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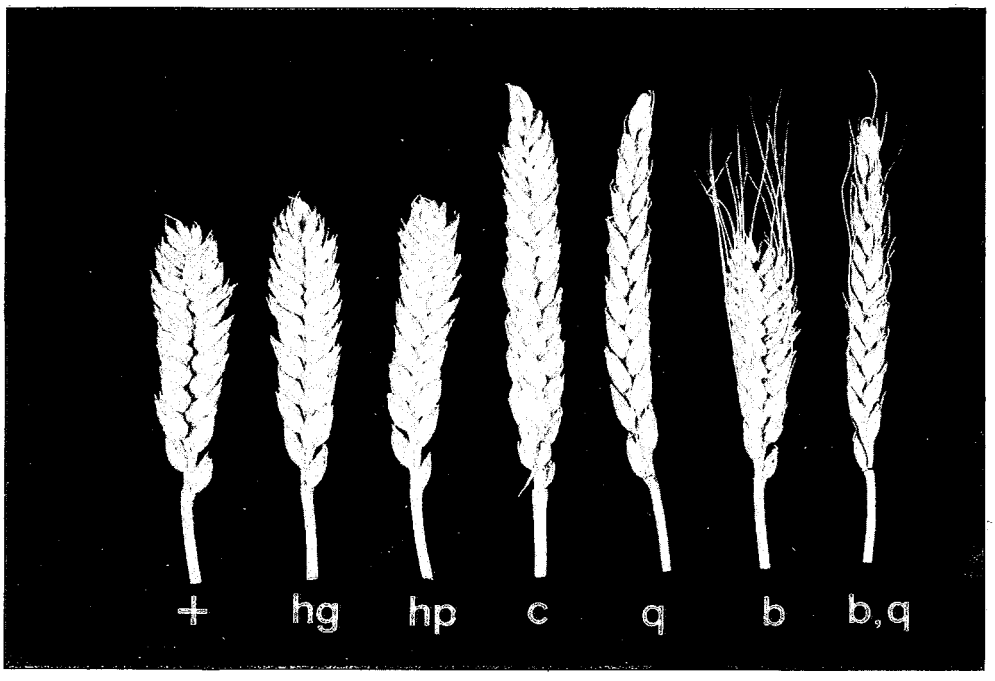

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WHEAT INFORMATION SERVICE

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Chromosomal influences on spikelet number per ear in hexaploid wheat (*Triticum aestivum* L.)

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One option in breeding for increased yield in wheat is to select for increased spikelet number per ear. This trait is strongly influenced by photoperiod and temperature (Halse and Weir 1970; Rawson 1971; Frank et al 1987) the interaction of which can cause variation in the duration and/or rate of spikelet initiation (Rahman and Wilson 1977, 1978). Close positive relationships have been reported between spikelet number per ear and the duration of the vegetative phase of development (Pinthus 1967; Halse and Weir 1970; Lucas 1972) and heading time in wheat (Pugsley 1971; Halloran 1977; Wall and Cartwright 1974; Flood 1985). Success in breeding for increased spikelet number per ear for a particular environment may therefore be limited if alteration in optimal heading time is not desirable for that environment.

The presence of genetic variation in wheat for rate of spikelet initiation independent of photoperiod effects (Rahman et al 1977) provides a possible option for increasing spikelet number without a concomitant delay in heading. More knowledge is required of the genetic and physiological basis of developmental processes in wheat to enable spikelet number per ear to be so manipulated. Of these processes vernalization response has been shown to be associated with spikelet number per ear. Artificial vernalization can cause reductions in spikelet number (Evans et al 1970; Kushnir and Halloran 1982a; Flood and Halloran 1984a) and positive relationships have been observed between spikelet number and levels of vernalization response among different wheats (Flood 1985). While vernalization response genes do not appear to influence the development of wheat after flower initiation (Flood and Halloran 1984b; Griffiths et al 1985) it is possible that pleiotopic effects of these genes, or closely linked genes, influence spikelet number.

The present study used seven sets of intervarietal substitution lines in Chinese Spring for chromosomes 5A, 5B and 5D, which are implicated in influencing vernalization response, to evaluate their effects on spikelet number per ear, with and without artificial vernalization.

Materials and Methods

Substitution lines of homoeologous group 5 chromosomes of seven cultivars viz., Hope, Thatcher, Kenya Farmer, Marquis, Red Egyptian, Timstein and Capelle Desprez in Chinese Spring, were used in this study. Seed of the substitution lines, the respective donor cultivars and Chinese Spring were sown into a potting mix in plastic containers, 40 mm square and 75 mm deep, which were supported in polystyrene holders accommodating 84 plots. After sowing, the soil mix was brought to field capacity and the seeds were allowed to imbibe for 48 h at 20°C and were then vernalized

at 4°C for six weeks under a light regime, of 8 h per day provided by fluorescent and incandescent lamps.

After vernalization the seedlings, plus an unvernalized set, were transplanted into 15 cm diameter plastic pots containing potting mix, as six replications of each line, per treatment. The plants from the vernalized and unvernalized treatments were grown under a long daylength (natural daylength extended to 18 h using a combination of fluorescent and incandescent lamps which had a minimum irradiance at soil level of 40 W m^{-2}).

At ear emergence, the total number of spikelets on the ear on the main stem of each plant was counted. Analyses of variance were carried out on these data to determine significant differences between the substitution lines and normal Chinese Spring.

Results

The spikelet number for the unvernalized long day (ULD) treatment ranged from 20.0 (CS/ Marquis 5A) to 29.0 (CS/Capelle Desprez 5A and 5D) for the lines (Table 1). In all lines and Chinese Spring the vernalized long day (VLD) treatment resulted in a reduction in spikelet number with a range of 14.7 ('Chinese Spring') to 18.8 (CS/Capelle Desprez 5D) (Table 1). In the ULD treatment ten of the lines were significantly lower, while three lines were significantly higher in spikelet number than normal Chinese Spring (Table 1). In the VLD treatment all lines had higher spikelet number than normal Chinese Spring with nine significantly so (Table 1).

Discussion

In all of the substitution lines and normal Chinese Spring there were substantially fewer spikelets per ear in the VLD than the ULD treatment. These differences reveal a component of spikelet number expression that is associated with vernalization response. Since previous work has indicated that vernalization genes in wheat influence development only up to flower initiation (Flood and Halloran 1984b; Griffiths et al 1985) the apparent association of vernalization response with spikelet number may reflect pleiotropy of these genes or their close linkage to genes influencing spikelet number.

The significant differences from Chinese Spring in spikelet number of the nine lines under VLD indicates the likelihood that the substituted chromosomes involved, carry genes with more direct effects on spikelet number than on vernalization response. The substitution lines could be grouped into five classes on the basis of their effects on spikelet number compared to normal Chinese Spring under the ULD compared with the VLD treatment: two chromosomes, Capelle Desprez 5A and 5D significantly increased spikelet number under both treatments; chromosome Kenya Farmer 5D caused a significant increase under the ULD treatment but no effect under the VLD treatment. Hope 5D and Thatcher 5A caused significant increases under VLD but no effect under the ULD treatment. Chromosomes Hope 5A and 5D, Red Egyptian 5A, Marquis 5D and Capelle Desprez 5B caused significant reductions in spikelet number under the ULD treatment and significant increases under the VLD treatment. Chromosomes Timstein 5B, Kenya

Table 1. Spikelet number per ear for Chinese Spring and seven Chinese Spring subsitution lines for unvernalized (ULD) and vernalized (VLD) long day (18 h) treatments.

Cultivar or substitution line	Treatments		Difference between ULD - VLD
	Unvernalised long day (18 h) (ULD)	Vernalised long day (18 h) (VLD)	
Chinese Spring (CS)	26.7	14.7	12.0
CS/Hope 5A	20.2**	16.3*	3.9
CS/Hope 5B	23.2**	16.5*	6.7
CS/Hope 5D	27.7	17.3**	10.4
CS/Timstein 5A	27.3	17.5**	9.8
CS/Timstein 5B	24.8*	16.0	8.8
CS/Timstein 5D	26.3	16.0	10.3
CS/Kenya Farmer 5A	25.2*	15.0	10.2
CS/Kenya Farmer 5B	23.7**	15.8	7.9
CS/Kenya Farmer 5D	28.7**	15.5	13.2
CS/Thatcher 5A	27.2	15.7	11.5
CS/Thatcher 5B	23.0**	15.0	8.0
CS/Thatcher 5D	25.8	16.0	9.8
CS/Red Egyptian 5A	23.8**	17.3**	6.5
CS/Red Egyptian 5B	26.8	16.0	10.8
CS/Red Egyptian 5D	26.5	16.0	10.5
CS/Marquis 5A	20.0**	15.2	4.8
CS/Marquis 5B	25.3	15.5	9.8
CS/Marquis 5D	21.7**	16.7**	5.0
CS/Capelle Desprez 5A	29.0**	17.7**	11.3
CS/Capelle Desprez 5B	22.3**	16.7**	5.6
CS/Capelle Desprez 5D	29.0**	18.8**	10.2
L.S.D. (P = 0.01)	2.0	2.0	
L.S.D. (P = 0.05)	1.5	1.5	

* Significantly different from Chinese Spring at the 5 per cent level.
** Significantly different from Chinese Spring at the 1 per cent level.

