasmic wheat-barley chromosome addition lines. Heredity **46**: 161–174.

SEARS, E.R. 1952. Misdivision of univalents in common wheat. Chromosoma **4**: 535–550.

———— 1954. The aneuploids of common wheat. Univ. of Missouri, College of Agriculture, Agricultural Experimental Station, Research Bulletin 572.

———— 1977. An induced mutant with homoeologous pairing in common wheat. Can. J. Genet. Cytol. **19**: 585–593.

———— and SEARS, L.M.S. 1978. The telocentric chromosomes of common wheat. Proc. 5th Internat. Wheat Genet. Symp. Indian Acad. Sci. New Delhi, 389–407.

Frequency of aneuploids in euploid progenies of hexaploid *Triticale*

H.M.I. HAFIZ and A.S. LARIK*

Botany Department, New Campus, Punjab University,
Lahore, Pakistan

Synthetic hexaploid *triticales* are cytologically unstable, and segregate a certain frequency of aneuploids in the progeny of 42-chromosome euploids (TSUCHIYA & LARTER 1971). These anuploids, particularly hypoploids including monosomics and nullisomics, have been demonstrated to give lower seed set in the primary floret, fewer seeds per spikelet, per spike and per plant than those in the euploid with 42-chromosome (TSUCHIYA 1973). Moreover, these aneuploids segregate a high frequency of aneuploids in their progenies as reported by TSUCHIYA (1973) and TSUCHIYA & LARTER (1969).

The results obtained from the extensive study of meiotic chromosome variation in 300 plants from three cultivars (NIAB-T-77, NIAB-T-158-4 and NIAB-T-103) clearly indicate that the hexaploid *triticales* are cytologically unstable. Overall average frequency of euploids (2n=42) ranged from 14% to 22% for three cultivars (Table 1). The frequency of monosomics and nullisomics ranged from 45% to 48% and 30% to 40% in the progeny of hexaploid *triticales* respectively. Data in Table 1, obviously reveal that:

1) Hexaploid *triticales* are cytologically unstable. They segregate various frequencies of aneuploids in euploid plants.

2) The cytological stability represented by the frequency of euploids in the population is controlled at least to some extent, by a genetic factor(s). Similar results were also recorded by MERKER (1973) and TSUCHIYA (1969, 1974). MERKER (1973) and TSUCHIYA (1974) have reported higher frequencies of hypoploids and lower frequencies of euploids in advanced strains of hexaploid *triticales*. Telocentric chromosomes were not observed in the present material (NAKAJIMA 1953, 1965) and KROLOW (1966), while MERKER (1973) and

Table 1. Frequencies of euploids and aneuploids in three hexaploid *triticale* cultivars.

Cultivar	Pedigree	Method of formation	Euploids (2n=42) %	Monosomics (2n=41) %	Nullisomics (2n=40) %	Total plants analysed
NIAB-T-103	*Triticum durum* × *T. persicum* × Rye	Induced mutations	15	45	40	100
NIAB-T-77	May II Arm "S" (*triticale*) × 2802-9N-2M-3N-2Y-OM (*triticale*)	Hybridization	14	47	39	100
NIAB-T-158-4	(NIAB-T-77 × NIAB-T-103) × NIAB-T-77	Hybridization	22	48	30	100

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

TSUCHIYA (1969) reproted the occurrence of telocentric chromosomes. These differences may be attributed to the differences of the materials studied and the environmental effect on cytological behaviour in meiotic division. However, cytological techniques employed could also be one of the causes of the differences.

Based on male and female transmission rates, the expected frequencies of euploids and aneuploids were calculated and compared to the observed ratio. Observed frequencies of euploid and aneuploid plants were close to the calculated value. However, it is safe to say that aneuploid gametes are able to transmit even through the pollen to a considerable high frequency in hexaploid *triticale*. This finding is in conflict to the results reported by PIERITZ (1966) in octoploid strains which showed a strong selection against abnormal gametes. Further, these results suggest that monosomics (2n=41) and other hypoploids could be the sources of more aneuploids, particularly hypoploids in population of hexaploid *triticale*.

From cytological instability represented by the frequency of aneuploids in the euploid population, it is reasonable to assume that these aneuploids have been derived from the fertilization of abnormal gametes resulting from irregular meiosis.

The results suggest that screening of euploids is very important and highly desirable in plant breeding and practical cultivation of *triticale*. For this, critical study of meiosis and routine chromosome counts in each population are necessary in *triticale* breeding until truely stable strains are established.

References

KROLOW, K.D. 1966. Z. Pflanzenzucht **55**: 105–138.
MERKER, A. 1973. Hereditas **74**: 1–6.
NAKAJIMA, G. 1953. Jap. J. Breeding **2**: 178–184.
———— 1965. La Kromosomo **61**: 1999–2004.
PIERITZ, W.J. 1966. Z. Pflanzenzucht **56**: 27–69.
TSUCHIYA, T. 1969. Wheat Newsletter **15**: 10–17.
———— 1973. Euphytica **22**: 592–599.
———— 1974. Triticale: First Man-Made Cereal. p 62–89.
———— and E.N. LARTER. 1969. Wheat Inf. Serv. **28**: 16–18.
———— and ———— 1971. Euphytica **20**: 591–596.

Seed setting and germination in crosses of AB-genome monosomic lines of Pb C 591 × Bijaga Yellow and their back cross generations in wheat*

R.R. HANCHINAL and J.V. GOUD

Department of Agricultural Botany, University of Agricultural Sciences, Dharwad Campus, Karnataka, India

Seed setting is a major problem in interspecific crosses. Variation in chromosome numbers in the two species used for crossing may be one of the reasons, which leads to the failure in fertilization, because of the imbalance of the chromosomes in the female and male gametophytes. Sometimes, though there is fertilization, the embryo abortion during the development stages is observed. Even if there is seed set, seeds are weak and shrivelled. Such seeds lack the proper development of embryo and endosperm. When such seeds are germinated, drastic reduction in germination is noticed.

WATKINS (1927), BOYES & THOMPSON (1937) and THOMPSON & CAMERON (1928) etc. studied the seed setting and germination in interspecific crosses between hexaploid wheat and tetraploid wheat. But the present investigation includes the seed setting and germination of crosses between AB-genome monosomic lines of Pb C 591 (*Triticum aestivum*) and Bijaga Yellow (*T. durum*) and their back cross generations.

Material and Methods

The first fourteen monosomic lines of hexaploid wheat variety Pb C 591 (monosomic for A or B genome) were crossed as female parents with *T. durum* cv Bijaga Yellow. In F_0 generation, both crossability and germination percentage was worked out. In F_1 generation, only the plants with 13″+8′ were selected in all the 14A and B genome lines and back crossed to Bijaga Yellow. Then crossability and germination percentage was worked out. In the first back cross generation, though the chromosome number was varying from 30 to 34, only such plants with 30 chromosomes (13″+2′) were selected and again back crossed to Bijaga Yellow. In second back cross generation, plants with 27 chromosomes (13″+1′) were selected and back crossed to Bijaga Yellow. In all these generations crossability as well as germination percentage was worked out.

Results and Discussion

As there was much variation in the seed setting and germination, in different generations, the subject is discussed generations wise.

1. Seed setting and germination in F_1 generation:

* Part of the Ph. D. thesis submitted by the first author to the University of Agricultural Sciences, Bangalore – 1980.

The average seed setting (12.32 percent) and germination (42.60 percent) of the F_1 hybrids involving monosomic series of Pb C 591 × Bijaga Yellow was low compared to disomic Pb C 591 (Table 1). In disomic cross it was 22.58 percent and 67.86 percent respectively. None of the crosses involving monosomic lines of Pb C 591 × Bijaga Yellow showed better seed setting with high germination. This may be due to the monosomic condition of female parent when crossed with tetraploid Bijaga Yellow where there will be greater imbalance of the proportion of chromosomes for the development of

Table 1. Crossability and germination percentage in crosses between first fourteen monosomic lines of Pb C 591 (monosomic for A- or B-) and Bijaga Yellow and disomic Pb C 591 × Bijaga Yellow

Populations	Number of ears pollinated	Number of florets pollinated	Number of seeds obtained	Number of seeds germinated
Monopentaploids				
1A	11	324	62 (19.14)	20 (32.25)
2A	12	336	74 (22.02)	22 (29.73)
3A	8	220	40 (18.18)	19 (47.50)
4A	16	188	36 (19.15)	16 (44.44)
5A	10	282	43 (15.25)	19 (44.19)
6A	28	628	48 (7.64)	20 (41.67)
7A	12	232	49 (21.12)	21 (42.86)
1B	20	520	36 (6.92)	15 (41.67)
2B	8	294	41 (13.95)	22 (53.66)
3B	28	664	38 (5.72)	20 (52.63)
4B	20	494	35 (7.09)	15 (42.55)
5B	10	240	30 (12.50)	15 (50.00)
6B	14	336	44 (13.10)	22 (50.00)
7B	10	234	39 (16.67)	16 (41.03)
Total:	207	4992	615 (12.32)	262 (42.60)
Eupentaploids	4	124	28 (22.58)	19 (67.86)

Figures in the parenthesis indicate the percentages.

embryo and endosperm. Because of the incompatibility of female and male gametophytes, fertilization does not occur, even if there is a fertilization, the embryo aborts during its developmental stages. Seed setting was drastically affected in the crosses involving 6A, 1B, 3B, 4B, 5B and 6B with Bijaga Yellow. MOKHTARZADEH (1975) reported the chromosomes 1A, 2A, 7A, 1B, 4B and 6B to carry genes which promote seed setting and in the absence of these chromosomes significant reduction in seed setting was observed.

In the present investigation, germination was reduced drastically in crosses involving the chromosomes 1A and 2A in monosomic condition with Bijaga Yellow. Failure to obtain viable seeds could largely be due to abnormal chromosome relationships between embryo and endosperm (STEBBINS 1958), and the dosage of genes and genomes in the endosperm. In addition, deleterious effects of genes located on chromosomes 1A, 2A, 4A, 5A, 6A, 7A, 1B, 4B and 7B in the corresponding Bijaga Yellow could probably be the prime cause of the observed zygotic lethality. The same factors might have been the cause of zygotic lethality in the interspecific hybrids observed previously (THOMPSON & HOLLINGSHEAD 1927, WATERHOUSE 1933, 1952).

2. Seed setting and germination in first back cross generation

The average seed setting (10.46 percent) and germination (43.48 percent) was lower than the control hybrid i.e. disomic hybrid or eupentaploid (Table 2). It may be concluded that all chromosomes from the A and B genomes of Bijaga Yellow except the chromosome 3B influenced the seed setting of the interspecific hybrids. But SEARS (1954) found all the chromosomes including 3B in common wheat to influence fertility. The decreased seed set in the present investigation may be due to the presence of major promoter genes for seed setting of the back cross progeny. The presence of all chromosomes carrying the major or minor promoter genes for seed setting may collectively have a complementary epistatic effect on the suppressor genes and result in relatively high seed set of the pentaploid hybrids.

MOKHTARZADEH (1975) reported chromosomes 1A, 1B, 4B and 6B to carry genes with major effects for the promotion of seed setting and 4A, 2B, 6A and 7B to carry inhibitary genes.

In the present study, seed setting was drastically reduced in the crosses involving parents with monosomic condition for 2A, 3A, 6A, 4B, 5B, 6B and 7B and better seed setting was observed in crosses involving monosomics for 1A, 4A, 5A, 7A, 2B and 3B.

Disturbance in the seed setting of the interspecific hybrids may be expected as a result of interactions between A and B genomes originating from different sources (PISSAREV 1966). In addition, the absence of chromosomes influencing fertility and crossability may reduce significantly the fertility of the monopentaploid hybrids. Loss of chromosomes carrying genes which promote or suppress fertility can be revealed by very low or very high fertility in the monopentaploid plants when compared with the average of the monosomic lines (BOZZINI & GIORGI 1971). Based on the results of the present experiment, chromosomes 2A, 3A, 1B, 4B, 5B and 6B in Bijaga Yellow can be considered as the carriers of

Table 2. Crossability and germination percentage in crosses between first fourteen monopentaploid lines (13″+8′) and Bijaga Yellow in first back cross generation

Populations	Number of ears pollinated	Number of florets pollinated	Number of seeds obtained	Number of seeds germinated
Monopentaploids				
1A	6	267	34 (12.73)	19 (55.88)
2A	14	340	21 (6.18)	15 (71.43)
3A	20	480	20 (4.17)	16 (80.00)
4A	7	190	30 (15.79)	23 (74.07)
5A	6	171	27 (15.79)	20 (74.07)
6A	14	476	52 (10.92)	16 (30.77)
7A	4	174	21 (12.07)	14 (66.67)
1B	9	260	21 (8.08)	13 (61.90)
2B	17	490	60 (12.24)	18 (30.00)
3B	1	114	27 (23.68)	20 (74.00)
4B	12	360	22 (6.11)	14 (63.64)
5B	8	208	12 (5.77)	7 (58.33)
6B	12	309	30 (9.71)	12 (40.00)
7B	8	220	23 (10.46)	10 (43.48)
Total:	138	4059	400 (9.85)	217 (54.25)
Eupentaploids	4	124	28 (22.58)	19 (67.86)

Figures in the parenthesis indicate the percentages.

promoter genes for seed fertility. The cytoplasmic effect of the hexaploid parent in reducing the hybrid fertility has already been ruled out (KIHARA 1968, SUEMOTO 1968).

In the present study reduction in seed germination was confined to lines 6A, 2B, 6B and 7B. This may be due to abnormal chromosome relationships between embryo and endosperm.

3. Seed Setting and germination in second back cross generation:

As in case of F_1 and BC_1 generations, in second backcross generation also, seed setting was poor, particularly in lines 2A, 3A, 4A, 2B, 4B, 6B and 7B seed setting was very less. It seems chromosomes 2A, 3A, 4A, 2B, 4B, 6B and 7B in Bijaga Yellow carry genes which promote seed setting.

Seed germination was increased in second back cross generation. This may be due to the following reasons, when plants with 13″+2′ were crossed to Bijaga Yellow, 72.81 percent of the plants obtained by this cross were found to be disomic for A and B genomes (14″) (Table 3). So, most of the 13″+2′ plants may be producing 14 chromosome female gamete and when this gets fertilized with Bijaga Yellow pollen (n=14), there will be normal seed setting, because of the absence of variation in chromosome number.

4. Seed setting and germination in thrid back cross generation:

Table 3. Crossability and germination percentage in crosses between plants having 13″+2′ in each of A- and B- genome monosomic lines and Bijaga Yellow in second backcross generation

Line	Number of ears pollinated	Number of florets pollinated	Number of seeds obtained	Number of seeds germinated
1A	10	308	62 (20.13)	59 (95.16)
2A	6	156	20 (12.82)	18 (90.00)
3A	8	246	42 (17.07)	38 (90.48)
4A	7	210	39 (18.57)	36 (92.31)
5A	18	288	73 (25.35)	73 (100.00)
6A	7	222	53 (23.87)	49 (92.45)
7A	6	206	46 (23.00)	43 (93.48)
1B	6	228	48 (21.05)	43 (89.58)
2B	9	282	53 (18.79)	50 (94.34)
3B	9	252	60 (23.81)	57 (95.00)
4B	8	264	42 (15.91)	42 (100.00)
6B	8	254	44 (17.32)	44 (100.00)
7B	8	250	40 (17.00)	40 (100.00)
Total:	110	3160	622 (19.68)	592 (95.18)

Figures in the parenthesis indicate the percentages.

Table 4. Crossability data and germination percentage in crosses between plants with 13 bivalents plus univalent (13″+1′) and Bijaga Yellow in third back cross generation

Line	Number of ears pollinated	Number of florets pollinated	Number of seeds obtained	Number of seeds germinated
1A	3	140	48 (34.28)	46 (95.83)
3A	6	194	58 (29.99)	53 (91.38)
4A	5	152	39 (25.66)	39 (100.00)
6A	5	148	56 (37.84)	53 (94.64)
7A	2	48	36 (75.00)	36 (100.00)
2B	2	32	25 (78.12)	25 (100.00)
3B	4	124	48 (38.71)	44 (91.67)
4B	4	112	43 (38.39)	43 (100.00)
6B	6	158	50 (31.65)	44 (88.00)
Total:	37	1108	403 (36.37)	383 (95.04)

Figures in the parenthesis indicate the percentages.