Farmer 5A and 5B, Thatcher 5B and Marquis 5A also caused reductions in spikelet number under the ULD treatment but there was no significant effect under the VLD treatment. The inconsistent effects between the two treatments (ULD and VLD) on spikelet number of the substitution chromosomes, indicates a certain independence of the components of spikelet number influenced by the presence and absence of vernalization response. This suggests that genes are present on these chromosomes which influence the rate and/or duration of spikelet initiation and whose effects are not necessarily pleiotropic expressions of vernalization response genes. Genetic control of the rate of spikelet initiation in the absence of vernalization and photoperiod influences has

been reported previously (Rahman et al 1977). Such effects, whether increasing or reducing spikelet number, in the presence or absence of vernalization response indicate that in crosses between different wheats it would be feasible to select for increased spikelet number from transgressive segregation between vernalization genes and those with direct effects on spikelet number.

Four of the six 5A chromosomes in Chinese Spring (i.e., from Hope, Timstein, Red Egyptian and Capelle Desprez) caused significant changes in spikelet number in the absence of vernalization response. Chromosome 5A possesses a major gene for vernalization response (Halloran 1986, Law et al 1976) and the *Q* gene conferring the *"vulgare"* head character (Sears 1954) and floret fertility (Frankel et al 1969). Chromosome 5A appears therefore to have made a significant contribution to the floral biology of hexaploid wheat and is likely to have contributed substantially to its spikelet number determination. *Triticum monococuum*, the A genome donor to wheat, possesses substantially higher spikelet number than the proposed B genome donors, *T. longissimum* and *T. speltoides* (Bamakharamah et al 1984), *T. sharonensis* (*Aegilops sharonensis*) (Kushnir and Halloran 1928b) and D genome donor, *T tauschii* (Bamakhramah et al, loc cit; Lagudah 1986). It is likely, therefore, that the superiority of *T. monococcum* for this character resides largely with effects of chromosome 5A.

Further study of the variation for, and the physiological basis of, high spikelet number in *T. monococcum* would appear to be relevant for the possible incorporation of increased spikelet number in hexaploid wheat.

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Mutation of five marker genes in wheat by the gametocidal gene of *Aegilops speltoides, Gc1a*

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Summary

A common wheat line carrying the gametocidal gene, *Gc1a,* originating from *Aegilops speltoides* was crossed to a line carrying five dominant marker genes. In the F_1 generation of the cross using the *Gc1a* carrier as a male parent, unexpected plants which lacked expression of one or two marker characters appeared. Only a few mutations were observed in the reciprocal cross. Moreover, most of the mutants observed in the F_1 plants of the former cross were not chimeric. These findings indicate that in the former cross, the marker genes derived from the female gametes were mutated by the gametocidal gene of the male gamete in the first zygotic cell.

Introduction

Many papers have reported that gametocidal genes of wheat relatives can induce chromosomal mutation. Recently, Endo (1990) published a review on this phenomenon and in it he classified the chromosomal mutations into two groups, that is, mutations induced in gametes and those in zygotes. The zygotic mutation was first observed by Tsujimoto and Tsunewaki (1985) in the F_1 generation of crosses between various euploid common wheat cultivars and a common wheat line carrying the gametocidal gene of *Aegilops speltoides* (*Gc1a*) in the homozygous condition. Because the line of *Gc1a* homozygote did not manifest abnormal gametes, it was clear that the mutation observed in the F_1 must have been induced in the F_1 zygotes.

To make the feature of the zygotic mutation caused by *Gc1a* clearer, we made crosses between a line carrying five dominant marker genes and the line carrying the *Gc1a* and observed the expression of the marker genes in the F_1 plants.

Materials and Methods

The line carrying the gametocidal gene, *Gc1a,* originating from *Aegilops speltoides* in the background of *Triticum aestivum* cv. 'Chinese Spring' was crossed to a wheat line carrying five dominant marker genes in the background of cultivar 'S-615', and phenotypes of the F_1 plants were observed. The marker genes of the marker line and their chromosome locations are: *B1* (5Aq) for awn suppression, *Q* (5Aq) for speltoid suppression, *C* (2Dq) for compact spikes, *Hg* (1Ap) for hairy glumes, and *Hp1* (4Aq) for hairy necks. On the other hand, the gametocidal gene carrier (abbrev. CS-*Gc1aGc1a*) has recessive alleles of *B1, C, Hg* and *Hp1* and a dominant allele of *Q,* i.e.,

Table 1. Mutants observed in the F_1 generation of the cross between CS-*GclaGcla* and multiple marker line (MML).

Cross combination	Year tested	No. of plants observed	% of mutants	No. of loci mutated				
				Bl	*C*	*Hg*	*Hp1*	*Q*
MML x CS-*GclaGcla*	1985	164	6.7[a]	2	0	2	5	8
MML x CS-*GclaGcla*	1986	117	11.1[b]	4	1	2	5	4
	Total	281	8.5	6	1	4	10	12
CS-*GclaGcla* x MML	1985	112	1.7	0	0	0	0	2
CS-*GclaGcla* x MML	1986	46	0.0	0	0	0	0	0
	Total	158	1.3	0	0	0	0	2
MML x CS	1986	90	0.0	0	0	0	0	0

a : Two plants lacked both *Bl* and *Q*, two lacked both *Hp* and two *Q* or *Hg* and *Q*. One of the plants lacking *Hg* and *Q* was chimeric. b : Three plants lacked both *Bl* and *Q*.

the genotypes is *b1b1 QQ cc hghg hp1hp1*. Therefore, the F_1 plants should have a genotype of *B1b1 QQ Cc Hghg Hp1hp1*. If a mutation occurred, the dominant phenotype would disappear in the F_1. Regarding *Q*, speltoid spikes will appear when dose of *Q* decreases from the normal two to one, therefore, the mutation is also recognized in the F_1.

Results

Plants lacking one or two marker characteristics appeared in the F_1 plants by crossing between the marker line as female and CS-*Gc1aGc1a*, thereas only a few mutants of *Q* were observed from the reciprocal crosses (Table 1, Fig. 1). Since mutants did not appear in the control F_1, it is clear that *Gc1a* induced the mutations. The mutation frequencies were different among the genes ($\chi^2 = 12.5$, df = 4), and the mutation spectra in both 1985 and 1986 were similar. Except for one case, chimeric mutants were not observed among the F_1 mutants.

Germination of the F_1 seeds was reduced when CS-*Gc1aGc1a* was used as the male parent due to the presence of many non-viable shriveled seeds (Table 2). On the other hand, shriveled seeds were not produced by the reciprocal crosses nor by the control crosses.

Discussion

Three important features of *Gcla* as a mutational inducer were revealed by the present study. Firstly, *Gc1a* causes mutations at higher frequency when it is transferred from the male gamete. Secondly, mutational frequencies are different among the five genes observed. Thirdly, mutational events must occur only in the first zygotic cell since it was observed that *Gc1a* derived from the male gamete mutated the genes from the female gamete and that most F_1 mutants were not chimeric.

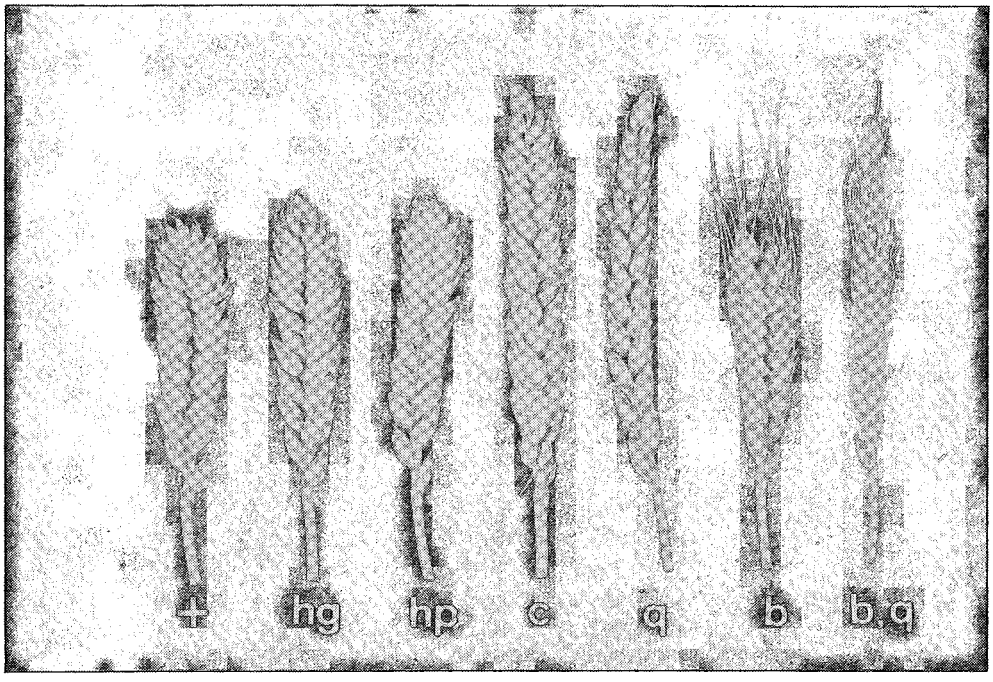

Fig. 1. Spikes of mutants lacking one of marker characters.
From the left, an F_1's spike carrying all five marker genes and mutants lacking *Hg*, *Hp1*, *C*, *Q*, *B1* and both *B1* and *Q*.

Table 2. Shriveled seeds observed in the F_1 generation of the cross between CS-*GclaGcla* and multiple marker line (MML).

Cross combination	Year crossed	No. of seeds obtained	% of shriveled seeds	% of germination
MML x CS-*GclaGcla*	1984	220	12.3	80.0
MML x CS-*GclaGcla*	1985	310	81.6	37.3
	Total	530	52.8	55.3
CS-*GclaGcla* x MML	1984	112	0.0	100.0
CS-*GclaGcla* x MML	1985	46	0.0	100.0
	Total	158	0.0	100.0
MML x CS	1985	104	0.0	86.5

The first and third features of *Gc1a* as described above suggest that the *Gc1a* gene was activated in the male gametes, and inactivated before the first zygotic cell division. The genes originating from the male gametes also may have been mutated by the activated *Gc1a* gene. However, this was not detectable due to lack of marker genes besides *Q* in the male gametes. The mutants of the *Q* gene, for which mutation frequency was higher than among the other genes investigated, may have included those originating from the male allele. On the other hand, *Gc1a* derived from the female gamete hardly mutated the genes of male gametes with the exception of a few speltoid mutants which may be attributable to the mutation of *Q* from the female gamete.

Tsujimoto and Noda (1989, 1990) reported that most mutants of the *Q* gene caused by *Gc1a* or its related gene, *Gc1b*, are involved in chromosomal breakage at proximal sites of the *Q* locus and subsequent deficiency of the regions including *Q*. The break points did not appear to have fixed locations although it is unclear whether they are dispersed at random along the chromosomes. If the mutants of the other genes observed in the present study were caused by chromosomal deficiency of the segments including the genes, the mutational frequency of the marker genes would be proportional to the distance of the genes from the centromere. The genes *Q* and *Hg* are located in distal areas which do not link with the centromere (Rao 1983; McIntosh and Bennett 1978), *C* and *Hp1* link with the centromere with 2.26 and approximately 30 cM, respectively (Rao 1972; Driscoll and Sears 1965). The distance of *B1* has not been determined. However, Tsujimoto and Noda (1990) recently reported from the data of a deletion mapping that it must physically comprise 13% of the distal end of whole long arm of chromosome 5A. The mutational frequencies of the five genes tended to correlate positively with the distance from the centromere. However, more F_1 plants should be examined before drawing a concrete conclusion.

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Radiation effect on mitosis and meiosis in wheat

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Gamma radiations interfere with the process of cell division resulting in cytological abnormalities and reduced frequency of dividing cells (Swaminathan 1964). The effects of mutagenic treatments are usually measured by certain parameters, among others being, seedling height and chromosome aberrations during mitosis and meiosis. Present study deals with radiation effect on seed germination, mitotic index, seedling height and cytology of two varieties of *Triticum aestivum* and two varieties of *Triticum durum.*

Materials and Methods

Two varieties of aestivum wheat i.e. UP 262 and WH 147 and two varieties of durum wheat viz. HD 4502 and Raj 1555 were taken for the present study. Air-dried seeds with moisture content of 11.5 ± 0.5 per cent were given different doses of gamma rays. Studies were carried out on the first generation with regard to germination, mitotic index, seedling height, and various cytological abnormalities induced in the treated material.

The seeds were soaked in distilled water for 24 hours and then they were surface sterilized for 10 minutes in 0.2 per cent mercuric chloride. They were washed in distilled water and placed for germination in petri-dishes on the soaked filter paper. The petri-dishes were placed in an incubator at 25°C. Germination percentage and seedling height were recorded for five days. Meiotic and mitotic cell divisions were studied in pollen mother cells and root tip cells, respectively.

Results and Discussion

Experimental results revealed that germination rate in all the varieties showed a slight increase at lower doses (1 – 3 kR) as compared to the control, whereas it decreased at higher doses (Table 1). More reduction was seen in durum wheats.

Seedling height is often used as a measure of radiation damage in seeds. In all the varieties there was a stimulation in seedling growth at lower doses (1 – 3 kR) as compared to the control, whereas seedling height decreased as the dose increased from 5 kR to 30 kR (Table 1). Similar results were observed for mitotic index.

Stimulation in germination may be due to the formation/activation of some stimulatory substances e.g. auxins, which take active part in germination (Simonis 1966), whereas the reduction may be caused by radiation induced damage through the alteration in endogenous hormonal levels (Mishra et al 1980). Some of the damage could also be due to a direct effect of radiations in killing meristematic cells. Stimulation in seedling height may be due to faster cell division,

Table 1. Effect of gamma irradiation on germination, seedling height and mitotic index.

Character	Variety	Dose					
		0 kR	1 kR	3 kR	5 kR	15 kR	30 kR
Germination (%)	UP 262	97 ±2.86	97 ±2.14	98 ±3.11	97 ±3.11	86 ±2.21	72 ±2.82
	WH 147	94 ±2.44	96 ±2.72	96 ±2.41	92 ±2.49	81 ±2.47	74 ±2.14
	HD 4502	98 ±1.98	98 ±2.19	98 ±2.37	95 ±2.16	79 ±2.92	70 ±2.31
	Raj 1555	96 ±2.03	98 ±2.36	96 ±2.64	92 ±2.72	72 ±2.16	66 ±1.82
Seedling height (cm)	UP 262	6.23 ±.72	6.91 ±.42	7.02 ±.72	6.42 ±.49	2.98 ±.22	2.23 ±.19
	WH 147	5.87 ±.46	6.55 ±.35	7.19 ±.46	5.80 ±.36	2.76 ±.31	2.04 ±.26
	HD 4502	7.33 ±.81	7.72 ±.41	7.90 ±.38	7.47 ±.77	4.02 ±.40	3.12 ±.40
	Raj 1555	7.01 ±.23	7.46 ±.53	8.06 ±.59	6.93 ±.54	3.63 ±.33	2.98 ±.21
Mitotic index	UP 262	19 ±1.81	21 ±2.42	25 ±2.90	17 ±2.02	13 ±1.12	7 ±0.54
	WH 147	17 ±2.02	21 ±2.01	23 ±2.62	17 ±1.46	12 ±0.86	9 ±0.99
	HD 4502	17 ±1.92	19 ±2.23	23 ±2.18	18 ±1.82	15 ±1.41	11 ±1.33
	Raj 1555	14 ±1.16	19 ±1.96	19 ±1.99	15 ±1.36	12 ±0.82	8 ±0.79

Table 2. Cytological abnormalities during mitotic cell division after seed irradiation.

Variety	Dose	Metaphase	Anaphase		Average abnormality (%)	% cells with sticky chromosome
		% cells with laggards	% cells with laggards	% cells with bridges		
UP 262	0 kR	– –	—	– –	– –	– –
	5 kR	1.32	12.44	2.82	5.53	1.21
	15 kR	4.86	28.42	14.71	16.00	3.27
	30 kR	6.02	49.68	21.19	25.63	6.44
WH 147	0 kR	–	–	–	–	–
	5 kR	1.14	14.32	2.11	5.86	–
	15 kR	2.72	26.88	13.25	14.28	1.91
	30 kR	5.39	43.62	19.17	22.73	5.82
HD 4502	0 kR	–	–	–	–	–
	5 kR	–	10.48	1.80	6.14	–
	15 kR	1.21	26.81	11.81	13.28	2.04
	30 kR	4.23	40.06	17.24	20.51	5.63
Raj 1555	0 kR	–	–	–	–	–
	5 kR	–	13.12	–	13.12	–
	15 kR	1.40	27.63	13.29	14.11	1.88
	30 kR	4.96	41.12	20.03	22.04	6.12

change in auxin balance or enhancement in enzyme activity. Radiations are capable of considerably changing the type of information of certain DNA molecules (Simonis 1966). This may be the reason for the increase in mitotic index at lower doses and a decrease at higher doses.

Various types of abnormalities observed during mitosis in somatic cells of root tip were in the form of laggards, bridges and chromatin stickiness (Table 2). These increased with an increase

in radiation dose. The most frequent abnormality was in the form of laggards at anaphase, and the second was bridges. During meiosis cells with univalents at metaphase was observed most frequently, and the second was the cells with laggards at anaphase (Table 3). Univalents may result either from the failure of chromosomes pairing at zygotene (asynapsis) or from the disjunction of homologous chromosomes at diplotene (desynapsis), because chiasma formation did not occur. Possible explanation for the formation of bridges may be that broken ends containing centromere from two different chromosomes unite to form dicentric chromosome, or that chromosomes are clumped together due to stickiness and are often unable to separate compelety at anaphase. Chromatin stickiness may be caused by some changes in the surface properties of the chromosomes which caused them to adhere to each other on coming in contact (Khanna 1986).

Considering the overall data, it appears that hexaploid wheats seem to be a little more radiosensitive as compared to the tetraploid wheats. This could be due to a greater chromosomal volume in the hexaploid wheat. Gupta and Roy (1985) reported that gamma-rays induced more meiotic abnormalities in tetraploid *Physalis peruviane* as compared to the diploid *P. ixocarpa.*

Table 3. Cytological abnormalities during meiotic cell division after seed irradiation.