In third back cross generation in monosmic lines 3A, 4A and 6B, seed setting was reduced compared to other lines (Table 4). This was also observed in F_1, BC_1 and BC_2 generations. This may mainly be due to the presence of promoter genes for seed setting on chromosomes 3A, 4A and 6B in Bijaga Yellow and the absence of these chromosomes has drastically reduced the seed setting.

As early as 1962, KIHARA & TSUNEWAKI observed low seed fertility in monosomic plants of durum wheat and normal seed fertility in trisomic plant. NORONHA-WAGNER; & MELLO-SAMPAYO (1966) observed that the vigour and fertility of monosomics and trisomics was below normal. MOCHIZUKI (1968) also observed poor seed setting in monosomic lines of *durum* wheat. MOCHIZUKI (1970) observed poorly developed embryos and endosperms in all monosomic lines of *durum* wheat, because of which the seeds were shrivelled and germination percentage as well as viability of seeds was very less, NISHIKAWA (1971) also reported that the seeds of telosomic plants of tetraploid wheat were shrivelled.

As in case of second back cross generation, in third back cross generation also, seed germination increased. In BC_2 generation, plants with 13″+1′ alone were selected and back crossed to Bijaga Yellow. As there is a very low transmission frequency of monomiomic condition, even from female side also, in *durum* wheat, female gamete

contributes 14 chromosomes which gets fertilized with Bijaga Yellow pollen (n=14). There will be perfect 14'' formation in them, because of this reason high germination of crossed seeds was observed in BC_3. These germinated seeds were mostly disomics i.e. plants with 14'' (98.32 percent) and only 1.68 percent were observed to be monosomic plants.

Literature Cited

BOYES, J.W. and THOMPSON, W.P. 1937. *J. Genet.* **34**, 203–227.
BOZZINI, A. and GIORGI, B. 1971: *Theor. Appl. Genet.* **41**, 67–74.
KIHARA, H. 1968. *Proc. 3rd Int. Wheat Genet. Symp.* 125–134.
———— and TSUNEWAKI, K. 1962. *What Inf. Serv.* **14**, 1–3.
MOCHIZUKI, A. 1968. *Proc. 3rd Int. Wheat Genet. Symp.* 310–315.
———— 1970. *Seiken Ziho.* **22**, 39–49
NISHIKAWA, K. 1971. *Seiken Ziho* **22**, 51–55.
NORONHA-WAGNER, M. and MELLO-Sampayo, T. 1966. *Proc. 2nd Int. Wheat Genet. Symp. Hereditas* (suppl.), **2**, 382–392.
PISSAREV, V. 1966. *Proc. 2nd Int. Wheat Genet. Symp. Hereditas* (suppl.) **2**, 279–290.
SEARS, E.R. 1954. *Missouri Agric. Expt. Stn. Res. Bull.* **572**, 1–52.
STEBBINS, G.L. 1958. *Adv. Genet.* **9**, 147–215.
SUEMOTO, H. 1968. *Proc. 3rd Int. Wheat Genet. Symp.* 14–152.
THOMPSON, W.P. and HOLLINGSHEAD, L. 1927. *J. Genetics.* **17**, 283–307.
WATERHOUSE, W.L. 1933. *Proc. Linn. Soc. N.S. Wales*, **58**, 99–104.
———— 1952. *Proc. Linn. Soc. N.S. Wales* **77**, 331–336.
WATKINS, A.E. 1927. *J. Genet.* **18**, 395–396

Genetic analysis of tetraploid wheat *triticum durum* Desf. Cv Bijaga Yellow by utilization of monopentaploid hybrids*

R.R. HANCHINAL and J.V. GOUD

University of Agricultural Science, Dharwad Campus,
Karnataka 580 005, India

Tetraploid wheat does not tolerate the loss of a chromosome, or part of a chromosome with the same facility as hexaploid wheat (LONGWELL & SEARS 1963, MOCHIZUKI 1968). Consequently nullisomics, monosomics, telosomics and other tetraploid wheat aneuploids have been little used in genetic analysis of *T. durum*.

In recent years, JOPPA & WILLIAMS (1977a, b) and JOPPA *et al.* (1979) tried to establish D-genome substitution monosomics and addition and substitution lines in tetraploid wheat. But in the absence of complete series of aneuploids in tetraploid wheat, the other alternative methods are essential for genetic analysis.

ALLAN & VOGEL (1960) tried, without success, to analyse smooth awn determination by crossing monosomics of Chinese Spring with a durum wheat which carried this character. More recently KUSPIRA & MILLIS (1967), BOZZINI & GIORGI (1971) and MOKHTARZADEH (1975), using this technique, attempted to identify the chromosomes controlling different quantitative characters in durum wheat.

Potentialities and limitations of monopentaploid analysis for assigning genes on different chromosomes for some of the morphological characters in durum wheat cv. Bijaga Yellow are presented in this paper.

Material and Methods

The first fourteen monosomic lines of hexaploid wheat variety Pb C 591 (monosomic for A or B genome) were crossed as female parents with *T. durum* cv. Bijaga Yellow. For each line, majority of the F_1 populations obtained were of two types i.e. normal eupentaploids with 2n=35 chromosomes and monopentaploids with 2n=34 chromosomes. Few plants in some lines had 2n=33 chromosomes.

The plants were raised in earthern pots of uniform size, providing the uniform environment in green house, at Botany garden, Agril. College, Dharwad. Cytological analysis was performed at the time of flowering.

Observations were taken for six characters namely plant height (cm), days to heading, peduncle length (cm), first internode length (cm), second internode length (cm) and number of tillers per plant. The material was grown in completely randomised design with three replications and the analysis of the experiment was performed (SUNDARARAJ *et al.* 1972).

* Part of the Ph. D. thesis submitted by the first author to the University of Agricultural Sciences, Bangalore, 1980.

Means and standard errors were calculated in each line. To detect the critical lines means of the monopentaploid populations were compared with eupentaploid mean by students 't' test given by SUNDARARAJ *et al.* (1972).

Results and Discussion

As outlined by KUSPIRA & UNRAU (1959), two methods might be employed to establish gene chromosome relationships in tetraploid wheat using common wheat aneuploids. One method is to produce a hexaploid by crossing a tetraploid variety with *Aegilops squarrosa* (D-genome), polyploidise the hybrid and analyse the F_1, F_2 and F_3 generations of crosses between the artificial hexaploid and a series of hexaploid monosomics or nullisomics.

An alternative method would be to cross the tetraploid with the first fourteen lines of the hexaploid monosomics and analyse the F_1 generation genetically or cytogenetically. If tetraploids are crossed with hexaploid monosomics, the pentaploid hybrids will all be monosomic for chromosomes 1D to 7D as well as being either monosomic or disomic for one of the first fourteen chromosomes (KUSPIRA & MILLIS 1967, BOZZINI & GIORGI 1971).

One of the difficulties of a cytogenetic analysis of tetraploids by crossing these with hexaploid monosomics is that, most of the monopentaploid hybrid lines are completely or nearly completely sterile (HANCHINAL & GOUD 1981), thus causing the difficulty in studying further segregating generations. Therefore only recessive or partially dominant alleles of the variety to be tested can be identified and attributed to a specific chromosome in the F_1 generation. All this is based on the assumption that differential expression between disomics and monosomics is caused by the lack of genes on the missing chromosome.

Genetic investigations of plant height in wheat are numerous but not conclusive. Plant height has been reported to be under polygenic control with innumerable modifiers (ALLAN & VOGEL 1963, ALLAN *et al.* 1968). Cytogenetic investigations have led to the location of genes affecting plant height on almost all chromosomes in one or the other variety. In the present investigation, four critical monopentaploid lines viz., 2A, 4A, 6A and 6B were shorter than the eupentaploid, indicating the presence of dwarfing genes on these chromosomes (Table 1). The other two critical lines i.e. 3B and 4B were taller than the eupentaploid, indicating the presence of genes for tallness on these chromosomes.

SEARS (1954) and BHOWAL (1970), identified chromosomes of homoeologous group, I, II, III, IV and 6A possessing genes for plant height expression in common wheat. But BOZZINI & GIORGI (1971) identified 1A, 2A, 6A, 2B, 3B, 4B and 5B to be critical for this character.

As in the case of plant height, the nature of dominance with respect to days to heading is an unsettled issue. Dominance or partial dominance of earliness is reported by several workers (CRUMPACKER & ALLARD 1960, JOHNSON *et al.* 1966, BOZZINI & GIORGI 1971, AHMAD and AKSEL 1972, BHAT & GOUD 1979). But few other reports indicated lateness to be dominant over earliness (PARODA *et al.* 1972, CRUMPACKER & ALLARD 1972). In the present investigation partial dominance type of gene action for delay in heading was

Table 1. Means of F_1 (monopentaploid and eupentaploid) populations and parents with respect to plant height, days to heading, peduncle length, internode length and number of tillers per plant.

Populations	Plant height (cm)	Days to heading	Peduncle length (cm)	Internode length (cm)		Number of tillers per plant
				1st	2nd	
Monopentaploids						
1A	85.00±2.31	66.67±2.44**	31.16±4.33**	16.00±2.54*	10.33±1.69	11.30±2.07**
2A	59.66±4.63**	73.17±0.48	24.66±1.76	10.83±5.46**	10.83±0.93	12.12±1.11*
3A	86.66±0.89	73.33±0.42	28.73±0.15	17.66±0.41**	9.66±1.17	12.30±1.16*
4A	74.16±1.17**	71.50±0.50	30.50±2.18	14.33±1.17	8.56±0.83	15.71±1.46
5A	90.00±1.16	81.17±0.60**	13.10±0.06**	8.00±0.55**	7.83±0.91	7.71±0.36**
6A	74.33±0.89**	72.33±0.67	31.20±0.49**	15.20±0.64	7.33±0.77	18.11±0.51
7A	88.53±1.35	67.33±0.67**	34.50±1.32**	14.33±0.88	9.70±1.05	14.07±2.97
1B	84.33±0.45	71.83±0.60	29.96±0.52	15.03±0.55	11.80±0.68*	16.80±0.93
2B	88.50±0.76	74.50±0.43**	34.33±0.73**	15.30±0.75	12.63±0.90**	19.65±0.63
3B	94.00±0.58**	70.67±0.33	36.43±0.54**	16.33±0.60*	13.83±0.93**	10.08±0.68**
4B	93.00±0.58**	72.50±0.43	35.50±0.58**	17.16±0.73**	14.26±0.82**	11.77±0.64**
5B	81.17±0.44	68.00±0.37**	21.50±0.29**	13.00±0.58	7.33±0.44	15.67±0.88
6B	51.00±1.16**	71.50±0.43	16.83±0.93**	7.00±0.58**	3.16±0.60**	9.17±0.56**
7B	84.16±0.60	76.00±0.37**	28.23±0.65	13.03±0.32	17.13±0.07	18.13±0.35
Eupentaploids	85.20±2.04	72.11±0.72	27.26±0.41	14.03±0.15	8.86±0.18	16.78±1.60
Pb C 591	94.96±1.00**	76.83±0.48**	29.80±0.17	11.32±0.32**	8.09±0.15	12.12±1.10*
Bijaga Yellow	119.00±2.08**	58.31±0.93**	50.40±0.63**	20.30±0.61**	14.00±0.29**	20.60±1.39*

* Significant at 5 percent level.
** Significant at 1 percent level.

observed. The critical lines 5A, 2B and 7B delayed heading indicating that the chromosomes promoting lateness and the chromosomes 1A, 7A and 5B showed the presence of genes for earliness located on them in Bijaga Yellow (Table 1).

Peduncle length is predominantly controlled by polygenes and it is under additive gene action (VIRK & AULAKH 1975). Longer peduncle is a dominant character (CECCARELLI *et al.* 1973). Partial or complete dominance of long peduncle has been indicated by the studies of HSU & WALTON (1970). But in the present investigation partial dominance of shorter peduncle was observed. BHAT & GOUD (1979) reported that the chromosomes i.e. 2A, 3A, 5A, 6A, 7A, 1B, 2B, 4B, 5B, 6B, 5D, 6D and 7D increased the peduncle length. In the present investigation, six critical lines 1A, 6A, 7A, 2B, 3B and 4B increased the peduncle length while the other three critical lines 5A, 5B and 6B decreased it (Table 1). From the present investigation it is evident that, chromosomes 1A, 6A, 7A, 2B, 3B and 4B in Bijaga Yellow carry genes inhibiting the peduncle length whereas chromosomes 5A, 5B and 6B carry promoter genes.

Cytogenetic investigations of internode length are scanty. However, SHNAIDER & DOROKHOVA (1979) assigned the genes responsible for reduction in internode length on 1A, 3A, 4A, 5A, 6A, 1B, 2B, 3B, 7B, 1D and 3D in variety T_{13} and on 1A, 2A, 3A, 6A, 7A, 1B, 2B, 3B, 6B, 2D, 3D and 6D in variety Norona. In the present study, partial dominance

for short internode length was observed. The two chromosomes i.e. 5A and 6B of Bijaga Yellow carried genes for first internode length and 6B alone reduced second internode length significantly whereas the critical lines for 1A, 2A, 3A, 3B and 4B for first internode and 1B, 2B, 3B and 4B for second internode increased the internode lengths (Table 1).

Number of tillers per plant showed low heritability (NANDAPURI 1958, PANIGRAHI 1962, SELIM 1963). Partial dominance of low tillering ability over high tillering was found by SELIM (1963). In contrast to the above, CHAPMAN (1967), observed only additive gene action for tillering ability. The present investigation supports CHAPMAN's (1967) results. Monopentaploid lines 1A, 2A, 3A, 5A, 3B, 4B and 6B were found to be critical for this character (Table 1). All these critical chromosomes had significantly lesser number of tillers. BHAT & GOUD (1979) reported the genes for decreased number of tillers to be located on chromosomes 2D and 3D and for increased number of tillers to be present on 7B and 6D chromosomes of UP 301. SEARS (1954) found nullisomics for chromosomes 2B and 3D having few tillers as compared to Chinese Spring disomic parent, which implied that these chromosomes had genes for increased tillering.

Since Bijaga Yellow has more number of tillers, the decreased tiller numbers in seven monopentaploid populations involving the chromosomes of Bijaga Yellow may be attributed to hemizygous dominant nature of genes controlling the tiller numbers which in homozygous condition gave more tiller numbers.

Literature Cited

AHMED, S.U. and R. AKSEL 1972. *J. Hered.*, **63**: 287–292.
ALLAN, R.E. and O.A. VOGEL 1960. *Wheat Inf. Serv.* **11**: 3–4.
——— and ——— 1963. *Crop Sci.* **3**: 538–540.
———, ——— and C.J.Jr. PETERSON 1968. *Crop Sci.* **8**: 701–704.
BHAT, S.R. and J.V. GOUD 1979. *Wheat Inf. Serv.* **50**: 14–18.
BHOWAL, J.G. 1970. *Indian J. Genet.* **30**: 170–179.
BOZZINI, A. and B. GIORGI 1971. *Theor. Appl. Genet.* **41**: 67–74.
CECCARELLI, S.E., PIANO, G.M.B. GIANNONI and S. AERIANI 1973. *Genet. Agr.* **27**: 378–395.
CHAPMAN, S.R. 1967. *Diss. Abstr.* **27**: 37583.
CRUMPACKER, D.W. and R.W. ALLARD 1962. *Hilgardia.* **32**: 275–318.
HANCHINAL, R.R. and J.V. GOUD 1981. *Theor. Appl. Genet.* (Press).
HSU, P. and P.D. WALTON. 1970. *Can. J. Genet. Cytol.* **12**: 738–742.
JOHNSON, V.A., K.J. DIEVER, A. HAUNOLD, and J.W. SMITH 1966. *Crop Sci.* **6**: 336–338.
JOPPA, L.R. and N.D. WILLIAMS, 1977a. *Crop Sci.* **17**: 772–776.
——— and ——— 1977b. *Agron. Abstr.* **60**:
———, J.A. BIETZ and N.D. WILLIAMS 1979. *Proc. 5th Int. Wheat Genet. Symp.* IAR New Delhi. pp. 420–476.
KUSPIRA, J. and L.A. MILLIS 1967. *Can. J. Genet. Cytol.* **9**: 79–86.
——— and J. UNRAU 1959. *Can. J. Genet. Cytol.* **1**: 267–312.
LONGWELL, J.H. and E.R. SEARS. 1963. *Am. Natur.* **97**: 401–403.
MOCHIZUKI, A. 1968. *Proc. 3rd Intern. Wheat Genet. Symp. Aust. Acad. Sci. Canberra.* pp. 310–315.
MOKHTARZADEH, A. 1975. *Theor. Appl. Genet.* **46**: 1–5.
NANDAPURI, K.S. 1958. *Diss. Abstr.* **19**: 583814.
PANIGRAHI, N.R. 1962. *Diss. Abstr.* **22**: 293211.