Variety	Dose	Metaphase	Anaphase		Average abnormality (%)	% cells with sticky chromosomes
		% cells with univalents	% cells with laggards	% cells with bridges		
UP 262	0 kR	–	1.46	–	1.46	–
	5 kR	4.32	3.86	–	4.09	6.21
	15 kR	30.22	25.86	8.32	21.47	20.21
	30 kR	49.16	48.46	18.66	38.76	44.47
WH 147	0 kR	–	1.96	–	1.96	–
	5 kR	5.21	4.23	–	4.72	9.84
	15 kR	32.36	28.34	10.06	23.59	22.83
	30 kR	52.41	47.23	19.21	39.62	47.22
HD 4502	0 kR	–	–	–	–	–
	5 kR	3.88	4.02	–	3.95	5.63
	15 kR	23.82	21.37	6.77	17.32	18.39
	30 kR	44.36	38.81	16.86	33.34	40.18
Raj 1555	0 kR	–	–	–	–	–
	5 kR	3.96	6.08	–	5.02	7.20
	15 kR	24.98	23.92	7.23	18.71	20.86
	30 kR	47.21	40.02	17.92	35.05	43.23

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Association of different traits with monosomic addition lines of *Aegilops squarrosa* in *Triticum durum*

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Certain alien-addition lines of *Aegilops squarrosa* in durum wheats have been used to study the association of certain characteristics with different D-genome chromosomes (Alston 1970; Makino 1981). However, in those attempts, it was not possible to recover and unequivocally identify the seven D-genome addition lines. Moreover, the available D-genome chromosome addition lines were developed in mixed backgrounds involving several durum parents. Dhaliwal et al (1990) for the first time developed a complete set of D-genome monosomic addition lines of *Aegilops squarrosa* (DD) accession 3754 in *T. durum* Desf. cv. PBW-114 using Giemsa C-banding. Four monosomic addition lines were for normal chromosomes 1D, 2D, 3D and 6D while the remaining three chromosomes 4D, 5D and 7D were represented by translocated chromosomes 4DS-5DS, 7DS-5DL and 7DL-4DL.

All the seven monosomic addition lines of *Ae. squarrosa* in durum background PBW-114 were planted at the Punjab Agricultural University, Regional Research Station, Gurdaspur, Punjab, India in winter 1989-90 for the investigation of association of various traits with individual D-genome chromosome. Monosomic addition plants for each of the addition lines were identified through cytological analysis and association of morphological characters (Dhaliwal et al 1990). Disease severity and other traits was recorded on five monosomic addition plants of the seven monosomic addition lines.

Monosomic addition lines 2D and 7DS-5DL possessed gene(s) for leaf rust and stripe rust susceptibility, respectively (Table 1). Monosomic addition lines 3D and 6D were completely

Table 1. Association of monosomic addition lines of *Aegilops squarrosa* in *Triticum durum* cv. PBW 114 with disease resistance and other Characters.

Line	Leaf rust	Stripe rust	Karnal bunt (%)	Vitreousness/ yellow berry	Seed shape	1000-grain weight (g)	Flag leaf width (cm)
PBW 114	Free	Free	4.75	Yellow berry	Normal	35.40	2.02
Mono. addition 1D	Free	Free	1.75	Yellow berry	Normal	28.84	1.80
Mono. addition 2D	20 MR	Free	6.92	Vitreous	Normal	36.12	1.64
Mono. addition 3D	Free	Free	0.0	Yellow berry	Normal	26.20	1.33
Mono. addition 6D	Free	Free	0.0	Yellow berry	Round	34.90	2.00
Mono. addition 4DS-5DS	Free	Free	2.75	Yellow berry	Normal	34.80	1.80
Mono. addition 4DL-7DL	Free	Free	2.67	Yellow berry	Normal	30.27	1.83
Mono. addition 7DS-5DL	Free	10S	1.31	Yellow berry	Normal	33.52	1.44

MR: medium resistant; S: susceptible.

free from Karnal bunt, showing that these chromosomes carried epistatic gene(s) for Karnal bunt resistance. Gill et al (1987) also reported genes for Karnal bunt resistance on 3D and 6D chromosomes of *T. aestivum* by using ditelosomic series of *T. aestivum* cv. Chinese Spring. Chromosome 2D addition line had vitreous grains while all other lines and the durun parent had grains with yellow berry. Therefore, chromosome *2D* of *Ae. squarrosa,* possesses gene(s) for grain vitreousness. Gene(s) for round-shaped grain were present on chromosome 6D. Gene(s) for small grain size seemed to be located on chromosomes 1D and 3D as revealed by data on 1000-grain weight. Line 3D had the narrow leaves as compared to other addition lines. Makino (1981) also had reported genes for narrow leaves on chromosome 3D of *Ae. squarrosa.*

By using these seven monosomic addition lines Dhaliwal et al (1990) had reported the association of gene(s) for non-waxy character on chromosome 2D, lax head shape on chromosomes 2D, 7DS-5DL and 4DL-7DL, gene(s) for red glume colour on chromosome 1D, and red seed colour on chromosome 3D. The knowledge of association of gene(s) controlling disease resistance, seed characteristics, yield components and morphological traits with various *Ae. squarrosa* chromosomes can be used to identify the monosomic addition lines without resorting to cytological analysis, explore *Ae. squarrosa* germplasm for variability for the traits and breed durum and bread wheats using *squarrosa* lines with requisite variability.

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Effect of wheat straw extract on the germination and seedlings growth of wheat (cv. Pavon)

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Abstract

Wheat straw water extract at concentrations of 0.0, 0.2, 0.4 and 0.6% were evaluated to see their effects on the germination and seedling growth of wheat (cv. Pavon) under laboratory condition. With increasing concentrations of residue extract, the germination, shoot and root growth of wheat crop were significnatly decreased. Root growth was affected more than shoot. This may be due to the inhibitory effect of water-soluble substances released from wheat straw.

Introduction

Crop residues on the surface of the soil are very effective in controlling soil erosion by wind and water. However, when crop residues are left on the soil surface, crop yields are occasionally reduced as compared to the incorporation of residues into the soil. Substantial evidence has been accumulated to show that phytotoxic substances are present in most crop plants and may be responsible for reduced crop growth (Borner 1960; Garb 1961). Guenzi and McCalla (1962) showed that the water extracts of a number of crop residues inhibited the germination and growth of sorghum, corn and wheat in a laboratory experiment. LeTourneau et al (1956) found that water extracts from 23 common weed and crop species inhibited germination and growth of wheat seedlings.

Researchers elsewhere have generally shown that allelopathy from wheat residue reduces the subsequent wheat yield (McCalla 1971; McCalla and Haskins 1964; McCalla and Norstadt 1974). They showed that water-soluble substances in crop residues reduced the germination and growth of wheat seedlings and other crops. Allelopathic chemicals from soils, crop residues and weeds are known to reduce the growth of several crops and there are numerous examples of allelopathy among crop plants. Allelopathy is often more evident in disturbed plant communities, such as agricultural ones.

The objective of this investigation is to study the effect of aqueous extract of straw from wheat crop to germination and growth of wheat seedlings (cv. Pavon).

Materials and Methods

i) Preparation of residues: Mature straw of wheat plant was collected from the experimental wheat field at AEARC, farm, Tandojam in April 1989. The samples were first dried in the sun for 12 hr. then transferred to a forced-draft oven for thorough drying at 75 ± 5°C for 24 hr. Dried samples were then ground in a Wiley mill to pass a 1.18 mm^2 screen. Ground samples were kept in plastic bags at room temperature.

ii) Laboratory trials: Three levels of wheat straw extracts 0, 0.2, 0.4 and 0.6% (w/v), were prepared for use in petri-dishs germination study with wheat seeds. The extracts were prepared by soaking the dried ground residues in distilled water for 24 hr. at room temperature in 250 ml Erlenmyer flasks. The extracts were then filtered into 100 ml beakers using N0. 41 Whatman filter paper.

Wheat seeds were disinfected in 1% sodium hypochlorite solution for 2 minutes and them rinsed with distilled water. Ten healthy wheat seeds were placed in a petri-dish lined with filter paper and 5 ml of extract added from each treatment. The treatment at extract level was replicated three times in a randomized complete block design. All the petri-dishs were kept in an incubator at 28 ± 2°C for 120 hrs. The experiment was terminated after 120 hrs. The number of seed germinated were counted. Their shoot and root length were also measured. The experiment was conducted twice and the results were expressed in terms of the averages of the two trials. The data were analyzed to evaluate the treatment effect.

Results and Discussion

The incorporation of wheat straw water extract has significant inhibitory effect on germination of wheat seed (Table 1). At the maximum water extract level (0.6%), the percent reduction in germination was 39 compared to control. Similarly highly significant decrease was recorded with the increasing concentration of wheat straw extract on shoot and root growth of wheat crop. The percent decreases in shoot and root growth at the maximum residue extract were 51 and 62, respectively. The results of the findings clearly show differential phytotoxicity of aqueous extract of wheat straw. The reduced growth of wheat parameters in this experiment demonstrated that water soluble toxins released from the residues or produced by microorganisms during decomposition and thus affected the crop growth.

McCalla and coworkers (McCalla and Haskins 1964; McCalla 1971; McCalla and Norstadt 1974) did pioneer research on the wheat crop in the eastern Nebrasks (USA) area. They showed

Table 1. Effect of wheat straw water extract on the germination and seedling growth of wheat (cv. Pavon).

Wheat residue extract (%)	Germination %	Shoot length (cm)	Root length (cm)
0.0	98 a (–)	8.52 a (–)	7.13 a (–)
0.2	85 b (13.3)*	6.19 b (27.3)	5.94 b (16.7)
0.4	74 c (24.5)	5.23 c (38.6)	3.13 c (56.1)
0.6	60 d (38.8)	4.15 d (51.3)	2.75 d (61.5)

* Figures in the parentheses indicate percent decrease over control.

that watersoluble substances in crop residues reduced the germination and growth of seedlings of wheat and other crops. They further stated that wheat and other crops were shown to contain a number of phenolic acids and the five most dominant ones were ferulic, p-coumaric, syringic, vanillic and p-hydroxybenzoic acids. Phytotoxic plant residues can serve for selective weed control (Putnam and DeFrank 1983).

It was also observed that root growth was affected more than the shoot growth. The roots which were in continuous contact with the straw extract were exposed to possible toxic compounds evolved either through the process of leaching or microorganisms action upon decomposition (Azmi and Alam 1989; Waller et al 1987). Other workers have reported that plant residues caused injury if the residues were in contact with or in the immediate vicinity of plant roots (Rice 1984; Patrick 1971).

It would be concluded from this study that wheat straw water extract has depressing effects on the germination and growth of shoot and root of wheat crop.

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Influence of some wild plant and crop residues on growth and nutrient content of wheat

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Summary

A pot experiment was carried out to evaluate the effect of incorporation in soil of plant residues on growth and nutrient content of wheat (cv. Sarsabz). Growth parameters and grain yield significantly increased with the incorporation of plant residues. Maximum grain yield compared to control, was obtained when Prosopis residue was incorporated. The N, P, K, Ca and Na contents in wheat plant at both harvests increased in majority of the cases compared to control. It was concluded that plant residue incorporation has beneficial effect on wheat.

Introduction

Plant residues from various sources constitute an important component of the soil. These materials in the form of living, dying and dead plant tissues, each with immense chemical diversity, are ultimately decomposed through the action of biotic and abiotic agencies. Incorporation of crop residues into the soil not only plays an important role in the soil's chemical and biochemical environment, but also affects the rate at which nutrients become available to crop plants as well as to other forms of life in soil (Darra et al 1968; Mogdoff and Amadon 1980; Power and Legg 1978). During the decomposition many complex interactions, transformations and synthesis also occur. Thus, at any one time, the soil and the environment of plant roots could contain a vast variety of chemical compounds and plant nutrients many of which, no doubt, have important effects on all phases of plant development (Pannamperuma 1984; Sain and Broadbent 1974). Some wild plants such as prosopis (mesquite), withania (somnifera) and abutilon which are common in the sorthern part of Pakistan are reported to have very high antibacterial activities (Naqvi et al 1987). In their laboratory studies residues have shown active inhibitory effects on the nitrification of nitrogenous fertilizers (Alam and Azmi 1989).

The ultimate benefit of any plant residue addition to soil would depend on the ability of the organic matter to create a favourable environment in the soil to supply the essential plant nutrients and thus reducing the addition of artificial chemical fertilizers to soil. Therefore, the aim of this study is to assess the effect of the incorporation of plant residues and farm yard manure on the growth, yield and nutrient content of wheat crop.

Materials and Methods

The soil collected from AEARC, farm, Tandojam was alluvial in nature and alkaline in reaction. Some of its properties were as, pH 7.8, N 0.069%, T.S.S. 0.10%, $CaCO_3$ 12.5% and organic matter

Table 1. Nutrient composition of some plant residues used in the experiment.

Name of residues	Nutrient elements (% of dry wt.)				
	N	P	K	Ca	Na
Abutilon	2.00	0.40	1.80	0.70	0.14
Withania	2.60	0.40	3.60	0.71	0.06
Prosopis	3.60	0.48	1.60	0.61	0.05
Neem leaf	1.90	0.36	1.60	0.86	0.09
Wheat straw	0.70	0.01	1.80	0.25	0.06
Rice straw	0.70	0.01	2.30	0.40	0.31
Rice husk	2.28	0.16	0.80	0.16	0.10

1.25%. It was air-dried, powdered and pass through a 2mm sieve and 8 kg lots were weighed into plastic pots. An amount of 50 kg N/ha + 50 kg P_2O_5/ha was given to pots having the powdered residues separately of prosopis, withania and abutilon at the rate of 3g/kg soil. N was applied in the form of urea and P in the form of single superphosphate. To the other pots where full dose of 100g N/ha + 50 kg P_2O_5/ha added were also incorporated separately with 3g powdered residues/kg soil of wheat and rice straws, rice husk, neem leaf and farm yard manure. A control treatment was also maintained without the addition of any residue. The chemical composition of the residues added to pots are given in Table 1. The NP fertilizers and plant residues were mixed well with the soil. The pots were watered to field capacity. Ten wheat seeds (cv. Sarsabz) per pot were sown. After germination, four seedlings/pot were maintained. The pots were arranged in a randomized block design with four replications. The plants were irrigated with water as and when needed. After 60 days of growth, plant height and number of tillers were recorded. At this stage, third leaf from each treatment was also collected for chemical analysis. The second harvest was carried out at 75 days. The rest of the plants were harvested at maturity and growth parameters and yield contributing characters were recorded. Plant samples of first and second harvests were ground in a Wiley mill. One gram of sample was digested using concentrated sulphuric acid and 30 percent hydrogen peroxide. Total P was determined using vanadomolybdo-yellow colour method (ASA 1982). Nitrogen was estimated by micro-kjeldahl method and K, Ca and Na by flame photometer.

Results and Discussion

The incorporation of various types of plant residues and farm yard manure in the soil significantly increased the different plant growth parameters and yield contributing characters of wheat crop at all harvest occasions compared to control (Table 2). At maturity, the maximum straw and grain yields were obtained by incorporating the residue of prosopis, followed by withania, rice husk and rice straw. The higher increase in grain yield and other growth parameters with different residues may possibly be due to differences in the physical and chemical nature of the incorpo-

Table 2. Effect of some plant and crop residues on the growth and yield of wheat (var. Sarsabz).

Plant residues treatment (3g/kg soil)	60 days		75 days		At maturity				
	Plant height (cm)	Dry matter wt. (g)	Plant height (cm)	Dry matter wt. (g)	Plant height (cm)	Wt. of earhead (g)	Straw yield (g)	Grain yield (g)	100 grain wt.(g)
Control	28.5 e	0.24 d	37.7 b	0.75 b	41.8 c	2.60 b	1.14 c	1.50 d	2.30 b
Prosopis	37.5 bcd	0.44 abc	51.7 a	1.60 a	57.3 ab	7.42 a	3.64 a	6.65 a	4.70 a
Withania	45.3 ab	0.66 a	53.5 a	1.78 a	51.5 b	7.97 a	3.30 ab	6.50 a	4.19 a
Abutilon	34.8 bcd	0.62 a	51.0 a	1.36 a	54.5 ab	6.64 a	2.41 a	4.44 c	3.59 a
Rice husk	41.8 abc	0.48 abc	56.5 a	1.41 a	61.3 a	9.40 a	3.47 ab	6.47 a	3.90 a
Wheat Straw	49.0 a	0.55 ab	57.3 a	1.49 a	54.8 ab	9.19 a	3.25 ab	5.69 b	3.17 a
Rice Straw	34.3 cd	0.43 abc	51.8 a	1.25 a	54.0 ab	7.73 a	2.45 b	6.10 a	3.87 a
Neem leaf	50.0 a	0.49 abc	60.3 a	1.66 a	58.5 ab	8.26 a	3.21 ab	5.63 b	3.59 a
F.Y.M.	42.3 abc	0.37 bc	51.3 a	1.36 a	56.5 ab	6.81 a	2.53 b	4.77 c	3.68 a

rated residues in the soil. The plant residues incorporated soil had a better physical condition. It may also have been a better supplier of plant nutrients through the mineralization and microbial decomposition of plant residues. It has been reported that soil microorganisms which decompose and metabolize organic substances generally contribute to the storage and supply of important nutrients for crop plants such as N and P, which thereafter helps in the growth and development of plants. Amount of soil microorganisms also affects the amount of enzymes in soil which in turn effects the decomposition rates of the respective components of soil organic substances including the compounds of microbial bodies. Most organic components of soil are decomposed into inorganic substances due to the action of soil enzymes (urease, hydrogenase) mainly secreted by microorganisms.

In this experiment most probably similar processes were also going into the soil on the breakdown of plant residues used in this experiment and thus the incorporated residues help in the increase of crop production. In the pots incorporated with residue of prosopis, withania and abutilon and half doses of N (50 kg N/ha) yielded more grain yield than the rest of the crop residues added with full dose of N (100 kg N/ha). This possibly shows that plant residues having antibacterial activities help in the slow release of applied nitrogen fertilizer throughout the growth of the wheat crops which seems to be sufficient for the wheat growth under the present experimental conditions.

It was observed that content of most of the nutrients analyzed from residues treated wheat plant was higher than the control plants (Table 3). The higher content of nutrients in wheat plant released during mineralization of incorporated plant residues possibly help in the growth and

Table 3. Effect of plant residues and farm yard manure incorporation on the nutrient contents of wheat plants.

Plant residues treatment (3g/kg soil)	Nutrient content percent of dry wt. (60 days)					Nutrient content percent of dry wt. (75 days)				
	N	P	K	Ca	Na	N	P	K	Ca	Na
Control	2.01	0.22	3.33	0.73	0.20	1.29	0.16	2.01	0.29	0.29
Prosopis	3.50	0.35	4.79	0.83	0.22	1.76	0.21	2.80	0.42	0.24
Withania	3.32	0.35	4.96	0.82	0.25	1.50	0.37	2.60	0.36	0.17
Abutilon	2.97	0.28	4.29	0.73	0.24	1.75	0.19	2.70	0.41	0.21
Rice husk	2.45	0.25	4.96	0.70	0.21	2.10	0.23	2.95	0.41	0.22
Wheat Straw	2.98	0.23	4.77	0.76	0.23	1.40	0.30	2.80	0.34	0.14
Rice Straw	2.71	0.30	4.68	0.77	0.20	1.52	0.24	3.11	0.34	0.13
Neem leaf	2.63	0.30	4.74	0.80	0.24	1.40	0.24	2.70	0.35	0.13
F.Y.M.	2.80	0.38	4.79	0.90	0.29	1.54	0.23	2.95	0.37	0.16
S.E.	0.01	0.01	0.07	0.01	0.01	0.06	0.01	0.06	0.01	0.02

development of plant resulting in the higher grain yield of wheat crop.