PARODA, R.S., U.P. SINGH and A.B. JOSHI, 1972. *Indian J. Agric. Sci.* **42**: 653–665.
SEARS, E.R. 1954. *Missouri Agric. Expt. Stn. Res. Bull*–572. 1–59.
SELIM, A.K.M. 1963. *Ann. Agric. Sci. Cairo.* 1960, **5**: 87–110.
SHNAIDER, T. and T. DOROKHOVA, 1979. *Biologia.* **28**: 250–259.
SUNDARAJ, N.S. NAGARAJU, M.N. VENKATARAMU and M.K. JAGANNATH. 1972. *Design and Analysis of Field Experiments. Univ. Agril. Sci.* Bangalore. pp. 91–136.
VIRK, D.S. and H.S. AULAKH. 1975. *Cereal Res. Comm.* **3**: 37–48.

Karyotype and seed protein profile determination of *Agropyron striatulum* natural Greek populations

M. MOUSTAKAS and H. COUCOLI

Department of Botany, University of Thessaloniki, Greece

Agropyron striatulum (*Elymus striatulus* RUN.) is a diploid littoral species (2n=14), firstly found by RUNEMARK in the Aegean Greek area. It is considered to participate in a closely related group, within the series Junceae, which includes also *A. rechingeri* (2n=28), *A. junceum* subsp. *mediterraneum* (2n=42) and *A. diae* (2n=56) (HENEEN & RUNEMARK 1962).

According to SAKAMOTO's classification (1973), *A. striatulum* should be assigned to group III of the *Agropyron-Elymus-Sitanion* complex. Some members of this group have been extensively studied by CAUDERON (1966) who defined *A. striatulum* as one of the four old world diploid species included in *Elytrigia* group.

A cytological study performed by HENEEN and RUNEMARK (1972) on the material of their Aegean *A. striatulum* collection showed chromosomal polymorphism expressed as slight differences in the appearance of satellited chromosomes.

The present authors, within a research program being currently in progress (COUCOLI & SYMEONIDIS 1980, TSEKOS *et al.* 1981) present here a separate cytological and seed protein isoelectrofocusing analysis of a particular indigenous *A. striatulum* material collected recently in several North-Greek littoral zones. By combining karyotypical data with protein profile patterns, a sensitive feature capable of differentiating even between types morphologically and cytologically indistinguishable, this study aims at further delimitating the chromosomal constitution of *A. striatulum* and checking the stability or polymorphism within and between populations.

Totally a number of 23 plants representing 5 populations and found morphologically similar were examined, all collected from four littoral North Greek biotopes.

Karyotypical observations

The established karyotype of *A. striatulum* (the procedure was described by COUCOLI & SYMEONIDIS 1980) was found to be a symmetrical one, with chromosomes varying in length between 7 and 9 μm approximately (Fig. 1). In spite of this symmetry, according to the data presented in Table 1, all chromosome members could be identified, due to the following reasons: 1) The two longest pairs, though not significantly differing in chromosome length, can be easily distinguished from each other by arm ratio. The one (No. 1) was constantly recognized as submetacentric, the second (No. 2) represents a typically metacentric chromosome. 2) The two SAT pairs are fairly distinguishable by their morphology, chromosome No. 3 being strongly heterobrachial (A.R.=0.44), with a small satellite ranging

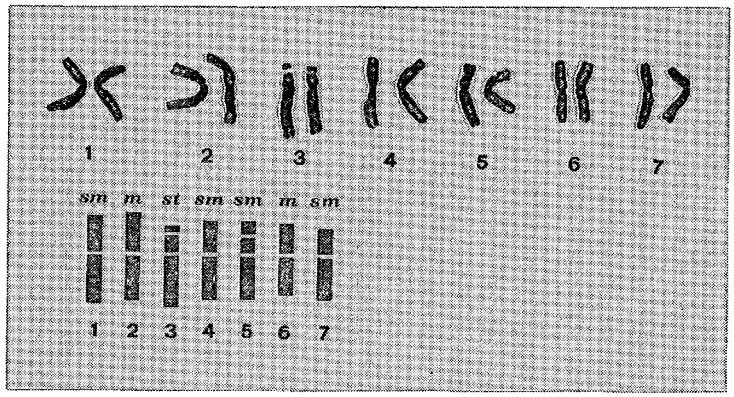


Fig. 1. Above: the karyotype of *A. stiatulum*. Below: the corresponding idiogram.

Table 1. Length of chromosomes in absolute mean values (μm) and relative lengths measured in 10 plates of *A. striatulum*.

Chrom pair	Total		Short Arm		Long Arm		Arm ratio	Centromere class
	A.L.	R.L.	A.L.	R.L.	A.L.	R.L.		
1	8.93	16.36±0.68	3.83	7.00±0.49	5.10	9.36±0.51	0.75	SM
2	8.69	15.86±0.84	4.10	7.48±0.52	4.59	8.38±0.54	0.89	M
3	7.94	14.53±0.46	2.41 (0.60*+1.81)	4.42±0.30 (1.10*±0.15)	5.53	10.11±0.32	0.44	ST (SAT)
4	7.85	14.35±0.57	3.35	6.13±0.59	4.50	8.22±0.37	0.75	SM
5	7.42	13.55±0.51	2.94 (1.40*+1.54)	5.36±0.31 (2.45*±0.13)	4.48	8.19±0.42	0.65	SM (SAT)
6	6.87	12.59±0.70	3.12	5.82±0.28	3.75	6.77±0.50	0.86	M
7	6.99	12.76±0.49	2.62	4.76±0.39	4.37	8.00±0.46	0.60	SM

A.L. Absolute Length R.L. Relative Length * Length of satellite

in length around the one fourth of the total short arm. This chromosome (Fig. 1) corresponding to the typical form A_2 (HENEEN & RUNEMARK 1972) was found in all populations, covering the majority of the cells analysed, whereas a variant of the same chromosome, identified as A_1 (with a larger satellite) was sporadically observed and confined exclusively in one population (the most abundant one). The two homologues of SAT pair No. 5 (SM in centromere class) coincide with B_1 morphological type, being easily recognized by their size and arm ratio, though they do not always show prominently their large satellites, especially the one chromosome of the pair, probably due to heteromorphic conditions. This feature was in particular observed in plants exclusively found in one population. Chromosomes No. 6 and 7, though overlapping in size can be clearly separated by arm ratio. Finally, chromosome No. 4 is fairly distinguished by its intermediate size.

The cytological analysis of the present material gave evidence rather in favour of karyotypic constancy than of chromosomal polymorphism, as it was formerly shown for the

small isolated island populations of *A. striatulum* studied by HENEEN & RUNEMARK (1972). The observed variant A_1 proved limited (a few individuals of one population) and, besides, no other SAT chromosome polymorphism was detected.

The observed karyotype is likely to represent a J_1J_1 genome formula. The original J genome, as referred by OSTERGREN (1940), HENEEN (1962), CAUDERON (1966) and summarized by CAUDERON (1979) and DEWEY (1981) occurs broadly in *A. junceum* (L.) Beauv. complex, having been used for variant genome designations (J_1-J_6) in other closely related species (HENEEN 1977).

Seed protein profiles

Seed proteins were extracted from individual plants by grinding 100 mg of mature seeds with 1.0 ml cold (4°C) distilled water over an ice bath. The resulting mixture was centrifuged at 10.000 g for 15 min. and the supernatant was lyophilized. The subsequent isoelectric focusing of water soluble proteins was performed by using polyacrilamide gels with carrier ampholite pH 4.0–6.5.

Representative seed protein profiles are shown in Fig. 2. Although slight variability was detected both within (more) and between (less) populations, all the examined plants (23) were found to possess the same basic seed protein profile composed of 34 bands. No qualitative protein phenotypic differences were found and all the observed variation concerned the intensities of some bands among which bands numbered 5, 6, 8 and 13 manifested the most conspicuous intensity differences.

The most frequent protein profiles are two, precisely number 1 (observed in four out of five populations) and number 2 (detected in three populations). The profile number 3,

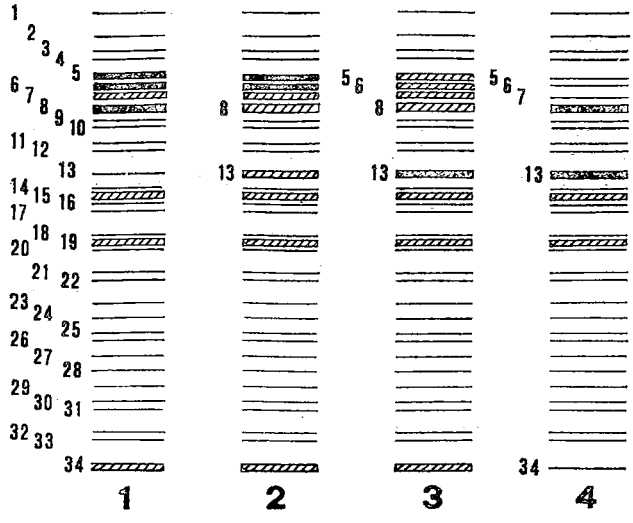


Fig. 2. A schematic representation of four protein profile patterns found in *A. striatulum*.

common enough, showed mutually reverse intensities in bands 5, 6 and 13 comparatively with the profile 2. The pattern number 4 was detected only once (in the most abundant population).

The observed differences in the darkness of bands suggest that the formation of certain bands in seed protein profiles are probably under control of quantitative gene systems (LADIZINSKY & HYMOWITZ 1979).

The above mentioned slight variation in band intensities should be a consequence of a specific structural gene arrangment modified in activity by gene regulation (KREFT *et al.* 1976), a feature which does not alter the consistent protein pattern, a fairly conservative characteristic of the species. Thus, the obtained data can be considered as a resolving power with regards to J_1J_1 genome identification, since the remarkable uniformity of the patterns is in agreement with the observed karyotype constancy.

It should be added that the findings pointed by HENEEN & RUNEMARK (1972) about *A. striatulum* chromosomal polymorphism and by STRID (1968) and BOTHMER (1975) about other Aegean species which showed also heterogeneity of chromosomal compositions cannot be taken as markedly opposing the present data. Their sources of material coming from margin areas of an ecosystem (small isolated islands) could give the possibilities for maintaining cytological instabilities resulting in polymorphisms. Instead, our *A. striatulum* populations grown in abundance and checked as highly fertile are likely to represent a more balanced genomic situation.

References

BOTHMER, R. von 1975. Karyotype variation in *Allium bourgeaui*. Hereditas **79**: 125–132.

CAUDERON, Y. 1966. Genome analysis in the genus *Agropyron*. Proc. 2nd Int. Wheat Genetics Symp., Lund 1963, Hereditas, suppl. vol. 2, p. 218–234.

———— 1979. Use of *Agropyron* species for wheat improvement. Proc. Conf. Broadening Genet. Base Crops, Wageningen, 1978. Pudoc, Wageningen. p. 175–186.

COUCOLI, H. and L. SYMEONIDIS, 1980. Karyotype analysis on some greek wild species of *Hordeum* (*marinum* group) and *Taeniatherum*. Sci. Annals, Fac. Phys. and Mathem., Univ. Thessaloniki, 20a: 77–91.

DEWEY, D.R. 1981. Cytogenetics of *Agropyron ferganense* and its hybrids with six species of *Agropyron*, *Elymus* and *Sitanion*. Amer. J. Bot. **68**: 216–225.

HENEEN, W.K. 1962. Karyotype studies in *Agropyron junceum*, *A. repens* and their spontaneous hybrids. Hereditas **48**: 471–502.

———— 1977. Chromosomal polymorphism in isolated populations of *Elymus* (*Agropyron*) in the Aegean. III *Elymus diae*. Hereditas **86**: 225–236.

———— and H. RUNEMARK. 1962. Chromosomal polymorphism and morphological diversity in *Elymus rechingeri*. Hereditas **48**: 545–564.

———— and ———— 1972. Chromosomal polymorphism in isolated populations of *Elymus* (*Agropyron*) in the Aegean. I *Elymus striatulus* sp. nov. Bot. Notiser **125**: 419–429.

KREFT, I., B. JAVORNIK and N. MILKOVIC. 1976. Studies on the gene control of electrophoretic protein pattern in Barley. Proc. 3rd Int. Barley Genet, Symp. Garching 1975. Barley Genetics III. p. 30–35.

LADIZINSKY, G. and T. HYMOWITZ. 1979. Seed protein electrophoresis in taxonomic and evolutionary studies. Theor. Appl. Genet. **54**: 145–151.

OSTERGREN, G. 1940. Cytology of *Agropyron junceum*, *A. repens* and their spontaneous hybrids. Hereditas **26**: 305–316.

SAKAMOTO, S. 1973. Patterns of phylogenetic differentiation in the tribe *Triticeae*. Seiken Zihô **24**: 11–31.

STRID, A. 1968. Stable telocentric chromosomes formed by spontaneous misdivision in *Nigella doerfleri* (*Ranunuculaceae*). Bot. Notiser **121**: 153–164.

TSEKOS, I., L. SYMEONIDIS und S. KARATAGLIS. 1981. Elektrophoretische Variation der sauren Phosphatase und der Alkohol-Dehydrogenease in Griechenland beheimateter diploider Arten von *Aegilops* (*Ae. caudata* und *Ae. comosa*, Poaceae). Biochem. Physiol. Pflanzen **176**: 463–480.

EMS-induced sphaerococcum mutation in Triticale

Sevdalin GEORGIEV

Institute of Introduction and Plant Resources – Sadovo 4122,
Plovdivsko, Bulgaria

Using monosome analysis (SEARS 1947) estabilished the localisation of the gene which controls the symptoms characteristic of *T. sphaerococcum* Perc., as a hemizygous ineffective/ zero allele/in 3D/XVI chromosome. Later by the telocentric method (PRABHEKARA RAO 1977) affirmed the localization of this gene in the short arm of 3D chromosome.

As a result of the application of radiation and chemical mutagens, mutants of the sphaerococcum type were obtained in 2x, wheats (GEORGIEV & NICOLOFF 1975, GEORGIEV 1979), 4x wheats (BOZZINI 1965) and 6x species of the *Triticum* genus (SWAMINATHAN *et al.* 1963), GEORGIEV 1976).

Induced sphaerococcum type mutation in *Triticale* has not been described until now, and the present work is preliminary communication and description of a sphaerococcum type of mutation in Triticale (2n=6x=42) after treatment with EMS.

Materials and Methods

Seeds of the hexaploid *Triticale* cultivars MT 47 – Armadilo, calibrated in advance, were treated with 0.5% aerated water solution of EMS at pH=4.5 (Sörensen buffer) for 3 and 5 hours. Five hundred seeds (0.1 ml/seed) were treated from each variant at 24°±0.5°C. After rinsing with running water for 30 to 40 minutes the seeds were sown parallel with controls – seeds soaked in distilled water in advance.

For M_2 the sowing was carried out in progenies.

Results and Discussion

Among the plants in the M_1 generation in the variants of Armadilo treated with 0.5% EMS at pH=4.5 for 3 hour and 0.5% EMS at pH=4.5 for 5 hours, 3 chimeral plants with characteristics typical of the phenotype of the hexaploid species *T. sphaerococcum* Perc., 2n=6x=42, have been observed.

The mutant sector in the M_1 chimeral plants affected only part of the spike (Fig. 1).