It would be concluded from this study that the incorporation of plant residues into soil is a good source for supplying the plant nutrient elements, which afterwards help in the growth and development of crop plant.

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Wheat Information Service
Number 71: 24 – 26 (1990)

A study of correlation and patn analysis in spring wheat

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An important objective in most wheat breeding programmes is to enhance the genetic potential for grain yield. Grain yield in wheat is determined by three major components, namely, number of tillers per plant or per unit area, average number of grains per ear and average grain weight. A knowledge of inter-relationship between yield and its components and among component traits themselves and path analysis is essential to know the effectiveness of selection for simultaneous improvement in these traits. Keeping all this in view, an attempt was, therefore, made to have some information about the relative contribution of these three important component traits to the grain yield in spring wheat.

Materials and Methods

During 1983 – 84, fortyseven F_4 progenies each of the two wheat crosses, namely, WL 711 x HD 2122 (cross 1) and HD 2122 x Sonalika (cross 2), were grown in a randomized block design with three replications in single row plots of 2.5m length having row to row distance of 23 cm and plant to plant distance of 10 cm. The observations were recorded on ten randomly selected competitive plants per plot for grain yield per plant, tiller number, grain number and 1000-grain weight. Plot means were used for calculating correlations and direct and indiect effects of three component traits on grain yield. The path coefficient analysis was carried out as described by Dewey and Lu (1959).

Results and Discussion

The phenotypic and genotypic correlations among grain yield and its components in F_4^4 progenies for two wheat crosses, namely, WL 711 x HD 2122 (cross 1) and HD 2122 x Sonalika (cross 2) are given in Table 1. The genotypic correlation coefficients were higher in magnitude than the phenotypic correlation coefficients for almost all the traits in both the crosses. This indicated that the association between these traits was genetically inherited. It is clear from this table that yield was positively and significantly associated with tiller number per plant, number of grains per ear and 1000-grain weight in both the crosses. The direct effects of three component characters on grain yield (Table 2) indicated that tillers/plant had largest contribution followed by grain number and 1000 grain weight in cross 1. Jaimini et al (1974) and Quick (1978) also found tiller number and grain number/ear having high direct effect on grain yield. On the contrary, in cross 2,

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Table 1. Phenotypic (P) and Genotypic (G) correlation coefficients for grain yield and its three components traits in F_4 progenies of two wheat crosses 1 (WL 711 x HD 2122) and 2 (HD 2122 x Sonalika).

Trait	Cross		Grains number/ ear	1000-grain weight	Grain yield/ plant
Tiller number/	1	P	0.351**	–0.263	0.572**
plant		G	0.365	–0.289	0.634
	2	P	–0.276	–0.372**	0.298*
		G	–0.293	–0.348	0.315
Grains number/	1	P		–0.293*	0.436**
ear		G		–0.334	0.481
	2	P		0.104	0.501**
		G		0.126	0.539
1000-grain	1	P			0.457**
weight		G			0.386
	2	P			0.652**
		G			0.714

* Significant at 5% level; ** Significant at 1% level.

Table 2. Direct and indirect effects of three component traits on grain yield in F_4 progenies of two wheat crosses, 1(WL 711 x HD 2122) and 2(HD 2122 x Sonalika).

Trait	Cross	Effects via			Genotypic correlation coefficients with grain yield
		Tiller number/ plant	Grain number/ ear	1000 grain weight	
Tiller number/plant	1	0.671	0.096	–0.133	0.634
	2	0.654	–0.103	–0.236	0.315
Grain number/ear	1	0.137	0.473	–0.209	0.491
	2	–0.157	0.554	0.142	0.539
1000-grain weight	1	–0.082	–0.124	0.592	0.386
	2	–0.092	0.068	0.738	0.714

Residual effect = 0.396 (cross 1).
= 0.438 (cross 2).

The underlined figures are direct effects.

the character 1000 grain weight was having the largest contribution followed by number of grains per ear and number of tillers per plant. Ahmad et al (1978) and Gupta et al (1979) also reported high direct effect of kernel weight and grains per ear on grain yield.

The highly significant and positive correlation of tillers/plants in cross 1 and 1000 grain weight in cross 2 with grain yield was due to the substantial direct influence of these characters in the two crosses, respectively, which were in agreement with the results reported by Paroda and Joshi (1970). Indirect effect of tiller number/plant via grain number/ear was also positive as compared to that via 1000-grain weight where it was negative in cross 1. Grain number/ear also had high positive direct effect on grain yield. Its negative contribution via 1000 grain weight in cross 1 and via tiller number/plant in cross 2 is approximately compensated by indirect effects through tiller number/plant in cross 1 and 1000 grain weight in cross 2. The 1000 grain weight in cross 1 and tiller number/plant in cross 2 though had high positive direct influence on grain yield, their effects were negative through tiller number/plant and grain number/ear in cross 1 and through grain number/ear and 1000-grain weight in cross 2, respectively. This is why their correlation coefficients were comparatively low.

Although results of the two crosses investigated differed in respect of maximum contribution made by component characters towards yield (tillers/plant in cross 1 and 1000-grain weight in cross 2), the positive and high direct effects of all three components on grain yield in both the crosses indicated that if an increase in grain yield is to be obtained, selection should be made for genotypes having more number of tillers, grains/ear, and higher 1000-grain weight. But in selection programme, there must be compromise between these three components so that the increase in one component is not nullified by the decrease in the other.

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Wheat Information Service
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Chromosomal location of gene for auricle development in common wheat

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Like most *Graminaceae* species, common wheat (*Triticum aestivum* L.) has the leaf made up of blade, sheath, ligule and auricle. As accessories of leaf, ligule and auricle are of botanical significance. McIntosh and Baker (1968) located the genes controllong ligule development on chromosomes 2B and 2D, but little is known about the gene for auricle.

In using Chinese Spring (CS) ditelocentries to map alien segments, we found that only ditelo-2DS was without auricle (Fig. 1A). Cytological identification confirmed its ditelocentric nature, 2n = 40 + 2t (Fig. 1B).

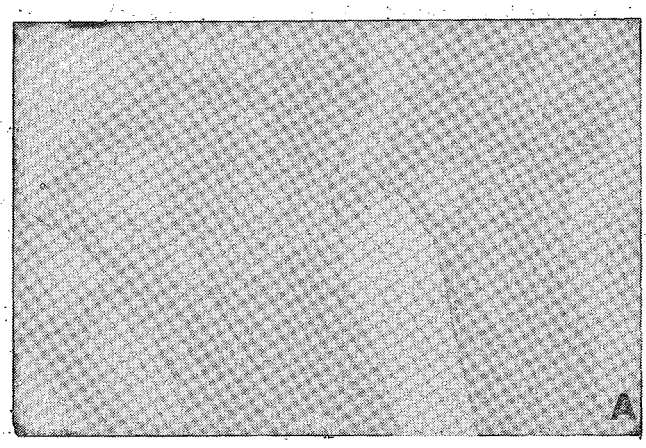

Fig. 1A Left: normal leaf of CS disomic, Right: auricleless leaf of 2DS ditelocentric.

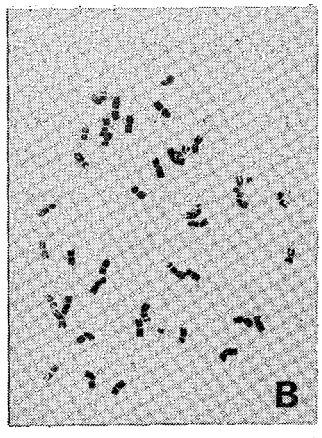

Fig. 1B 2DS ditelocentric, 40 + 2t.

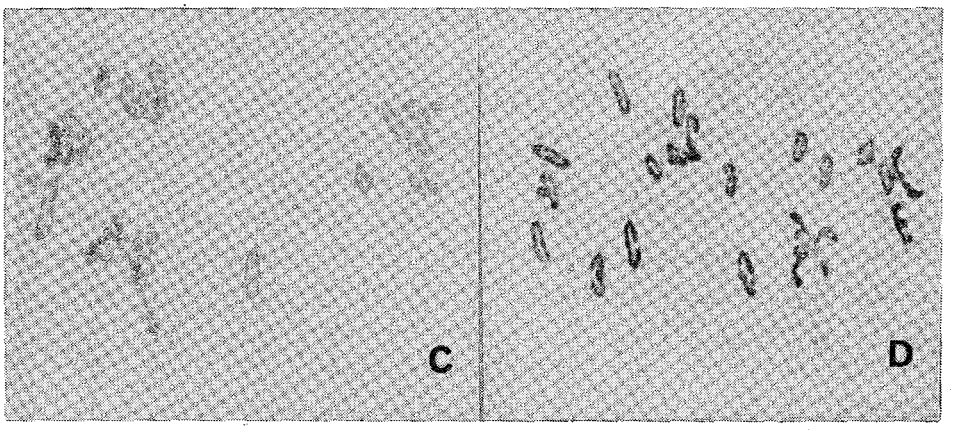

Fig. 1C MI of F_1 monotelosomic of (CS 2D monosomic x 2DS ditelosomic), 20" + t'

Fig. 1D MI of F_1 monotelodisomic of (CS 2D monosomic x 2DS ditelosomic), 20" + t1"

What caused diteto-2DS auricleless, deletion of 2DL arm or point mutation? For this purpose, a monosomic analysis was made. Monosomic 2D was pollinated with ditelo-2DS and 25 F_1 hybrids were produced. Seventeen auricleless offspring were monotetelosomic, 20" + t' (Fig. 1C); the remaining 8 auriclate plants were monotelodisomic, 20" + t1" (Fig. 1D). Obviously, the gene responsible for auricle development is on chromosome 2D of CS.

In order to determine the position of this gene on chromosome 2D, F_2 populations were surveyed for auricle. One hundred and seventy plants grew from 270 seeds of selfed monotelodisomic F_1 hybrids with the emergence rate of 62.9%, 4 of which were deficient of auricles and with chromosome number of 40 + 2t; in contrast, 66 plants grew from 210 seeds of monotelosomic F_1 hybrids with the emergence rate of 31.4%, and all of them were auricleless. Thus, two conclusions can be drown. First, the gene controlling auricle is on the long arm of CS chromosome 2D. Second, chromosome 2D of CS is of much importance to seedling emergence in field conditions because monotelosomic F_2 had the emergence rate just half as high as monotelodisomic F_2 had.

The present paper is the first report of cytogenetic study on auricle in common wheat. According to McIntosh (1988), it is suggested that this gene be named as *Aur*, its recessive allete as *aur*. As a genetic marker, the possible use of *aur* in screening nullisomic 2D and other related research could be expected.

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Wheat Information Service
Number 71: 29 – 31 (1990)

Spike abnormality in interspecific wheat hybrids

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Interspecific wheat F_1 hybrids between bread wheat and wild emmer (*Triticum dicoccoides* Körn.) produced spike that partially or completely lacked spikelets on the rachis. It is presumed that the phenomemon of suppression of spikelets (absence and incomplete development of spikelets) in the rachis is due to the interaction of certain genetic factors in F_1 hybrid.

Lethality or semi-lethality in intervarietal, interspecific and intergeneric wheat F_1 hybrids is frequently encountered. So far in wheat, hybrid necrosis, hybrid chlorosis and hybrid dwarfness (grass clumps) have been reported. These physiological disorders are the result of genic interaction and lead to premature and gradual death of certain F_1 hybrids. Such F_1 hybrids, if flower, produce spike with normal spikelets and florets.

Ten accessions of wild emmer wheat (*Triticum dicoccoides* Körn, *2n = 4x* = 28, genome AABB) were earlier crossed to two Indian bread wheat (*T. aestivum* L., *2n = 6x* = 42, genome AABBDD) cultivars, C306 (*Ne1ne2 ch1Ch2*) and Sonalika (*ne1Ne2 ch1Ch2*) with the aim of identifying necrosis and chlorosis genes present among them (Tomar et al 1988). One particular accession of *T. dicoccoides* (SWAN 248) when crossed to C306 and Sonalika produced spikes in F_1 hybrid that partially or completely lacked spikelets from the rachis. The absence of spikelets and incomplete development of spikelets and florets on the rachis (developmental abnormality) in F_1 hybrids have not been reported so far.

To confirm the observations, seven bread wheat cultivars, namely, C306, Charter (new line), HD2428, Hira, Kalyasona, Sonalika and WL711 and an accession of *T. sphaerococcum* L. (*2n = 6x* = 42, genome AABBDD) were crossed as female parents to *T. dicoccoides* (SWAN 248). Three reciprocal crosses using Kalyansona, Sonalika and WL711 as male parents were also made. The crossed seeds were sown in pots in greenhouse as well as in the field and were provided similar conditions for growth. The germination of F_1 seeds and seedling growth up to the 3-4 tiller stage was normal. Tillers were produced profusely but the percentage of ineffective tillers was as high as 46%. Leaves were narrow and medium long like that of *T. dicoccoides*. In a few F_1 hybrids the culm was thin with reduced peduncle length particularly in late tillers. Some of the F_1 hybrids were intermediate in height. No reciprocal difference with respect to spike morphology was observed. Spike emergence was normal in only those tillers where apical spikelets were present; it was very much delayed where spikelets were totally missing or only rachilla had developed showing that the number and position of florets on the rachis influenced the

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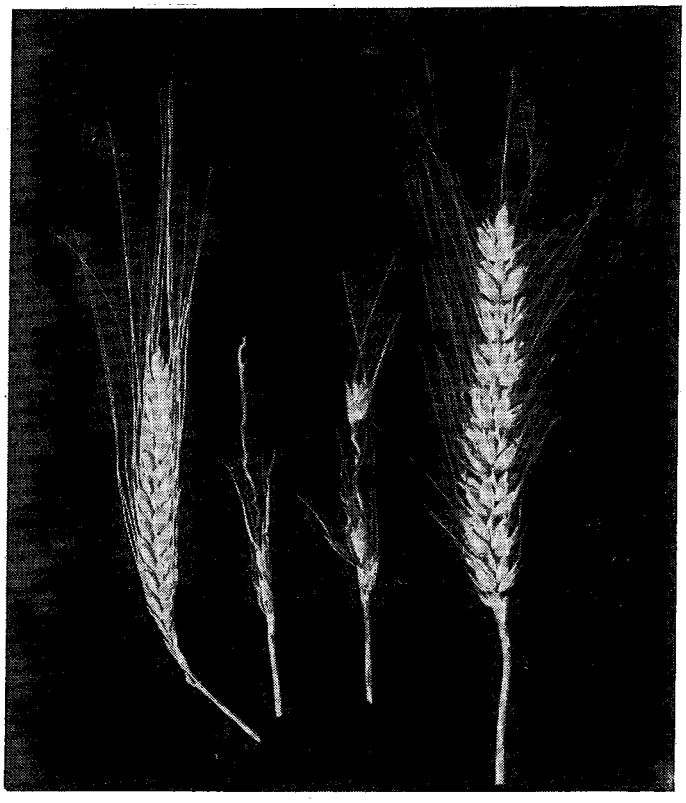

Fig. 1 Spike abnormalities in F_1 hybrids. From left to right: *Triticum dicoccoides; T. dicoccoides* x *T. aestivum* cv. WL711; WL711 x *T. dicoccoides*.

spike emergence. Suppression of spikelets was noticed in all the F_1 hybrids (Fig. 1) except in the cross Charter x *T. dicoccoides* where spikes with normal spikelets and florets on the rachis were produced. All the crosses produced abnormal spikes having basal, intermediate and apical spikelets whereas a few tillers in the WL711 x *T. dicoccoides* and Kalvansona x *T. dicoccoides* crosses produced only rachis with complete absence of spikelets. In the F_1 hybrid involving C306, two out of 60 tillers (4 plants) had produced near normal spikes indicating the variable degree of absence (suppression) of spikelets on the rachis. Fig. 2 shows the range of abnormality observed among the F_1 hybrids with regard to spike. These abnormalities were first noticed in the year 1985-86 among the crosses of *T. dicoccoides* (SWAN 248) with C306 and Sonalika. Crosses were repeated and the partially fertile pentaploid F_1 hybrid, Sonalika x *T. dicoccoides* was selfed. Two out of eleven F_2 segregants were observed to have spikes similar to that of the F_1 hybrid. It was difficult to establish any genetic ratio as the F_2 population comprised aneuploids and size of the population was very small.

The absence of spikelets occurs when certain genetic factors come together in F_1 hybrid and the gene interaction affects the spikelet formation at early stage of spike development. It will be premature to propound any hypothesis but the assumption is that the suppression of spikelets

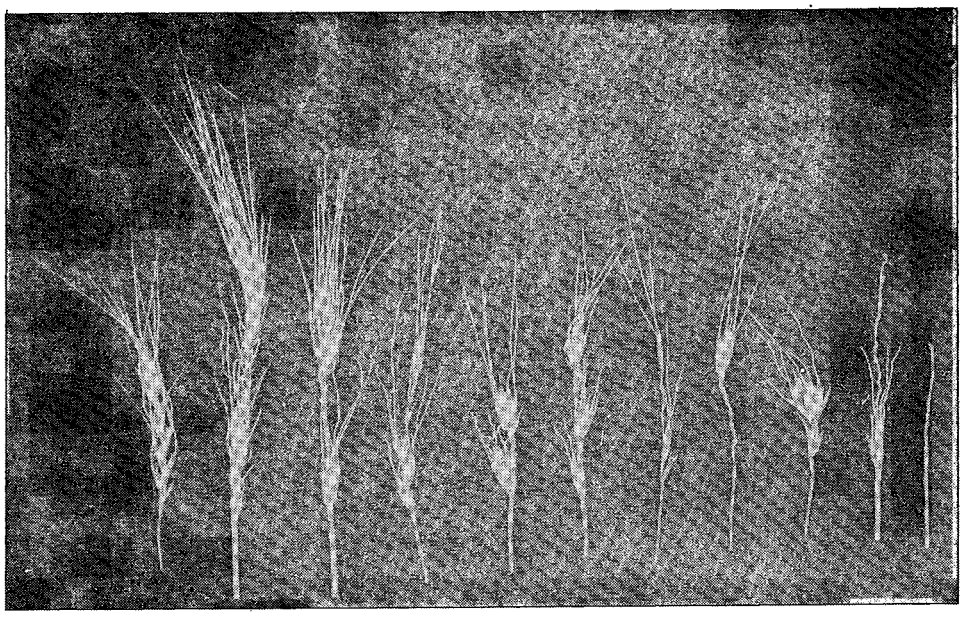

Fig. 2 Range of spike abnormalities among the different F_1 hybrids is wheat.

in the rachis is caused by the epistatic interaction of genes in the hybrid. It is likely that the initial differentiation of cells determining the development of rachis, spikelets and florets is suppressed due to the interaction of certain genetic factors coming together in F_1 hybrid from different parents. Unequal distribution of primordial cells to the developing spikelets may also lead to differential expression of spikelet suppression in the same F_1 plant.