As can be seen from Fig. 1B, the length of the glumes of the mutant spike is shorter as compared to the controls, and the length of the mutant stem is 20 cm, shorter than the remaining ones with standard phenotype. From these plants we obtained a total 18 grains originated both from the mutants and from the standard earlets of the chimeral spike. The seeds obtained are shortened, with a hemispherical shape and they had the typical form of the glumes.

Among 100 M_2 progenies of the tested total 2075 M_2 plants of MT 47 treated with

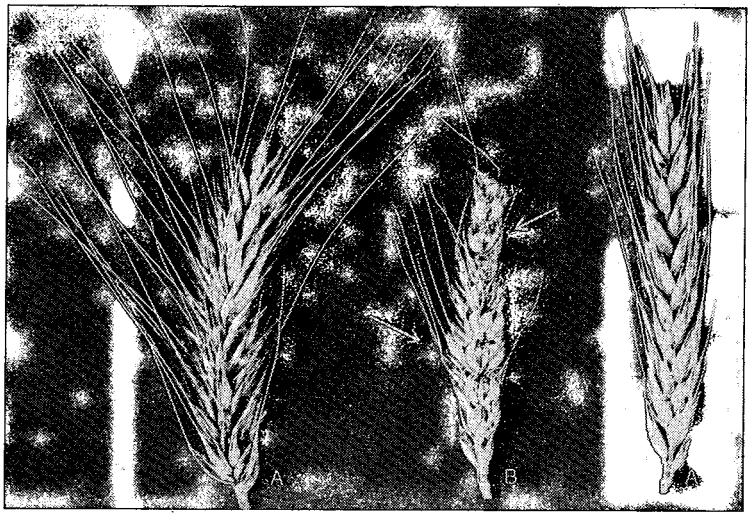


Fig. 1. A: Ear from MT47, B: chimeral ear with standard and sphaerococcum phenotype (indicated by arrows).

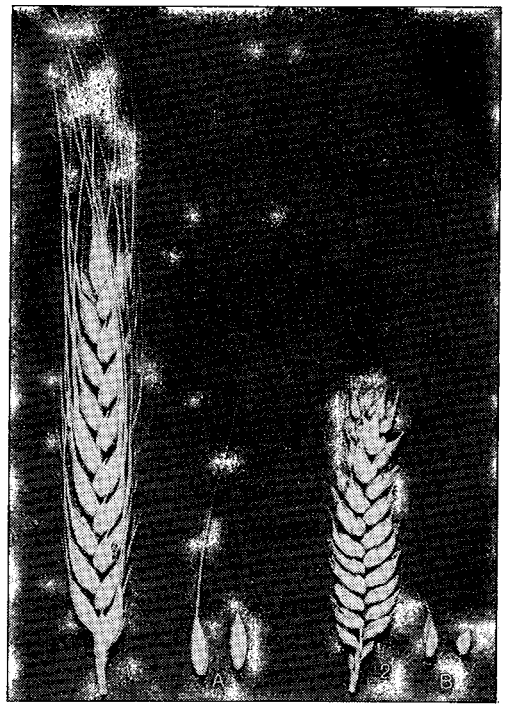
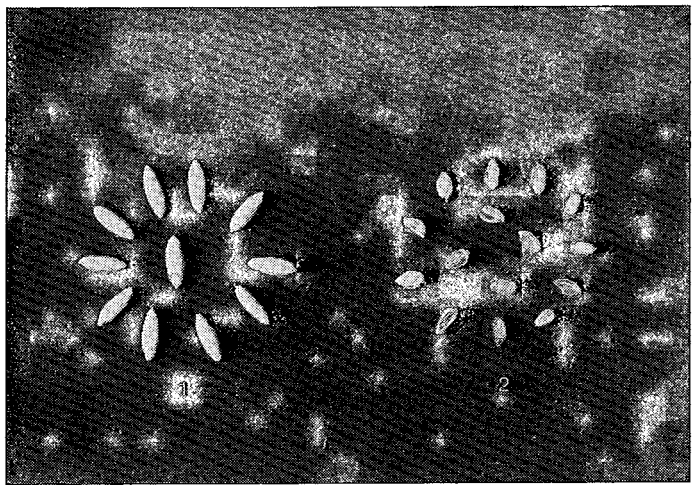


Fig. 2. Ears and ear glum (1 & A; MT47, 2 & B; mutant form type sphaerococcum).



Eig. 3. Seeds from MT47 and mutant forms (1; MT 47, 2; mutant forms type sphaerococcum).

0.5% EMS at 4.5 pH for 3h, five plants were observed with features typical of the hexaploid type *T. sphaerococcum* Perc.

The mutant plants were shorter by 30 cm than the plants with standard phenotype and possessed an errect habit with an upright disposition and shortened and bent on the top leaves.

As is seen from Fig. 2B and Fig. 3, the mutant plants possessed shortened compact ears, shortened and hemispherical ear glumes and seeds, with completely reduced length of the awns.

Tracing the genetic behaviour of these mutant forms in the M_3 we established that they were not constant since they segregated 3 mutant plants and 1 plant with standard phenotype, this being an indicator for the dominant inheritance of these mutant forms. From all the 411 plants received, 293 were with a sphaerococcum phenotype and 118 possessed a phenotype typical of the initial MT 47 *Triticale* plants.

The cytological analysis has shown the availability of 42 chromosomes in the somatic cells.

The described for the first time mutants sphaerococcum type in 6x *Triticale* are of certain interest in connection with clarifying some philogenetic and taxonomic aspects of genus *Triticum* L.

The presence of A, B and R genomes in 6x *Triticale* gives suggests the following possibilities with respect to the gene determining the sphaerococcum character: a it is most likely the gene determining the sphaerococcum effect to be localized in the A or B genomes of the 6x *Triticale*, similar to the already described by us sphaerococcum mutants in *T. monococcum* L., and *T. durum* (GEORGIEV 1979, 1980). b) it is also likely that not all the chromosomes from D genome of wheat are substituted by the chromosomes of the R

genome of rye in MT/47, which givs us grounds to consider that the sphaerococcum effect is determined by a gene(s) localized in chromosomes of the D genome.

In this case the sphaerococcum effect of the mutant described by us is determined by a new gene with a dominant character of inheritance, which shows that it is not allelic to the recessive gene in 3D chromosome of *T. sphaerococcum* Perc., described by SEARS (1947). c) it is much less probable the sphaerococcum effect to be determined by a gene localized in chromosomes of R genome of 6x *Triticale.*

The localization of this gene will be a subject to our future research.

Literature Cited

BOZZINI, A. 1965. Sphaerococcoid a radiation – induced mutation in *T. durum* Desf., Radiation Botany, **5**, 375.

GEORGIEV, S. and H. NICOLOFF. 1975. EMS – induced sphaerococcum mutation in *T. monococcum* L. Comptes rendus de L'Academie bulgars des Sciences, **28**, 10, 1415–1417.

GEORGIEV, S. 1976. EMS – induced mutants of the sphaerococcum type in *T. aestivum* L. Genetics and Plant Breeding, **9**, 218–227.

——— 1979. EMS – induced sphaerococcum mutation in *T. monococcum* L. Cereal Research Communications, **7**, 3, 183–189.

——— 1980. Cytology of structural sphaerococcoid mutants produced in *T. durum* by EMS treatment. Genetics and Plant Breeding, **4**, 280, 286.

PRABHAKARA RAO, M.V. 1977. Mapping of the sphaerococcum gene "S" on chromsome 3D of wheat. Cereal Research Communications, **5**, I. 15–17.

SEARS, E.R. 1947. The sphaerococcum gene in wheat. Genetics, **32**, 102–103.

SWAMINATHAN, M.S., A.D. JAGATHESAN and C.V. CHOPRA. 1963. Induced sphaerococcoid mutations in *T. aestivum* and their polygenic and breeding significance. Curr. Science, **32**, 539–540.

Reciprocal maintainer-restorer relationship between A and B lines of bread Wheat (*Triticum aestivum* L.)

Jagveer S. SINDHU

Crop Science Department, University of Saskatchewan
Saskatoon, Sask., Canada

Cytoplasmic genetic male sterility and fertility restoration systems in wheat present a unique opportunity for studying interaction of plasma genes with the nuclear genes. The male sterility factors located in cytoplasm and the presence or absence of fertility restorer genes in the nucleus of a given species are expected to exhibit specific interaction. Besides *Triticum timopheevi*, which has been considered as the best source of male sterile cytoplasm and the fertility resoring genes, reports indicate that nucleus of common wheat (*Triticum aestivum*) also restores pollen fertility of some male sterile lines (JOPPA & MCNEAL 1969, TAHIR 1969, MIRI, AMAWATE & JAIN 1970). These reports suggest the possibility of a reciprocal maintainer-restorer mechanism in wheat, which could be of considerable importance in broadening the genetic base of the hybrids. In this study efforts were made to investigate the possibility of such a mechanism in bread wheat.

Materials and Methods

The material for this study comprised 11 male sterile lines (A-lines) with *T. timopheevi* and *Aegilops ovata* cytoplasm in the genomic background of bread wheat (*T. aestivum*) and an equal number of maintainer lines (B-lines) with genome and also cytoplasm from *T. aestivum* (Table 1). Maintainers of these lines were crossed with the male sterile lines in all

Table 1. Male sterile (A) lines and their respective maintainer lines used for studying maintainer-restorer relationship in wheat

Male sterile line	S-cytoplasm	Source where obtained from
M.S. Sonora–64	*T. timopheevi*	J.A. Wilson, U.S.A.
M.S. Caprock	〃	E.C. Gilmore, U.S.A.
M.S. *T. timopheevi*	〃	〃
Stewart 63 *T. durum* × *T. dicoccodies, kotschyanum*		
M.S. Study	〃	〃
M.S. Chris	〃	L.H. Shebeski, Canada
M.S. Norin–26	*Ae. ovata*	H. Kihara, Japan
M.S. 68B, CB, 16–10	*T. timopheevi*	K.A. Lucken, U.S.A.
M.S. 69A, 0–63	〃	〃
M.S. 4696	〃	〃
M.S. 4692	〃	〃
M.S. Sanbruno	〃	E.S. Monge, Spain

possible combination. The F_1's were raised in the subsequent growing season and the spikes were selfed at the emergence stage. Seed set in the selfed heads indicated the possibility of fertility restoring gene(s) in the maintainer line.

Results and Discussion

All, but one, F_1's were sterile and there was no seed set in the selfed spikes. However, a positive relationship was observed between maintainer Mx 69, VAC (maintains the pollen sterility of the line M.S. 4692) and the male sterile line, M.S. 4696. The male sterile cytoplasm in both these A-lines was from *T. timopheevi* source (Table 1) and a particular B-line, Mx 69, VAC in this case, maintained pollen sterility of one A-line and restored completely fertility of another A-line.

The finding of partly reciprocal restoration is new in wheat is quite new. However, in pearl millet, BURTON & ATHWAL (1968) reported two interacting cytoplasmic male sterility systems, in which maintainer of one sterility source restored fertility to the second source and vice-versa. In view of the present finding a thorough search may be made in wheat and its allied species for recovering a reciprocal restoration system. The three lines reported here to reveal maintainer-restorer interaction, can profitably be used in a three way cross hybrid programme.

A possible explanation for such a maintainer-restorer mechanism could be that the restorer genes (R-genes) from *T. timopheevi* that have been transferred into wheat may not be allelic to sterility genes on the wheat chromosomes. It may be treated that the R-genes are additional material into the *T. aestivum* background. Restorer genes which are not allelic to sterility genes may co-exist in the same organism without covering the sterility genes.

References

BURTON, G.W. and ATHWAL, D.S. 1968. Reciprocal maintainer-restorer relationship between A_1 and A_2 sterile cytoplasms facilitates millet breeding. Crop Sci. **8**: 623–634.

JOPPA, L.R. and MCNEAL, F.M. 1969. Pollen fertilization by three spring wheats (*Triticum aestivum*, L.) of the male sterility induced by *T. timopheevi* cytoplasm. Crop Sci. **9**: 239–240.

MIRI, R.K., AMAWATE, J.S. and JAIN, H.K. 1970. N.P. 839, N.P. 883 and N.P. 880, new sources of fertility restoration in male sterile wheat. Wheat Inf. Serv. **31**: 9–11.

TAHIR, C.M. 1969. Sources of fertility restoring genes for *Ae. ovata* and *T. timopheevi* cytoplasms. Wheat Inf. Serv. **29**: 15–17.

Effect of plant population on yield components of *Triticum aestivum* L.

M.B. KUMBHAR and A.S. LARIK

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

Row width and seeding rate (plant spacing) traditionally have been considered important in winter wheat cultures (STICKLER 1961). Of the various important inputs for a successful crop of wheat the size of the plant population plays a crucial role in developing the yield potential of a variety. Spacing influences root development, plant growth and yield. Too close spacing results in excess competition between plants and thus reduces yield. Too wide spacing will not make full use of the available soil surface and will not give an economic return (MANGLICMOT *et al.* 1964).

The present investigation was therefore, initiated to determine the influence of row width and seed rate (plant spacing) on different quantitative traits of winter wheat varieties.

Material and Methods

Present research was conducted on the agronomic research area of the Faculty of Agriculture, University of Ankara during the year 1978–79 with three winter cultivars viz., Tosun 22, 66 T1435 and Bezostaya 1 using five between row spacings (10, 15, 20, 25, 30 cm) and five plant spacings (1, 2, 3, 4, 5 cm). A split-split plot experimental design with four replications was used with varieties as main plots, row spacings as sub-plots and plant spacings as sub-sub plots. Each sub-sub plot consisted of three rod rows 1.5 m long. Observations on culm length, spike length, spikelets per spike, seeds per spike, 1000-kernel weight and yield per spike were taken on 15 main stems selected randomly from 1 m length of the central row leaving border plants on both ends of the row.

Results and Discussion

Analysis of variance (Table 1) revealed highly significant ($P \geq .01$) differences among cultivars for all the metrical traits except spikelets per spike. Likewise highly significant ($P \geq .01$) effects were also observed for various row spacings and plant spacings. Details of main effects are depicted in Table 2.

Row spacings and plant spacings had a significant effect on culm length. In all the cultivars culm length increased progressively with the increasing population density (Table 2) as a result of competition for light. Similar results were reported by PUCKRIDGE & DONALD (1967), CLEMENT & COLLINS (1976) and FEJER *et al.* (1979). KIRBY & FARIS (1970) reported that the early and vigorous elongation of the lower internodes of barley plant in response to high density is brought about by density induced changes in gibberellic acid (GA).

Table 1. Variance ratio from analysis of variance for six parameters of three hexaploid wheat genotypes under varying population densities.

Source of variation	D.F.	Culm length	Spike length	Spikelets per spike	Seeds per spike	1000-kernel weight	Yield per spike
Genotype (A)	2	356.40**	365.52**	1.02ns	323.72**	696.48**	181.52**
Row spacing (B)	4	85.22**	143.84**	2.60ns	124.08**	64.57**	140.54**
Plant spacing (C)	4	435.23**	645.58**	12.29**	352.16**	94.94**	286.87**
A×B	8	2.87*	2.02ns	1.06ns	1.05ns	2.79*	3.12**
A×C	8	24.93**	4.45**	1.43ns	1.74ns	2.42*	4.00**
B×C	16	1.03ns	1.33ns	1.02ns	1.77ns	2.79**	1.68ns
Error (A×B×C)	32	—	—	—	—	—	—
Total	74						
S.E. for genotype		0.1685	0.0145	0.2096	0.1373	0.1874	0.008
LSD (.01)		0.49	0.04	NS	0.40	0.54	0.02
LSD (.05)		0.65	0.06	NS	0.53	0.73	0.03

* P 0.05; ** P 0.01; NS=non-significant

Table 2. Mean values of three winter wheat varieties for different quantitative characters as affected by population levels.

Row spacing (cm) × Plant spacing (cm)	Culm length (cm)	Spike length (cm)	Spikelets per spike	Seeds per spike	Yield per spike (gm)	1000-kernel weight (gm)
10×1	90.81	8.95	18.77	25.11	0.53	21.64
2	88.39	9.51	19.58	29.32	0.80	25.16
3	85.37	9.77	20.33	30.97	0.87	25.21
4	82.25	9.99	20.67	32.82	0.95	25.97
5	79.90	10.27	20.86	34.56	1.06	26.68
15×1	89.54	9.18	19.27	29.07	0.76	24.99
2	86.73	9.59	19.81	30.97	0.86	25.70
3	83.53	9.85	20.37	32.66	0.97	26.47
4	80.48	10.22	20.79	34.46	1.04	26.78
5	78.68	10.39	21.01	36.24	1.15	27.38
20×1	88.61	9.32	19.39	29.90	0.83	25.81
2	86.11	9.70	19.77	31.92	0.94	26.52
3	82.80	9.94	20.51	34.03	1.05	26.69
4	79.67	10.30	20.92	35.94	1.17	27.55
5	77.27	10.51	21.20	37.29	1.23	27.85
25×1	87.53	9.56	19.49	30.28	0.86	25.92
2	83.53	9.89	20.53	32.46	0.99	26.85
3	81.35	10.10	20.61	34.67	1.10	27.29
4	78.25	10.48	21.05	36.97	1.22	27.91
5	76.15	10.74	21.34	39.22	1.32	28.08
30×1	86.24	9.66	19.88	30.76	0.91	26.70
2	83.15	9.99	20.49	33.34	1.04	27.29
3	80.55	10.23	20.70	35.78	1.15	27.91
4	77.10	10.54	21.14	38.46	1.29	28.29
5	74.29	10.84	21.42	39.97	1.36	28.38
Mean	82.73	9.98	20.39	33.49	1.02	26.60

Population levels had a pronounced effect on spike length. Treatments of low densities had longer spikes than their counterparts at higher densities (Table 2). Competition for nutrients, water and light in the very early stages of ear development results in decreased spike lengths in dense population. These results are in good hormony with MADDENS (1974) and WILLEY & HOLLIDAY (1971). These authors reported that spikes growing under shade remain shorter than those growing under open light.

Spikelets per spike were affected significantly ($P \geq .01$) by plant spacing. However, it showed no response to row spacing (Table 1). Spikes at low population levels had more spikelets than their dense population equivalents (Table 2). The number of spikelets is controlled by competition among plants for light, assimilates and nitrogen (PUCKRIDGE 1968) and the proportion of spikelets surviving from ear emergence to ripeness displayed a trend from 52.4% for the low density to 37.5% for the high density population (LEAKY 1971).

Increasing competition between the plants with increasing plant densities affected the number of grains per ear in the same manner as the spike length and spikelets per spike (Table 2). The number of grains per ear is controlled by the number of spikelets present and the number of grains formed in each spikelet. In the present experiment some basal and a large number of terminal spikelets failed to develop at higher densities. The fertility of initiated spikelets depends largely on growing conditions. The physiological factors determining the number of ripe grains produced per ear are not clearly understood, but it is obvious that more spikelets are always available at ear emergence than are subsequently filled. The cause of the failure of spikelets to develop is not evident but may be related to competition for assimilates between spikelets, possibly controlled by gradients of growth regulatory substances. KIRBY & FARIS (1970) have reported that at high densities an increase in the level of GA-like substances coupled with a lower nutrient supply, would together produce a steeper-than-normal nutrient gradients in the apex early in the life of the plant, thus causing the reduced development of terminal spikelets. However, there is some evidence that with a higher light intensity more spikelets produce grains (FRIEND 1965, WILLEY & HOLLIDAY 1971) and that within each ear the number of florets and grains produced are closely connected with the rate of spikelet differentiation (KIRBY, 1974).

1000-kernel weight decreased progressively with increasing plant density (Table 2). In dense populations competition for light and assimilates from flowering to ripening results in reduced seed weight. The cause of reduced grain weight can be ascribed to the competition for photosynthetic material which occur between individual grains on the ear (NAZIR *et al.* 1975) and growing the spikes under shade from flowering to ripening resulted in reduced grain weight (WILLEY & HOLLIDAY 1971, KASIMOV 1976). 1000-kernel weight is an important factor for seed production. Bolder seeds can produce healthier plants. For this reason wider spacing is recommended for seed production.

Yield per spike was significantly affected ($P \geq .01$) by row spacing and plant spacing (Table 1). Spikes in the low population levels yielded more as compared to those in high population levels (Table 2). Initially there is a much greater ear potential than is normally

fulfilled, but this declines as crop growth and competition increases. At the lowest population there is little evidence of competition until the advanced stages of growth. At the higher populations the onset of competition is earlier and potential declines more rapidly. Even as early as ear initiation the ear potential is decreased quite substantially at the high populations; this could not be because of a direct effect on ear development but because competition has already reduced shoot size (WILLEY & HOLLIDAY 1971). It has also been reported that gibberellic acid inhibits the development of the barley spike (HUGHES *et al.* 1978), hence can be an important factor in reducing grain yield at high plant densities. KIRBY & FARIS (1970) suggests that levels of GA in the plant are affected by light intensity or composition. Light could therefore be an important environmental factor affecting both carbohydrate production and GA-regulated growth mechanisms under the conditions of manipulated plant density.

Acknowledgements

The valuable assistance of Professor O. Tosun of Agronomy Department, University of Ankara, Turkey, is greatly acknowledged. Senior author is also grateful to the Government of Pakistan and Government of Turkey for providing financial assistance under cultural Programme.

References

CLEMENT, E.L. & F.C. COLLINS 1976. Arkansas Farm Res. **25**: 5.
FEJER, S.O., G. FEDAK & B.J. GILLESPIE 1979. Z. Pflanz. **83**(2): 185–191.
FRIEND, D.J.C. 1965. Can. J. Bot. **43**: 345–353.
HUGHES, W.G., J.J. BODDEN & S. GALANOPOULOU 1978. Annal. Appl. Biol. **88**(2): 313–319.
KASIMOV, I. 1976. Rasteniev'dni Nauki **13**(3): 46–54.
KIRBY, E.J.M. 1974. J. Agri. Sci. Camb. **82**: 437–447.
——— & D.G. FARIS 1970. J. Exp. Bot. **21**: 789–798.
LEAKY, R.R.B. 1971. J. Agrie. Sci. Camb. **77**: 135–139.
MADDENS, K. 1974. Revue del' Agriculture **27**(3): 543–558.
MANGLICMOT, J.M., G.M. GARCIA, N.S. TAYLAN & A.R. MADAMBA 1964. Philippine J. Pl. Indus. pp 151–158.
NAZIR, S., M. RASHID, G. ALI, & M.A. GILL 1975. Pak. J. Agric. Sci. **12**(3/4): 133–136.
PUCKRIDGE, D.W. 1968. Aust. J. Agric. Res. **19**: 191–201.
——— & C.M. DONALD 1967. Aust. J. Agric. Res. **18**: 193–211.
STICKLER, F.C. 1961. Trans. Kansas Univ. Acad. Sci. **64**(1): 1–6.
WILLEY, R.W & R. HOLLIDAY 1971. J. Agric. Sci. **77**: 453–461.

Response of wheat and triticale cultivars grown under field conditions to drought stress

Hassan I. SAYED

College of Agriculture University of Riyadh, Riyadh, Saudi Arabia

The life cycle of the wheat plant in the Arabian Peninsula covers the period from November to April, during which the rainfall is inconsistent and negligible. Crop yield depends primarily on the amount of moisture available during the growing season. In view of the limited water resources in the area, breeding for drought tolerance could save in the amount of consumed water or produce more yield for the same amount of water consumed.

Few steps were suggested in breeding for drought stress (4). These are; (a) Careful evaluation of material for individual traits associated with drought resistance as well as for yield performance under stress conditions. (b) Intercrossing of cultivars with a number of these traits. (c) Subsequent selection, in the segregating generations, of lines combining these characteristics with high yields under stress.

Although recent breeding efforts have resulted in high yielding cultivars under high fertility, most of these have generally yielded the same or sometimes even less than previously developed cultivars under severely stressed conditions (5).

The objectives of this paper were; (a) To evaluate some high yielding cultivars for drought tolerance. (b) To identify some of the agronomic traits which relate to drought tolerance under the prevailing conditions.

Materials and Methods

The experiment was conducted during the winter season of 1979–1980 in the College of Agriculture, Riyadh University Experimental Station near Riyadh, Saudi Arabia. The Experiment consisted of 14 bread wheat (*Triticum aestivum* L.), nine durum wheat (*Triticum durum* Desf.) and one triticale (*X Triticosecale* Wittmack) cultivars (Table 1). Three cultivars, Mexipak, Arz and Jori 69 were chosen since they are widely grown in the area. The rest of the genotypes were selected for their high yielding ability in national breeding programs of the region. The experimental design was a randomized complete block with four replications. Each replicate consisted of six rows, 2.5 m long and 30 cm apart. The seed rate was 100 kg/ha and fertilizers were applied at a rate of 100 kg/ha N and 50 kg/ha P_2O_5. The phosphorus and half of the nitrogen fertilizers were added two weeks after emergence, while the rest of nitrogen was applied four weeks later.

The planting date was 29/12/1979, four weeks later than the recommended date in order to expose the plants to high temperatures late in the season thus pronouncing the effects of drought stress.

Table 1. Names and origin* of the different cultivars in the study.

ENTRY	VARIETY/CROSS	ORIGIN	ENTRY	VARIETY/CROSS	ORIGIN
	A-Bread wheat			B- Durum Wheat	
1	Mexipak 65	Mexico/Pakistan	15	Waha 'S'	Mexico
2	CM 15517–1L–2L–OSK	Mexico/Lebanon	16	Fg 'S' × Magh-Gta 'S'	Mexico
			17	Boyeros 'S'	Mexico/Syria
3	Pavons'	Mexico	18	CM 225–21M–1Y–OM–OY	Mexico/Syria
4	HD–2172	India			
5	CM 16045–13M–1Y–OM	Mexico/Syria	19	CM 18882–2Y–OY	Mexico
			20	Gdo VZ 469–Cr 'S'	Mexico/Turkey
6	CM 8865–D–4M–1Y–1M–OM	Mexico/Syria	21	Redhead 'S'	Mexico
			22	Bittern 'S'	Mexico/Syria
7	Vanern	Mexico/Syria	23	Jori 69	Mexico
8	IWP 19	India		C-Triticale	
9	633 VD VI	Turkey	24	Maya I-Arm 'S' × 2148–1N–1M–OY	Mexico
10	Cgn × Kal-Bb	Mexico			
11	Sakha 7	Egypt			
12	Arz	Mexico/Lebanon			
13	CM 8237–G–1M–3Y–2M–4Y–OM	Mexico/Lebanon			
14	Mesabi	Mexico/Syria			

* Source: Regional Wheat Yield Trials, ICARDA, Syria.

Table 2. Soil and irrigation properties of the experimental sites.

	Site 1	Site 2
a) Soil mechanical analysis		
Sand	77.12%	51.52%
Silt	16.68%	27.60%
Clay	10.20%	20.88%
Soil texture	Sandy loam	Sandy clay loam
b) Irrigation water		
Seasonal (total) amount	61 cm	126 cm (adjusted for rain)
IW/CPE ratio*	0.5	1.1
Irrigation Frequency	3 days	5–9 days (18 times)
Depth of irrigation water	2.0 cm	7.0 cm
c) Seasonal rainfall	5.34 cm	

IW: Irrigation water CPE: Cumulative Pan Evaporation

* Ratio for optimum yield 0.75–0.80.

The experiment was planted at two sites of the station. Table 2, shows the soil and irrigation particulars of both locations. Site 1, irrigated by a fixed line sprinkler system, was subjected to drought stress by controlling irrigation following seedlings' establishment. The amount of irrigation water was 55.0% of the Cumulative Pan Evaporation (CPE) for the same period applied at short interval and shallow depth. In addition, irrigation was halted for seven days, 65 days after emergence. Site 2, irrigated by surface flooding was kept free of drought stress. The amount of irrigation water was 110.0% of CPE given at longer intervals and greater depth (Table 2).

Data on number of days to heading, days to maturity and plant height were recorded. The number of tillers or the number of fertile spikes, number of kernels/spike and

dry matter weight were obtained from samples collected after 65 days and at harvest. Each sample consisted of all above ground growth from 0.06 m^2 area (20 cm of row) of each plot. Grain yield was estimated from the clean grain of the four central rows of each plot. After harvest, the two outer rows of each plot were dug to a depth of 60 cm using a ditcher plow. Ten plants were collected from each plot at random. The roots were thoroughly washed, dried and weighed.

Following analysis of variance and L.S.D test, correlation coefficients for each character between the two sites were calculated. Path-Coefficient analysis was carried out to determine the effect of yield component characters on grain yield at different sites.

Results

Inspection of the plants during different growth stages indicated that poor stand establishment, plant diseases or lodging were not apparent at either site. Therefore, grain yields were related, primarily, to drought stress. Samples collected at 65 days prior to the onset of the severe drought treatment, indicated that the cultivars at site 1 were under water stress and produced 59.0% less dry matter, 45.0% fewer tillers and headed 3.6 days earlier in comparison to site 2, (Table 3).

At the drought-stressed site, 20 cultivars flowered within the seven days period of no irrigation. The rest flowered within the week after irrigation was resumed. The deleterious effects of drought were pronounced on the rapid growing tissues and organs. Spikes failed to emerge from their sheathes as the peduncles ceased to grow and senescence was common on most leaves. In later stages, even when the plants were irrigated regularly, there occurred a rapid termination and final decline in grain development due to enhanced senescence, consequent decrease in photosynthetic activity and reduced transfer of assimilates to the ear. The plants were conspicuously shorter (43.0%) and matured 6.2 days earlier compared to site 2.

Table 3. Means' averages, reduction and correlation coefficients between sites for different characters.

Character	Means' averages		Reduction % (of site 2)	r
	Site 1	Site 2		
1) Dry matter at 65 days (t/ha)	4.80	12.40	59.0	−0.03
2) Tillers/m^2	315.00	575.00	45.0	0.02
3) Dry matter at harvest (t/ha)	5.30	16.50	68.0	0.08
4) Days to heading	70.90	74.50	3.6 days	0.89**
5) Days to maturity	100.50	106.70	6.2 days	0.51**
6) Plant height	41.50	73.40	43.0	0.42**
7) Root weight	4.60	7.40	38.0	0.18
8) Spikes (at harvest)/m^2	286.00	401.00	29.0	0.04
9) Kernels/spike	32.00	48.00	33.0	−0.16
10) 1000-grain weight	24.80	28.20	12.0	0.64**
11) Grain yield (t/ha)	0.62	2.89	79.0	0.06

*,**: Significant at 0.05, 0.01.

The increase in dry matter during the post-heading stages, 65 days to maturity, mounted to 9.0% of the total dry matter at site 1 compared to 25.0% formed at site 2. Root samples taken from the upper 60 cm of the soil were also lighter in weight for site 1 compared to site 2 (Table 3).

The average grain yield harvested at site 1 was reduced to 25.0% of that harvested at site 2. This was accompanied by a reduction in the three yield component characters namely; number of fertile spikes/m^2, number of kernels/spike and 1000-grain weight, of 29.0, 33.0 and 12.0%, respectively, (Table 3).

Path-Coefficient analysis of the two sites is presented in Table 4. At site 1, kernels/spike had the largest direct effect on grain yield in addition to an indirect effect through spikes/m^2. At site 2, 1000-grain weight had the largest direct effect on grain yield. Spikes/m^2 was second to 1000-grain weight despite its very small correlation with grain yield.

Table 4. Path-coefficient analysis of grain yield and related characters.

Grain yield VS:	Direct effects	Indirect effects via:				Correlation with grain yield
		Spikes/m^2	Kernels/spike	1000-grain wt.	T. dry matter	
			Site 1			
Spikes/m^2	0.06	—	0.11	−0.02	0.01	0.16
Kernels/spike	0.46	0.01	—	0.01	0.01	0.49**
1000-grain wt.	0.04	−0.01	0.08	—	−0.01	0.10
T. dry matter	0.03	0.02	0.06	−0.01	—	0.10
			Site 2			
Spikes/m^2	0.27	—	−0.02	−0.15	−0.02	0.08
Kernels/spike	0.09	−0.04	—	0.03	0.01	0.09
1000-grain wt.	0.60	0.07	0.01	—	−0.01	0.53**
T. dry matter	−0.05	0.14	−0.01	0.11	—	0.19*

*,**: Significant at .05, .01, respectively.