The pentaploid ($2n = 5x = 35$, genome AABBD) F_1 hybrid had 13.52 ± 0.21 mean bivalents and 7.78 ± 0.23 mean univalents. No other chromosome configurations were observed, except in the hybrid involving Kalyansona where trivalents and quadrivalents were recorded in low frequencies. A pentaploid hybrid is an aneuploid hybrid chromosomally unstable but the absence of spikelets on the rachis noticed in F_1's and also in F_2 generation derived after selfing the pentaploid hybrid seems to be genic and is not due to aneuploidy.

Production of abnormal spikes restrict the choice of parents to produce desirable cross combinations. It will be worthwhile to identify deleterious genes responsible for abnormal development of spike.

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Wheat Information Service
Number 71: 32 – 35 (1990)

Record

Work on breeding winter wheat varieties in the Institute for breeding and production of field crops of the Faculty of agricultural sciences – Zagreb: High-yielding wheat varieties

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- How far have we reached in breeding winter wheat in the Institute for Breeding and Production of Field Crops?
- Which problems occupy the experts most?
- What can we expect from this work on certain problems in future?

In the Institute for Breeding and Production of Field Crops Zagreb, and its Department of Small Grain Cereal Crops in Botinec, breeding winter wheat has a long tradition. Work on development of winter wheat varieties is intensive and has been in progress for over 30 years. In that sense, breeding work was started as far back as 1947 by Dr. Josip Potočanac in the then Department of farming. The work increasingly progressed and the results we have today – varieties – present the world achievment in wheat breeding. High-yielding wheat varieties are developed, which, with modern production technology, produce yields of even more than 10 t/ha. Thirty-seven winter wheat varieties have been registered. To achieve this was not an easy job. The success was reached by united group work of experts of most diverse profiles.

Highly intensified work on wheat breeding is conducted within several programs whose basic objective is to develop semi-dwarf varieties with increased production, wide adaptability, satisfactory quality of grain and flour, and with genetic resistance to the most important diseases. Zg-model of wheat varieties is characterized by high grain yield based on increased plant density, nevertheless resistant to lodging. They remarkably withstand high densities and 600-800 spikes/ m^2 is precisely what their yielding is based on, i.e. 600-800 germinable seeds/m^2 should be the seedling rate. Their tillering capacity is good and after overwintering they fill stands well. They are midearly varieties with good adaptability and yield stability. High yield stability of Zg-wheats is receiving much attention in this Institute and its Department of Small Grain Cereal Crops. In the process of breeding, selection is made among genotypes with such traits that allow the highest possible utilization of their genetic yield potential.

Materials used for breeding are our own wheat selections in combination with domestic or foreign sources of resistance and various varieties and lines that carry different positive agronomic and biological traits. From our own varieties, Zlatna Dolina, Sanja and similar genotypes have been used most, and also some lines from the breeding programs based on high production per

spike using *Rm* and *Ts* genes. Thus, mean weight of kernels per spike ranges around 1 g and considerably higher. Zlatna Dolina and Sanja were registered in 1971, and along with registered varieties from other institutes in the country present a marked progress in Yugoslavia's winter wheat breeding. With reference to this, we must undeline the year 1974 at which time began rapid spread of our varieties in wide production, replacing foreign varieties that were dominating until then. This refers first of all to Italian, Russian and French varieties.

With further improvement of our breeding program, new varieties of high genetic yield potential were developed, suited to various agro-ecological conditions of production, which is exceptionally important for their spread not only in this, but also in some neighbouring countries, in which some are registered (Hungary, Czechoslovakia, Bulgaria, Italy etc.). Those varieties are Super Zlatna, Sana, Zagrepčanka 2, and Lonja of which Zagrepcanka, and Sana in particular have been increasingly accepted in agricultural practice. In 1985, those Zg-selections accounted for 69.9% of acreages in Croatia and 30% of acreages in Yugoslavia. Among them, Super Zlatna and Baranjka dominated and they occupied approximately 50% of acreages (data published in "Privreda", 1985).

After 1985, a share of Zg-varieties among those sown was somewhat reduced. However, through a network of large- and small-scale trails, observation trials, performance trials and some other, our new breeding materials were tested throughout the country. Thus, soon after that, in 1987, 1988 and 1989 our new high-yielding winter wheat varieties were registered. They are: Marija, Zagrepčanka, Adriana, Irena, Dijana, Biljana and Marina, varieties that have been increasingly grown in wide agricultural practice within and outside the country. Some are registered abroad, such as Zagrepčanka in Hungary in 1983, Adriana in 1987 and Korona in 1988.

A variety represents a basic, or number one factor in wheat production. If we know that a share of a variety in the yield of a high-yielding genotype makes about 50%, then the possibilities for increasing yield and quality by introducing new high-yielding varieties into wide practice are obvious.

A growing interest in high-yielding wheats with improved quality is a stimulus to breed such varieties that will meet the demands of the market. Variety Marija is precisely one of the newly released Zg-selections which presents a marked progress in improvement of relationship between yield and quality. During the process of breeding, positive agronomic traits such as high yielding and improved grain and flour quality were combined in it. Those traits were recognized already during the testings in large-scale trials at several locations and years. That is the reason for its growing expansion, a variety suited to intensive production. Its protein content is up to 14% or even more than that, and sedimentation value is above 40 ml. Therefore, it belongs to 1st quality class and sub-group A2-B2. The same applies to Sana, a variety spread on wide area, which, apart from high yielding ability possesses good quality of kernels and flour.

Our new Zg-varieties of winter wheat increasingly appear on wheat fields throughout the country and their share among the varieties seeded is noticeable. Marija and Sana especially stand out, though the other such as Adriana, Zagrepčanka, Irena, Dijana as well as Biljana and Marina,

which are just at the begining of their spread, do not fall behind those. Our agricultural practice is being offered through a network of trials, an array of our new lines that are still in the process of registration. In normal years and when planted within optimal terms (October 10-25) Zg-varieties achieve mean yields between 7 and 8 t/ha of dry kernels and even more than that, with their genetic yield potential being far higher than that, over 10 t/ha.

The experts of this Institute are working on development of even better varieties with high yield capacity, good quality and resistant to diseases. Therefore, we are expecting to have, in the future, varieties with even better characters, more yielding, with improved quality and resistant to diseases.

– Can we be contented with what has been achieved in wheat production?

Over last few years, the achieved level of mean yields of wheat in Yugoslavia is stagnating and falling behind other European countries, while our objective is to produce about 6 million tons per year, maintaining the present acreages under wheat. The science and the profession are now facing the task to further increase mean yield of wheat. New varieties are created with which production of 6 million tons can be achieved. However, we have wheat varieties whose high genetic yield potential (over 10 t/ha) is not fully used. On social sector, this potential is used on the average up to 50% (on some state farms 60-70%). On private farms genetic yield potential is used considerably less (up to 30-35%). It is here where big reserves for even higher production lie.

The production achieved today, however, does not meet the needs and the problem of wheat still remains to be solved. The solution is complex and it consists of several factors, of which the most important are seeding rate, seeding data, use of mineral fertilizers, with an emphasis on nitrogen component, soil reclamation, the price of the produce etc.

To be able to achieve quality and stable yield of wheat grain, one of the basic conditions is to use quality seed of a variety, processed and treated against fungal diseases and soil pests. Also, just as important is to ensure disease and pest control during vegetation (by using fungicides and insecticides). One of obligatory measures is weed control by applying herbicides. Attention should be paid to rational fertilization with mineral fertilizers especially nitrogen component, without which high yields are not possible, because new high-yielding semi-dwarf varieties have strongly manifested requirements in nitrogen (Danojević, Tomasović, 1989; Tomasović, 1986, 1989).

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II. Editorial Remarks

Errata

The title and authors of the article of No. 69 page 13-17 should be changed to as follows:

Wheat breeding for resistance to *Fusarium* deseases especially to *Fusarium graminearum* Schw.

S. Tomasović, V. Vlahović and M. Matijašević

(Communicated by S. Tomasović)

There were a few mistakes in the article "Evaluation and utilization of diploid species of wheat" No. 67: 9 – 10.

Page 9, 2nd line of para. 3 "A tetraploid variety of *T. durum*" should be "A hexaploid wheat variety of *T. aestivum*". In the next line, "The F_1 triploid hybrid (2n=21) should be read as "The F_1 tetraploid hybrid (2n=28)". Similarly in the 4th line, it should be read as "The two tetraploid hybrid plants" instead of "The two triploid hybrid plants". In the 1st line of the title of the Table 1 (page 10), "*T. durum*" should be "*T. aestivum*". (Communicated by S.M.S. Tomar).

Announcement for Future Issues

WIS No. 72 and 73 will be planned for publication in March and September 1991, respectively. Manuscrips for No. 72 will be accepted anytimes not later than February 1991. Lists of genetic stocks and records of genetic resources are mostly welcome.

Acknowledgment

The cost of the publication has been defrayed by a contribution from Kihara Memorial Yokohama Foundation for the Advancement of Life Sciences. The editors of WIS wish to express our sincere thanks to the foundation.

We also thank the reviewers listed below for their valuable efforts and contributions on behalf of the 1990 edition of the journal.

J. Fujigaki
Y. Furuta
K. Kato
N. Kawakami
T. Koba
C. Nakamura
K. Tsunewaki
Y. Yasumuro

Explanation of the Picture on the Cover

Spikes of mutants lacking one of marker characters. From the left: an F_1's spike carrying all five marker genes and mutants lacking *Hg, Hpl, C, Q, B1,* and both *B1* and *Q.* See the article by H. Tsujimoto and K. Noda in this volume for the details.

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