Table 5. Means (ranks) for grain yield and yield component characters recorded for the top five yielders and the control cultivars.

Cultivar	Site 1				Site 2			
	grain yield (t/ha)	Spikes/m^2	Kernels/spike	1000-grain weight(g)	grain yield (t/ha)	Spikes/m^2	Kernels/spike	1000-grain weight (g)
1) Vanern's'	0.79(1)	361	35.6	23.0	3.15(7)	450	46.4	23.5
2) Mesabi's'	0.69(4)	391	25.0	22.8	3.51(4)	408	47.0	28.4
3) CM 18882-2Y-OY	0.64(7)	250	40.0	27.0	3.25(6)	400	46.1	21.1
4) Redhead's'	0.63(8)	366	28.4	27.0	3.72(1)	408	47.0	34.4
5) HD-2172	0.63(9)	325	31.8	25.5	3.01(10)	525	53.4	28.1
6) Mexipak	0.68(4)	341	19.3	22.5	2.70(15)	363	52.5	25.5
7) Arz	0.58(14)	291	34.0	25.7	2.66(16)	450	44.7	28.3
8) Jori 69	0.56(16)	258	31.3	29.1	2.73(14)	333	54.6	31.3
9) Maya-I-Arm's'	0.62(10)	335	36.9	22.8	2.52(20)	375	46.9	25.2
Site mean	0.62	286	32.1	24.8	2.89	401	48.0	28.2
L.S.D.	N.S.	90	7.5	1.6	0.69	69	8.6	3.6

The degree of association between the two sites showed significant correlations for plant height, days to heading, days to maturity and 1000-grain weight. The rest of the characters showed insignificant correlations indicating different levels of response to drought stress.

In conjunction with drought tolerance, only five cultivars, three bread and two durum wheat, ranked within the best ten yielders at both sites (Table 5). They included the top yielder at each site. The widely grown cultivar, Mexipak and the triticale line Maya-I ranked within the top ten at site 1 but dropped below average at site 2. Cultivar Arz and Jori 69 ranked below average at both sites.

Discussion

The plants at site 1 were under moisture stress during the pre-heading stages. They suffered from severe drought when the irrigation was halted.

The maximum number of tillers was established prior to heading with twice as much formed at site 2. The number of dead tillers at maturity was 9.0% at site 1 compared to 30.0% at site 2. The non-fertile tillers seemed to be unwanted luxury at site 1 since they represented wasteful soil moisture and assimilates needed for ear development (1, 4). Competition among tillers for assimilates could have limited the spike size (kernels/spike). This supports the concept of a limited number of tillers for dry conditions, which onset and mature about the same time (4, 8).

Drought stress during inflorescence development and anthesis reduced the number of kernels/spike to two-thirds of the potential as produced at site 2. Therefore, kernels/spike had the largest direct effect on grain yield.

The 1000-grain weight at site 1 was reduced by only 12.0% despite the fact that few green areas on the plants were functioning during the grain filling period. This indicated that assimilates from the stems were translocated to the grains to compensate for the deficit in dry matter production (3).

The overall response of grain yield to drought stress was mainly related to severe reductions in (a) the size of the sink and (b) the source of assimilates in the postheading stages. The former was related to reductions in spikes/unit area and kernels/spike. The latter resulted from senescence of the photosynthetic tissues during the grain filling period (2, 9). In contrast, at the site without water stress, the limiting factor to grain yield was the source of assimilates expressed in the 1000-grain weight. The size of the sink, represented by spikes /m^2, was secondary in this case.

The five top yielding cultivars were noted for their ability to avoid stress by maintaining high values for one or more yield component traits. This indicated different genotypic response and ability to drought tolerence. The bread wheat cultivars, Vanern 's', Mesabi 's' and HD–2172, depended in their grain yield on a large sink (spikes and kernels) and less on the source (1000-grain weight). In contrast, the durum cultivars, CM18882 and Redhead 's', were less dependent on the sink but more on the source (6). These five cultivars seemed

to meet the proposed criterion for drought resistance (5) of having the highest yields at the severely stressed environment, site 1, and a strong response to the more favourable environment, site 2.

Literature Cited

(1) BINGHAM, J. 1969. Agric. Progr. **44**: 30–42.
(2) FISCHER, R.A. 1973. In R.O. Slayter (ed.) Plant response to climatic factors. UNESCO, Paris.
(3) GALLIGHER, J.N., P.V. BISCOE & R.K. SCOTT. 1975 J. Appl. Ecol. **12**: 319–336.
(4) HURD, E.A. 1971. In K.L. LARSON and J.D.- EASTIN (ed.) Drought injury and resistance in crops. CSSA Spec. Pub. No. 2. Crop Sci. Soc. Am. Madison, Wis.
(5) KEIM, D.L. & W.E. KRONSTAD. 1979. Crop Sci. **19**: 574–576.
(6) ——— & ——— 1981. Crop Sci. **21**: 11–15.
(7) SLAYTER, R.O. 1969. In physiological aspects of crop yield. Am. Soc. Agron. Madison, Wis. pp. 53–88.
(8) THORNE, G.N. 1966. In F.L. MILTHORPE and J.D. IVINS (ed.). The growth of cereals and grasses. Butterworth, London.
(9) WARDLAW, I.F. 1970. Aust. J. Biol. Sci. **23**: 765–774.

Vernalization response in autumn-sown spring wheat

R.G. FLOOD* and G.M. HALLORAN

School of Agriculture and Forestry, University of Melbourne
Parkville, Victoria 3052, Australia

Vernalization response appears to be present in most temperate agricultural plants and in many species according to the strength of response, it causes strong differentiation of growth habit into spring and winter forms. Spring habit in wheat is conferred by the condition of little or no vernalization response while winter habit is conferred by a strong response. The adaptive value of strong vernalization response, or winter habit, is of obvious significance in preventing precocious floral initiation and freezing injury to the apex in autumn-sown wheat in environments with prolonged below-freezing temperatures during winter. However, the possible adaptive value of low levels of response in many spring wheats is not as immediately apparent.

Many autumn-sown spring wheats, as in Australia, possess moderate to low levels of vernalization response (HALSE & WEIR 1970, MARCELLOS & SINGLE 1971, PUGSLEY 1971, Syme 1973, Halloran 1975, 1977). While there has been no deliberate selection for the inclusion of vernalization response in the breeding of Australian wheat its general occurrence in these wheats indicates that selection for optimum flowering time or yield has most likely involved indirect selection for this character. Therefore, in breeding autumn-sown spring wheats for increased adaptability and yield, knowledge of the significance of changes to be effected in vernalization response towards this end, appear to be important.

The aim of this study was to examine a number of Australian autumn-sown spring wheats for the quantitative and qualtaitive nature of their vernalization responses. In this evaluation they were to be compared with vernalization responses in a set of near-isogenic lines of Triple Dirk which differ for vernalization response (*vrn*) genes (PUGSLEY 1968, 1970, 1972).

Materials and Methods

Sixteen Australian wheats, comprising current and superceded commercial cultivars, the Canadian cultivar Thatcher, plus a set of four near-isogenic lines of Triple Dirk (differing in vernalization response genes) (Table 1) were used in this study (Table 2).

Seed of the 21 wheats was imbibed for 48 hours at room temperature and sown into pots of a sterile soil mixture of loam, sand and ligna peat (3:2:1 by volume) with adequate nutrients and placed in a cold room at 3°C for vernalization. On emergence, the seedlings were given a 12 h photoperiod for the duration of the vernalization treatment provided by two 60 W incandescent lamps 40 cm above them. Separate batches of seed of each line

* Present address: Victorian Crops Research Institute, Private Mailbag 260, Horsham, Victoria 3400, Australia.

were vernalized for 4, 6 and 8 weeks, such that the vernalization periods were completed simultaneously. After vernalization the seedlings were kept at room temperature for three days to prevent possible devernalization.

Vernalized seedlings plus an unvernalized set (germinated five days before the end of the vernalization treatment) were planted in the same soil mixture described above. Ten seedlings (five per pot) of each vernalization treatment per line (0, 4, 6 and 8 weeks) were planted in 18 cm diameter pots. The experiment was placed outdoors in early

Table 1. Near-isogenic lines of Triple Dirk and their respective genotypes for vernalization response

Experimental Lines	Genotype
Triple Dirk	*Vrn* 1 *Vrn* 2
Triple Dirk D	*Vrn* 1 *vrn* 2
Triple Dirk B	*vrn* 1 *Vrn* 2
Triple Dirk C	*vrn* 1 *vrn* 2

Table 2. Days to ear emergence of 21 wheats after 0, 4, 6 and 8 weeks vernalization and grown under an 18 h photoperiod

Wheats	Year of commercial release	Days to ear emergence				L.S.D. (P=.01)
		Vernalization period (weeks)				
		0	4	6	8	
Triple Dirk	Not commercial	36.6	34.6	34.0	34.1	0.9
Triple Dirk D	Not commerical	39.8	36.2	35.2	34.7	1.4
Triple Dirk B	Not commercial	46.3	35.3	34.3	34.4	1.5
Triple Dirk C	Not commercial	*A	40.2	36.0	35.1	
Bindawarra	1980	58.4	37.1	35.0	34.7	1.1
Kewell	1977	57.4	40.0	38.6	38.4	1.7
Bencubbin	1922	48.8	37.6	37.2	36.4	2.0
Kalkee	1977	48.2	35.5	34.2	33.8	2.3
Olympic	1956	48.2	39.8	38.9	38.5	1.8
Emblem	1963	47.9	34.6	34.5	34.4	2.3
Insignia	1946	46.9	34.9	34.6	34.6	1.4
Summit	1966	46.2	39.5	37.2	36.0	2.0
Pinnacle	1946	45.1	40.9	38.0	39.5	2.6
Zenith	1973	44.3	38.8	36.8	35.5	1.6
Sherpa	1953	43.8	*B	41.6	38.1	1.9
VIC 001	Crossbred (not released)	43.6	35.5	34.7	34.8	1.8
Warigal	1978	41.0	39.9	35.0	34.5	1.8
Gabo	1945	40.1	33.8	34.5	33.2	1.3
Millewa	1978	39.7	37.2	34.1	34.7	1.2
Halberd	1970	38.9	35.2	34.3	35.3	1.4
Thatcher	—	38.7	35.0	35.3	36.3	1.6
L.S.D. (P=.01)		2.3	1.7	1.3	1.4	

A No plants headed at 130 days
B No plants survived in this treatment

December 1981 under 18 h photoperiod (natural photoperiod extended to 18 h by 150 W incandescent lights operated through a time clock) so that photoperiod would not limit development rate of the wheat. Minimum daily temperatures for the duration of the experiment were above those necessary for vernalization. Records were made of the number of days from planting to ear emergence on the primary tiller of each plant and an analysis of variance was performed on the data.

Results

Significant (P=.01) differences in days to ear emergence at 0 and 8 weeks vernalization for all the wheats indicates the general presence of vernalization response amongst them. However, for those wheats showing only small differences in days to ear emergence between 0 and 8 weeks vernalization, e.g., in Triple Dirk and Thatcher, the presence of a vernalization response may be questioned because of possible differences in the developmental stage between the 0 and 8 weeks treatments at the time of planting out. However, part of the difference in days to ear emergence between 0 and 8 weeks vernalization for Triple Dirk D (5.2 days) is likely to represent an influence of vernalization because Triple Dirk D possesses the vernalization-promoting gene *vrn* 2 while Triple Dirk possesses the gene *Vrn* 2. On this basis it appears that all of the Australian wheats in this study with the exception of Halberd, possess a vernalization response. In some of the wheats the absence of a significant (P=.01) difference in days to ear emergence after 6 and 4 weeks vernalization indicate that their responses were satisfied by at least four weeks vernalization and in the remainder, except Sherpa, by six weeks cold treatment. Sherpa was the only wheat to exhibit a significant reduction in days to ear emergence from the six to eight weeks vernalization treatment.

Many of the wheats were significantly (P=.01) different from each other in days to ear emergence at 0 weeks vernalization, which cannot be interpreted as solely due to differences in vernalization response between them. The existence of significant (p=.01) differences between some of the wheats in days to ear emergence after eight weeks vernalization, when the vernalization response of each line had been satisfied, indicates the possible presence of another factor(s), other than vernalization and photoperiod, influencing the time to ear emergence.

Discussion

This study confirms previous findings (HALSE & WEIR 1971, MARCELLOS & SINGLE 1971, PUGSLEY 1971, SYME 1973, Halloran 1975, 1977) of the presence of vernalization response in most Australian spring wheats. This indicates that it is most likely of adaptive significance in conferring yield potential to wheat in Australia and that it has been indirectly retained, and most likely selected upon, in conjunction with yield selection.

This study reveals that it is not of a uniform level in Australian wheats and there are indications of differences in the quantitative nature of the response – a threshold response

whereby all vernalization is removed after four weeks of cold (3°C) and a cumulative response which declines more gradually over six weeks of cold, and in the case of Sherpa up to eight weeks of cold. In studies on the nature of vernalization response in the near-isogenic lines of Triple Dirk (BERRY *et al.* 1980) threshold and cumulative responses were assigned to the action of *vrn* 3 and/or *vrn* 4 and *vrn* 1 genes, respectively. The gene *vrn* 2 was found to intensify both types of response. It could be speculated, therefore, that these types of response exhibited by those Australian wheats within the range of responses of the Triple Dirk lines were due to them possessing either the *vrn* 3 and/or *vrn* 4 genes in combination with either the *vrn* 2 or the *vrn* 1 gene. In terms of the absolute level of response none of the Australian wheats appear to possess both *vrn* 1 and *vrn* 2 carried by Triple Dirk C because of their much lower days to ear emergence values at 0 weeks vernalization compared with this line. However, certain wheats, e.g., Bindawarra possess a vernalization response much higher than Triple Dirk D (*Vrn* 1 *vrn* 2) or Triple Dirk B (*vrn* 1 *Vrn* 2) and much lower than Triple Dirk C (*vrn* 1 *vrn* 2). It is possible that such wheats possess different *vrn* alleles from the Triple Dirk lines at either of these two loci or at both loci or that there are other loci involved in determining their vernalization responses. Evidence has been produced that more than two loci are involved in the control of vernalization response in wheat (HALLORAN & BOYDELL 1967, Pugsley 1971, Gotoh 1979).

The presence of significant differences in days to ear emergence between some of the wheats after eight weeks vernalization, when all vernalization response had been removed, indicates the possible existence of a factor(s) influencing development rate other than vernalization and photoperiod. This component of development has been termed basic development rate (FLOOD & HALLORAN 1982). Further studies are necessary of the inter-relationship of basic development rate with vernalization and photoperiod responses, in influencing flowering time in wheat.

Acknowledgements

This research was undertaken while one of us (R.G.F.) was the holder of the William Farrer Memorial Research Scholarship (1979–1981) and on study leave from the Victorian Department of Agriculture.

References

BERRY, G.J., P.A. SALISBURY and G.M. HALLORAN 1980. Expression of vernalization genes in near-isogenic wheat lines: duration of vernalization period. Ann. Bot. **46**: 235–240.

FLOOD, R.G. and G.M. HALLORAN 1982. Basic development rate in spring wheat (in preparation).

GOTOH, T. 1979. Genetic studies on growth habit of some important spring wheat cultivars in Japan, with special reference to the identification of the spring genes involved. Japan. J. Breed. **29**: 133–145.

HALLORAN, G.M. 1975. Genotype differences in photoperiodic sensitivity and vernalization response in wheat. Ann. Bot. **39**: 845–851.

———— 1977. Developmental basis of maturity differences in spring wheat. Agron. J. **69**: 899–902.

———— and C.W. BOYDELL 1967. Wheat chromosomes with genes for vernalization response. Can. J. Genet. Cytol. **9**: 632–639.

HALSE, N.H. and R.N. WEIR 1970. Effects of vernalization, photoperiod and temperature on phenological development and spikelet number of Australian wheat. Aust. J. Agric. Res. **21**: 383–393.

MARCELLOS, H. and W.V. SINGLE 1971. Quantitative responses of wheat to photoperiod and temperature in the field. Aust. J. Agric. Res. **22**: 343–357.

PUGSLEY, A.T. 1968. Genetic studies of phasic development and their applciation to wheat breeding. Proc. 3rd Int. Wheat Genet. Symp. pp. 288–293. Aust. Acad. Sci., Canberra.

———— 1970. Thrity years improvement of Dirk wheat. Annual Wheat Newsletter **17**: 21. National Wheat Improvement Committee, U.S.A.

———— 1971. A genetic analysis of the spring-winter habit of growth in wheat. Aust. J. Agric. Res. **22**: 21–31.

———— 1972. Additional genes inhibiting winter habit in wheat. Euphytica **21**: 547–552.

SYME, J.R. 1973. Quantitative control of flowering time in wheat cultivars by vernalization and photoperiod sensitivities. Aust. J. Agric. Res. **24**: 657–665.

Salt tolerance in certain mutants of common wheat variety HD 2009

Devender KUMAR

Haryana Agricultural University, Regional Research Station,
Bawal – 123501 Haryana (India).

The yield return of field crops in the semi-arid and arid zones have considerably been poor owing to mainly presence of underground saline water. Even the stable and medium tolerant crop like wheat is not exception to it under medium to abrupt saline lands. The use of tolerant genotypes in such conditions is known to show edge over other means – soil reclamation and management practices. Thus, salt tolerance assessment of the cultivars which are of recent origin and improved, is regarded a continuous process. Furthermore, induced heritable differences for salt tolerance in wheat are also on records (Kumar *et al.* 1980, 1981). This study was, therefore, a step ahead to ascertain comparative salt tolerance of three stable mutants alongwith parental variety following application with synthetic saline waters.

Material and Methods

Amongst the mutants of HD 2009 wheat (Kumar 1978), after subsequent screening, three promising ones were evaluated for salt tolerance in M_5 during 1979–80. The soil of the site was sandy loam, light textured and possessed 1.5 mmhos/cm ECe. A split-plot design with three repeats was used. Levels of salinity (2.1, 8, 12 and 16 mmhos/cm) were assigned to main plots (6.0×2.0 m) and the genotypes to 2 m long rows in each plot at a distance of 25 cm apart. Waters of desired salinity were prepared as reported by Kumar *et al.* 1980. Equal quantity of seeds (@ 100 kg/ha) was sown for each genotype. Data on yield components and root characters were recorded on 10 random plants/plot whereas yield was assessed per plot basis. Mineral analysis in leaf (heading stage) and grain (maturity) for N, P, K, Ca and Na were done as following CHAUHAN *et al.* (1980).

Results and Discussion

The means for yield components and root characters decreased with a significant margin at 8 mmhos/cm EC onwards (Table 1). On the contrary, grain yield was little higher to control at the initial salinity and decreased markedly at 12 mmhos/cm EC onwards. Yield was, therefore, more adversely affected compared to its components. For instance, grain yield declined to an extent of 80% at 16 mmhos/cm EC over control. The decrease in yield components was rather low to the extent of 11.74, 40.40 and 55.35% in 1000-grain weight, plant height and tillers/plant, respectively at the highest salinity over control. These results are similar to those of KUMAR *et al.* (1980, 1981) that yield was more affected than its components. Compared to yield components, the adverse effects of salinity were of quite large extent on root characters i.e. 66.54 and 90.90% reduction in root length and

root volume was recorded at the highest salinity over control. It is thus, placable on records that yield decline in present study was, mainly due to greater adverse affects of salinity on tillering, root length and its development.

A reliable estimate of tolerance to salinity of the genotypes is reflected from the data of Table 2. The yield ranged from 287.5 (Bhp 31) to 389.3 g (Bhp 36) against 339.8 g for control. The former thus yielded significantly higher whereas latter lower to control variety. The mutant Bhp 36 also showed maximum values on Mean Salinity Index (MSI), least reduction at abrupt salinity over control and regression slope, encouragingly 50% yield decline was also associated with the highest (14 mmhos/cm) salinity. This mutant may,

Table 1. Effect of saline water on control and induced mutants.

Control/Mutants	Salinity (mmhos/cm)	Tillers/plant (No.)	Plant height (cm)	1000-grain weight (g)	Grain yield plot* (g)	Root length (cm)	Root Volume
Control (HD–2009)	Control	3.1	75.3	39.5	438.0	14.8	1.3
	8	1.6	72.1	38.2	435.0	9.7	0.5
	12	1.5	57.7	33.3	257.5	7.6	0.3
	16	1.2	44.4	28.3	108.8	4.6	0.1
Bhp 30	Control	2.6	81.1	49.8	440.0	13.6	0.9
	8	2.1	77.5	47.2	461.3	10.9	0.6
	12	1.6	67.2	40.9	265.0	8.8	0.4
	16	1.3	49.2	31.5	80.0	5.6	0.1
Bhp 31	Control	2.8	77.0	46.0	400.0	14.3	1.2
	8	1.8	72.3	46.0	425.0	10.8	0.6
	12	1.0	55.2	37.9	126.3	8.0	0.2
	16	1.2	46.7	30.9	42.5	4.1	0.1
Bhp 36	Control	2.7	75.7	40.5	467.5	11.9	1.0
	8	1.8	70.1	35.8	487.5	9.9	0.6
	12	1.7	57.0	34.7	307.5	8.9	0.3
	16	1.3	43.9	29.3	118.8	4.1	0.1
CD_1 (5%) for salinity		0.5	2.7	1.6	52.5	1.0	0.1
CD_2 (5%) for genotype		NS	1.6	1.1	29.3	NS	NS
CD_3 (5%) for interaction		NS	NS	2.5	NS	NS	NS

* 1.25×2 m.

Table 2. Relative salt tolerance in control and induced mutants

Control/Mutants	Mean grain yield* (g)	Reduction at 16 EC over control (%)	Mean Salinity Index (%)	Estimated salinity for 50% yield decline (mmhos/cm)	Regression of yield on salinity.
Control (HD–2009)	339.8	75.15	74.1	13.20	Y=307.70−24.32x
Bhp–30	338.0	81.81	72.2	12.97	Y=311.57−26.50x
Bhp–31	287.5	89.37	64.9	11.12	Y=248.50−28.72x
Bhp–36	389.3	74.58	79.2	14.00	Y=345.31−25.44x
CD 5%	29.3				

* Grain yield across salinity levels.

Table 3. Effect of saline water on certain minerals* in leaf (flowering stage) and grain (maturity) in control and induced mutants

Control/ Mutants	Salinity (mmhos/cm)	N		P		K		Ca		Na	
		L	G	L	G	L	G	L	G	L	G
Control (HD-2009)	Control	0.1	1.5	0.2	0.2	1.4	0.4	0.1	0.1	0.3	0.3
	8	0.2	2.5	0.1	0.2	1.4	0.4	0.1	0.1	0.6	0.4
	12	0.3	2.6	0.1	0.2	1.3	0.4	0.1	0.1	0.7	0.6
	16	0.3	2.7	0.0	0.1	1.2	0.3	0.1	0.1	1.0	0.8
Bhp-30	Control	0.1	1.2	0.2	0.2	1.4	0.4	0.2	0.1	0.4	0.2
	8	0.2	1.7	0.2	0.2	1.3	0.4	0.2	0.1	0.6	0.5
	12	0.3	2.4	0.2	0.2	1.2	0.4	0.1	0.1	0.7	0.6
	16	0.4	2.5	0.1	0.2	1.1	0.4	0.2	0.1	1.1	0.8
Bhp-31	Control	0.0	1.7	0.2	0.2	1.4	0.4	0.1	0.1	0.4	0.2
	8	0.2	2.3	0.1	0.2	1.3	0.4	0.1	0.1	0.4	0.4
	12	0.3	2.4	0.1	0.2	1.3	0.4	0.2	0.1	0.9	0.6
	16	0.3	2.5	0.1	0.2	1.2	0.3	0.2	0.1	1.1	0.9
Bhp-36	Control	0.2	1.2	0.2	0.2	1.5	0.5	0.1	0.1	0.2	0.2
	8	0.2	2.0	0.2	0.2	1.3	0.4	0.2	0.1	0.5	0.5
	12	0.3	2.5	0.1	0.2	1.3	0.4	0.2	0.1	0.8	0.7
	16	0.4	2.7	0.1	0.1	1.2	0.3	0.1	0.1	1.1	0.9

* Samples analysed in triplicate.
L=Leaf, G=Grain.

therefore be considered better tolerant to HD 2009. Similarly, the mutant Bhp 31 was rather sensitive and Bhp 30 was a medium tolerant. Results of KUMAR *et al.* (1981) are similar that tolerance was associated to higher MSI values and lower regression slope.

Mineral accumulation in leaf and grain may reflect adjusting tendency of plants to saline environment. The accumulation of K, Ca and Na was more in leaf whereas N and P were more accumulated in grain. Thus, translocation of former three was inhibited from leaf to grain whereas latter two were translocated to grain. Furthermore, the concentration of N and Na increased whereas that of P and K decreased with rising salinity. No trend was, however, observed for Ca. The tolerant mutant Bhp 36 was characterized by maximum accumulation of K in leaf and grain in conjunction with least concentration of Na in leaf. This phenomenon has been referred to as selectivity of ion transport by LEVITT (1972). Bhp 36 has, therefore, tolerated salinity by adjusting due to accumulation of more K and restricting deleterious ion Na. Potassium has been found a chief osmotic gradiant in a wide range of crops and its more accumulation helps in causing fast penetration into cell sap and increasing water retention capacity of cell protoplasm.

References

CHAUHAN, R.P.S., C.P.S. CHAUHAN and D. KUMAR 1980. Free proline accumulation in cereals in relation to salt tolerance. Plant Soil. **57**: 167–175.

KUMAR, D. 1978. The impact of seed moisture on radiosensitivity, mutation frequency and spectrum following gamma ray treatment of wheat cultivars HD 1553 and HD 2009. Indian J. Hered. **10**(3): 19–28.

KUMAR, D., R.P.S. CHAUHAN and R.V. SINGH 1980. Performance of certain mutants of common wheat for yield and nutritional quality under salinity. Wheat Inform. Serv. **51**: 26–28.

KUMAR, D., R.P.S. CHAUHAN and R.V. SINGH 1981. Salt tolerance of some induced mutants of HD–2009. Indian J. Agric. Sci. **5** (7): 475–479.

Levitt, J. 1972. Salt and ion stress. In *Response of plants to environmental stresses.* Acad. Press, NY pp 489–530.

FORM A

SIXTH INTERNATIONAL WHEAT GENETICS SYMPOSIUM
REGISTRATION FORM

Please type or print in block letters, and return to Dr. S. Sakamoto, Local Coordinating Secretary, Plant Germ-plasm Institute, Faculty of Agriculture, Kyoto University, Mozume, Muko, Kyoto 617, Japan, by **December 31st, 1982.**

NAME: Prof./Dr. Mr. Miss Mrs./Ms. (Please encircle)

_____ _____ _____

(Family name) (First name) (Middle name)

INSTITUTION:

_____

_____

MAILING ADDRESS:

_____

_____

ACCOMPANYING PERSON(S):

(Name) _____

_____

REGISTRATION:

Participant	Foreign	Regular Fee	¥ 20,000	¥ _____
		Late Fee	¥ 25,000	
	Domestic	Regular Fee	¥ 30,000	
		Late Fee	¥ 35,000	
Accompanying person(s)		¥ 5,000 × ____ person(s)		¥ _____
Total				¥ _____

REQUEST FOR FURTHER INFORMATION OF PRE- AND/OR POST-SYMPOSIUM TOUR

I/We request detailed information of: (please check)

☐ Pre-Symposium Tour, ☐ Post-Symposium Tour

Date_____ Signature_____

FORM B

SIXTH INTERNATIONAL WHEAT GENETICS SYMPOSIUM
PAPER SUBMISSION FORM

Please type or print in block letters, and send to Dr. S. Sakamoto, Local Coordinating Secretary, Plant Germ-plasm Institute, Faculty of Agriculture, Kyoto University, Mozume, Muko, Kyoto 617, Japan, by **December 31st, 1982,** together with the original abstract (Form C: Abstract Form).

I wish to submit a paper, an 'abstract of which is attached, for the following sessions: (Please check)

☐ Oral Sessions ☐ Poster Session

In the case of Oral Sessions:

Session No.

Topic of Session

Author:

_____

(Family name) (First name) (Middle name)

Coauthor(s):

_____

Address: _____

_____

Title of paper: _____

_____

_____

_____

Date_____ Signature_____

FORM C

SIXTH INTERNATIONAL WHEAT GENETICS SYMPOSIUM
ABSTRACT FORM

(SAMPLE)

THE EFFECT OF ALIEN CYTOPLASMS ON THE GRAIN PROTEIN IN WHEAT

M. Sasaki, Y. Yasumuro and N. Nakata

Faculty of Agriculture, Tottori University, Tottori, Japan

Grains of Chinese Spring (CS) lines with Ae. caudata, Ae. umbellulata, Ae. squarrosa, T. timopheevi, Ae. ovata, Ae. speltoides, Ae. variabilis, S. cereale cytoplasm and the original one were analysed for the Kjeldal protein and dibasic amino acids by the DBC method.

The lines of CS with each Ae. caudata, T. timopheevi, Ae. umbellulata and S. cereale cytoplasm were significantly higher than CS with the original one in the % grain protein, and the CS line with Ae. caudata cytoplasm lower in the dibasic amino acid per gram protein.

However, it is likely that most of the higher protein and lower dibasic amino acids of these alien cytoplasmic lines can be explained as the secondary effects of the variation of yield component characters affected by the alien cytoplasms.

ABSTRACT

FORM D

SIXTH INTERNATIONAL WHEAT GENETICS SYMPOSIUM

HOTEL RESERVATION FORM

Please type or print in block letters, and return to Kinki Nippon Tourist Co., Ltd., 6th IWGS, Kyoto Tokai Bldg. 4F, Karasuma-dori, Shijo-agaru, Nakagyo-ku Kyoto 604, Japan, by **August 31st, 1983.**

NAME: Prof./Dr. Mr. Miss Mrs./Ms. (please encircle)

_____ _____ _____

(Family name) (First name) (Middle name)

INSTITUTION:

_____

_____

MAILING ADDRESS:

_____

_____

ACCOMPANYING PERSON(S)

_____

I. HOTEL RESERVATION IN KYOTO

I/We wish to make hotel reservations in Kyoto as follows:

Hotel Sunflower Kyoto

Single room: ☐ type (a), ☐ type (b) ×_____room(s)

Twin room: ☐ type (a), ☐ type (b), ☐ type (c) ×_____room(s)

Other room: _____

Kyoto Tokyu Inn

☐ Single room, ☐ Twin room ×_____room(s)

Check-in: November _____, Check-out: December _____, _____ nights

I will share a room with: _____

Other specifications or alternative choice: _____

_____

DEPOSIT: ¥10.000× _____ room(s)=¥ _____

II. REMITTANCE (No personal check will be accepted.)

☐ I have arranged a bank transfer through _____

_____ to KNT. (Bank of Tokyo, Kyoto Office Account No. 0114499)

☐ I enclosed herewith a bank draft to the order of Kinki Nippon Tourist.

Date_____ Signature_____

II. Records

Catalogue of gene symbols for wheat, 1982 supplement

R.A. McIntosh

Plant Breeding Institute, P.O. Box 180, Castle Hill,
N.S.W., AUSTRALIA, 2154

This catalogue will undergo a complete review for presentation at the 6th International Wheat Genetics Symposium in 1983. Lists for reference purposes will close on August 1, 1982. It will be appreciated if wheat workers could advise of corrections or additions for inclusion in the new Catalogue.

Reaction to *Puccinia recondita*

*Lr*30 Reference 61C replaces 58 listed in 1981.

Reaction to *Puccinia striiformis*

*Yr*2	7B(133AA)
*Yr*6	7B(133AA)

Reaction to *Cochliobolus sativus*

Disease: *Cochliobolus* root rot.

*Crr**	(133B)	v: Apex (133B)	5B (133B)

* Resistance allele is recessive.

References

61C. Dyck, P.L., and E.R. Kerber. 1981. Aneuploid analysis of a gene for leaf rust resistance derived from the common wheat cultivar Terenzio. Can. J. Genet. Cytol. **23**: 405–409.

133AA. Labrum, K.E. 1980. The location of *Yr2* and *Yr6* genes conferring resistance to yellow rust. Proc. 5th European and Mediterranean Cereal Rust Conf. Bari, Italy, 41–45.

170B. McIntosh, R.A., N.H. Luig, R. Johnson and R.A. Hare. 1981. Cytogenetical studies in wheat XI. *Sr9g* for reaction to *Puccinia graminis tritici*. Z. Pflanzenzüchtg. **87**: 274–289.

133B. Larson, R.I., and T.G. Atkinson. 1981. Reaction of wheat to common root rot: Identification of a major gene, *Crr*, on chromosome 5B. Can. J. Genet. Cytol. **23**: 173–182.

III. Announcement

Sixth International Wheat Genetics Symposium (2nd circulor)

GENERAL INFORMATION

Date and Address of the Symposium

The Sixth International Wheat Genetics Symposium will be held at Kyoto, Japan, from November 28th to December 3rd, 1983.

The Symposium will be held in the Kyoto Kaikan (Kyoto Municipal Assembly Hall), Okazaki, Sakyo-ku, Kyoto 606, Japan (Tel. 075–771–6051).

Official Language

Contributions to the Symposium are in English, as are the presentation and discussion of the papers, and also the proceedings.

Correspondence

All the correspondence concerning the Symposium should be addressed to:

Dr. S. Sakamoto
Local Coordinating Secretary
Sixth International Wheat Genetics Symposium
Plant Germ-plasm Institute
Faculty of Agriculture, Kyoto University
Mozume, Muko, Kyoto 617, Japan
Telephone: 075–921–0652. Cable address: IWGS

SCIENTIFIC PROGRAM

The response to the invitation to present papers at the Symposium has been overwhelming and a very large number of papers have been received. It has been decided to limit the presentation of contributed papers to 10 minutes, and to lump discussions of similar papers into time slots that will be determined by the number of papers. We will try to avoid concurrent sessions.

The six-day Symposium will cover the following topics:

Session No.	Topics
1.	Evolution and speciation
2.	Induced and natural variations
3.	Genetic resources in wheat
4.	Alien genetic material
5.	Genetic analysis
6.	Cytogenetics

7. Biochemical and molecular genetics
8. Physiological and ecological genetics
9. Cytoplasmic genetics
10. Quantitative genetics
11. Tissue and cell culture
12. Breeding and breeding methods including hybrid wheat
13. Disease and pest resistance
14. Wheat quality
15. Triticale
16. Genetic approaches to raising the yield ceiling

REGISTRATION

Intending participants are requested to complete and return the accompanying Registration Form (Form A) as early as possible and in any case not later than **December 31st, 1982,** to the Local Coordinating Secretary. Any registration received after that date must include a late registration fee of 5,000 yen.

Registration Fee

		Application received on or befor December 31, 1982	Application received after December 31, 1982
Participant	Foreign	20,000 yen	25,000 yen
	Domestic	30,000 yen	35,000 yen
Accompanying person		5,000 yen	5,000 yen

Payment must be made in Japanese yen by a bank transfer to the following account:

Account Name: 6TH IWGS
Account No.: 058–512–0112089
Bank: The Bank of Tokyo, Ltd., Kyoto Office
Karasuma-dori, Nishiki-koji, Nakagyo-ku,
Kyoto 604, Japan
Telephone: 075–255–3111

Personal checks and bank drafts can not be accepted.

The registration fee covers Symposium participation, a copy of the proceedings, participation in the social events, reception and local bus transportation.

The registration fee is not refundable.

PRESENTATION OF PAPERS

There will be both invited and contributed papers in the Oral Sessions and contributed papers in the Poster Session. Most of the Sessions will begin with an invited paper.

Authors presenting papers are asked to participate in the Symposium, and only one paper per participant will be accepted.

Those who present a paper in one of above Sessions are requested to complete the accompanying Paper Submission Form (Form B) and send it together with the Abstract (Form C) to the Local Coordinating Secretary by **December 31st, 1982.**

Oral Sessions:

Papers may be submitted to be read in the Oral Sessions. Ten minutes are provided for each presentation. Discussions of similar papers will follow. Projection facilities will be available for 35 mm slides (5 cm×5 cm mounts) only.

Poster Session:

Displays may be submitted for the Poster Session. In this Session, authors will display at a scheduled time and place the information they wish to present. Papers submitted for the Oral Sessions may be transferred to the Poster Session if time and space demand. Each poster will be allocated at a booth with two aluminum panels of size 100 cm×100 cm, joined together like a folding screen, and standing on a table. The paper title, author's name(s), institution, and country must be provided by the author(s), in block letters, on a 25 cm×90 cm strip to be placed on the top of the panel board. Photos, Tables, Illustrations etc., should be attached with adhesive tape. Adhesive tape will be provided.

All exhibits must be prepared before the start of the Poster Session.

SUBMISSION OF MANUSCRIPTS

Abstract

All contributors (Oral and Poster Sessions) are requested to submit an abstract of their presentation, together with completed Form B. The deadline for receipt of these abstracts in **December 31st, 1982.**

The abstracts will be processed by photography, so it is necessary that the instructions for completing an abstract, as given in the Sample Abstract of Form C provided with this circular, must be followed. Only typewritten abstracts, of the length and breadth indicated in the Abstract Form (Form C), can be accepted. The text must be single spaced. The sequencing and spacing of title, author(s), institution and text are shown on the sample form.

The abstract should begin with an indication of the purpose/aims of the investigation, and should end with a brief statement of the conclusions to be drawn from the data presented. To facilitate the programming, each title should be sufficiently explicite to accurately describe the contents of the paper.

Proceedings

Complete papers presented either in the Oral or Poster Session will be published in the proceedings. To facilitate early publication the complete manuscript must be submitted to

the Local Coordinating Secretary by **June 30th, 1983.** Galley proofs will be ready at the beginning of the Symposium. Contributors are requested to leave their corrected proofs with the Symposium Secretariat before the departure from the Symposium.

The detailed guide instructions for preparing the manuscript will be sent to the contributors after receiving the abstracts. The proceedings will be published and mailed after the Symposium. Reprints may be ordered at the time of the Symposium.

TRAVEL INFORMATION

Kinki Nippon Tourist Co., Ltd. (KNT), Kintetsu International Express (KIE) abroad, and affiliates have been authorized by the Local Organizing Committee to serve as the official travel agent for the Sixth International Wheat Genetics Symposium, Kyoto, November 28 through December 3, 1983.

KNT, KIE and affiliates will handle all the necessary travel arrangments including hotel reservations and local transportation for the IWGS participants.

All questions and inquiries regarding travel to and/or in Japan should be addressed to the followings:

(JAPAN)
Kinki Nippon Tourist Co., Ltd.
Kyoto Foreign Tourist Center
c/o Kyoto Tokai Bldg. 4F
Karasuma-dori, Shijo-agaru,
Nakagyo-ku, Kyoto 604, Japan
Tel: 075–222–1224
Int'l Telex: 5422645 KNTKYOJ

(Europe)
BCA Voyages, DIF Tours
20 Rue des Petits Champs
75002, Paris, France
Tel: 296–80–82
Int'l Telex: (42) 211148

(USA)
Kintetsu International
Express (USA) Inc.
1270 Avenue of the Americas,
Suite 1813, New York,
N.Y. 10020, USA
Tel: 212–586–4350
Int'l Telex: (230) 147133 KIE NYK

Kintetus International
Express (EUR) B.V.
Friedens Strasse 11, Juniorhaus
D–6000 Frankfurt AM.
West Germany
Tel: (0611) 234942 Int'l Telex: 041 6587

HOTEL ACCOMMODATIONS

Under the supervision of the Local Organizing Committee, KNT is holding the necessary number of rooms at the following hotels in Kyoto for the duration of the Symposium.

Hotel Sunflower Kyoto:
51 Higashitennoh-cho, Okazaki,
Sakyo-ku, Kyoto 606, Japan

Tel: 075–761–9111
Int'l Telex: 5422311

Hotel Sunflower Kyoto will serve as the headquarters for the Symposium. This hotel is located about 15 minutes walk from the Symposium site, Kyoto Kaikan, and about 15 minutes by taxi from Kyoto Station. The types of rooms and the number of each type is shown below. Your applications will be processed on a first come first served basis. Please bear in mind that if KNT can not grant your first choice, they will automatically allot you an alternate room.

Rooms in Hotel Sunflower Kyoto

Single Room: ¥7,000 per night

a) 35 Western style rooms with private bathroom
b) 52 Japanese style rooms without private bathroom

Twin Room:

a) 10 Standard twin rooms with private bathroom ¥10,400
b) 14 Deluxe twin rooms with private bathroom ¥14,600
c) 42 Japanese style rooms with private bathroom ¥10,400

N.B. Triple rooms can be secured upon request. In a Japanese style room, you take your shoes off when you enter and you will sleep on a "Futon" (Floor beds) spread on a Tatami-mat floor. Public bathroom is available for persons staying in the Japanese style rooms without a private bathroom.

Kyoto Tokyu Inn:

Kamikazan Yamashima-ku, Kyoto 607,
Japan
Tel: 075–593–0109
Int'l Telex: 5422–704

Kyoto Tokyu Inn is located on the hillside of Higashiyama mountains, east of downtown Kyoto. It is a little far from the Symposium site and from downtown (See the attached map of Kyoto), but there is easy access to downtown via city bus (20 minutes ride).

Free transfer service will be provided between the hotel and the Symposium site every morning before, and every evening after the meeting.

Single Room: ¥5,800
Twin Room: ¥8,400

N.B. All rates listed above are room charge only, but include service charges and government tax.
(No meals are included.)

In order to reserve rooms, participants are requested to complete the attached Hotel Reservation Form (Form D) and send it to KNT not later than **August 31st, 1983,** along with the necessary deposit of ¥10,000 per room. Upon receipt of your application and

acknowledgement of your remittance, KNT will reply with a confirmation.

Your application form should be addressed:

6th IWGS
Kinki Nippon Tourist Co., Ltd.
Kyoto Foreign Tourist Center
Kyoto Tokai Bldg. 4F, Karasuma-dori,
Shijo-agaru, Nakagyo-ku, Kyoto 604, Japan

The deposits must be made in Japanese yen by bank transfer to the following account:

Account Name:	IWGS KNT
Account No.:	0114499
Bank:	The Bank of Tokyo Ltd., Kyoto Office Karasuma-dori, Nishiki-koji, Nakagyo-ku, Kyoto 604, Japan Telephone: 075–255–3111

For a cancellation of hotel reservations, a written notice must be sent to KNT. KNT will refund the deposits, deducting the bank transfer charge and the following cancellation charge:

Up to 10 days before the first night of stay .....No charge
3–9 days before .....50% of deposit
Less than 2 days or no notice given .....100% of deposit

TOURS

Pre-Symposium Tour

Under the supervision and cooperation of the Local Organizing Committee of the Symposium, KNT will organize the Pre-Symposium Tour.

The tour will begin in Narita, the gateway to Japan, on November 22nd, 1983 (Tuesday). We will meet at a hotel in Narita located very close to Narita Airport (New Tokyo International Airport).

The following day we will visit the "National Institute of Agricultural Sciences" in Tsukuba, and we will stay overnight in Tsukuba. This is a newly developed area and is nicknamed the "city of brains". It is being created by the Government of Japan under the concept that international exchange and cooperative research activities are essential to outsanding innovations in science and technology.

In the morning of Thursday the 24th, we will visit the "Agricultural Research Center" in Tsukuba science city, then drive through our national capital, Tokyo, to Yokohama city for a visit to the "Kihara Institute for Biological Research". We will stay overnight in Hakone National Park.

On Friday the 25th, we will enjoy a short sightseeing tour of Hakone National Park

and in the afternoon we will visit the "National Institute of Genetics" at Mishima city. We will then drive, via Tomei Expressway, to the city of Nagoya where we will stay overnight.

The following day, we will visit a flour milling factory in Nagoya and a flour unloading facility at the Nagoya sea-port. We will then travel by train to Toba city, Ise Shima National Park.

On Sunday the 27th, we will visit Mikimoto Pearl Island, the home of cultured pearls, and a house of "Kagura-gama", a Japanese pottery making house in Toba city. Then we will take a train to Kyoto, the Symposium city. Upon arrival at your hotel in Kyoto, the tour will have terminated.

The tour will cost about ¥85,400 per person, on the basis of sharing twin rooms throughout. 5 breakfasts and 4 lunches are included.

Post-Symposium Tour

This tour begins in Kyoto on December 4th, 1983 (Sunday). We will visit highlights of Kyoto city including a firm that produces "Fu" (light cake) from wheat gluten. (Overnight in Kyoto).

The following day, we will visit the city of Nara, another ancient capital of Japan. A visit to a "Somen" (Japanese fine noodle) maker is included. Then take a train to Osaka city. (Overnight in Osaka).

On the 6th, Tuesday, the tour will end after we check out of the hotel in Osaka.

The tour will cost about ¥34,000 per person, on a sharing twin room basis. 2 breakfasts and 2 lunches are included.

For those interesting in these tours, detailed information and official application form will be mailed to you if you check the appropriate boxes in the Form A (Registration Form; due **December 31st, 1982**).

Please note that a minimum of 20 participants is needed for each tour. If the number of participants is less than 20, KNT will have to cancel the tours.

OTHER INFORMATION

Passport and Visa

All foreign visitors desiring to enter Japan must have a valid passport. Visas are not required for tourists who are citizens of the following countries:

Argentina, Austria, Bangladesh, Belgium, Canada, Chile, Colombia, Costa Rica, Cyprus, Denmark, Dominican Republic, El Salvador, Finland, France, Federal Republic of Germany, Greece, Guatemala, Honduras, Iceland, Ireland, Iran, Israel, Italy, Lesotho, Luxembourg, Malta, Mauritius, Mexico, Netherlands, New Zealand, Norway, Pakistan, Peru, Portugal, San Marino, Singapore, Spain, Surinam, Sweden, Switzerland, Tunisia, Turkey, United Kingdom, Urguay and Yugoslavia

(as of January 31, 1982)

For further information, participants are recommended to consult with their local

travel agencies, carriers or Japanese diplomats.

Vaccination

No special vaccination is necessary except that visitors from cholera infected areas must possess a valid international certificate of vaccination against cholera.

IV. Editorial Remarks

Announcement for Future Issues

WIS No. 56 will be planned for publication in January, 1983, Manuscripts for this issue are most welcome and accepted any time, not later than December 31, 1982.

WIS is open to all contributions regarding methods, materials and stocks, ideas and research results related to genetics, breeding and cytology of *Triticum*, *Aegilops*, *Secale*, *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. Authors receive 50 reprints of their contributions free of charge. Extra copies are printed by order at cost price. Communications regarding editorial matters should be addressed to:

Wheat Information Service,
c/o Kihara Institute for Biological Research,
Mutsukawa 3–122, Minami-ku,
Yokohama 232, Japan

Membership Fee

WIS is distributed only to the member, and yearly Membership Fee is ¥2,000. The Fee should be paid with Foreign Postal Money Order, or through The Mitsubishi Trust and Banking Co. (account number; 410–1305325 WIS), otherwise considerable loss is caused due to the bank charges. For Japanese members, Postal Transfer (account number; Kyoto 2–55524 WIS) is available.

Back numbers are available by order at cost price.

Acknowledgement

The cost of the present publciation has been defrayed partly by the Grant-in-Aid for Publication of Scientific Research Result from the Ministry of Education, Government of Japan, and partly by contributions from the Flour Millers Association, Tokyo, and Kihara Institute for Biological Research. 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. 1～54 and valuable contributions for the present issue. Increased support would be appreciated.

The Managing Editor

Explanation of the Figure on the Cover

The N-banded karyotype of a BC plant (*Triticum aestivum* cv. Chinese Spring/ *Aegilops variabilis*/ /*T. aestivum* cv. Chinese Spring) containing 39 chromosomes rather than the expected 56 chromosomes. See the article by JEWELL and MUJEEB-KAZI on page 8 for the details.

ＷＩＳ　　No. 55

発行所　国際小麦研究連絡会議
財団法人　木原生物学研究所内
横浜市南区六ツ川 3-122-21
（郵便番号 232）
Tel. (045) 741-5082

発行者　山　下　孝　介

発行日　昭和 57 年 9 月 1 日