EXTRACTION OF ANCESTRAL CONSTITUENTS OF NATURAL POLYPLOIDS. II. STUDY OF THE FIRST BACKCROSS OF THE PENTAPLOIDS (AABBD) AND 34-CHROMOSOME PLANTS TO THE HEXAPLOID, *TRITICUM AESTIVUM* (AABBDD)*

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Abstract

For the extraction of tetraploid component of a hexaploid the production and backcrossing of fertile pentaploids is essential. The first backcross of the F_1 pentaploids to varieties Chinese Spring, Peko, Koga, Svenno and A. T. 38 of Triticum aestivum *were made. When the hexaploids were used as pollen parent, the total seed set was 16%; in the reciprocal direction it was 3%. There were differences in the crossability of different monosomic lines used and in the survival and sterility of the pentaploids and 34-chromosome plants recovered from the first backcross.*

Introduction

Pentaploid hybrids (2n=5x=35. AABBD), involving hexaploid (AABBDD) and tetraploid (AABB) wheats have five sets of chromosomes of three genomes A, B and D. In such a pentaploid hybrid, there are usually 14 bivalents and 7 univalents at meiosis. The two pairs of homologous genomes A and B form bivalents and the chromosomes of the single D genome are seven univalents. When a pentaploid is selfed, plants with varying chromosome numbers from 28-42 are obtained in the progeny. This property of pentaploid has theoretical as well as practical implications. The extraction of a tetraploid component from *T. aestivum* by a series of backcrosses requires that the F_1 pentaploids and the pentaploids from all subsequent backcross progenies are backcrossed with *T. aestivum*. The practicability of this method will depend primarily on how many pentaploids are there in each progeny and how fertile they are, and on the success of the backcrosses.

The present paper deals with the first backcross of the pentaploids and 34-chromosome plants to the varieties and monosomic lines of *Triticum aestivum*.

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The studies are confined to the crossability and recovery of the pentaploids and 34-chromosome plants.

Materials and Methods

The seed produced from the crosses of varieties and monosomic lines of *Triticum aestivum* and tetraploid species of *Triticum* (Siddiqui 1969), was sterilized by soaking in 0.25% acqueous solution of mercuric chloride for 10-15 minutes and then transferred to moist filter papers in Petri dishes. The Petri dishes were placed in the germinator at 20C.

Somatic chromosome numbers were usually determined in the root tips of the germinating seeds and sometimes in the root tips from potted plants.

Seedlings with 34 and 35 chromosomes were selected and transplanted in John Innes potting compost No. 2 and individually labelled. Florets were pollinated 3 days after emasculation.

Results

The results of the 1st backcrosses in which the pentaploid F_1 hybrids derived from 5 varieties of *T. aestivum* and the F_1 hybrids with 34 chromosomes obtained from crosses between monosomics of Chinese Spring and tetraploid wheats are summarised in Table 1. In this Table '*T. aestivum* (general)' includes all the backcrosses in which pentaploid hybrids were backcrossed to a variety of *T. aestivum* other than the parental variety.

The results of the reciprocal crosses were markedly different (Table 1). When F_1 pentaploids and some F_1 34-chromosome plants were used as pollen parents, the total seed set was 3%. In the reciprocal direction it was 16%. This may well be due to a difference between the pollen fertilities of the pentaploids and hexaploid plants. Almost all the pollen from the hexaploids was fertile, but the pollen fertility of 9 'pentaploid' F_1 combinations ranged from 45% to 65% only (mean 54%; Siddiqui 1964). Alston (1963) reported a comparable difference between reciprocal crosses, the seed sets being 8% and 2% when hexaploid *T. aestivum* and hybrid (*T. aestivum* x *T. durum*) plants respectively were used as pollen parents. He reported that the pollen fertility of pentaploid hybrids ranged from 34 to 60%.

Eighty per cent of the pollen of the pentaploid F_1 hybrid, Koga x Iumillo (Table 1) was fertile, and this is probably why more seeds were set (18%) in the backcross when this pentaploid was used as pollen parent. In the original crosses (Siddiqui 1969) Koga gave more seeds (14%) when pollinated with Iumillo than with any other tetraploid that was used (0-6%).

When the Chinese Spring disomic was used as the female parent the total seed set was 3% (Table 1). The mean percentage of total seed set was the same with the monosomics. However when the results for individual monosomic lines are analysed (foot of Table 2), it seems possible that there may be differences in crossability, though the numbers involved are small and definite conclusions cannot therefore be drawn. Ten different monosomic lines were used in this backcross, and some of the monosomics, *e.g.*, IV (4A) and XIV (1A), seem to have been better female parents than others, *e.g.*, I (1B) and XII (3A).

When the backcrosses were made in the reciprocal direction using the F_1 hybrids as female parents, the Chinese Spring monosomics used as pollen parents gave a seed set of 25%, compared with the average seed set of 11% for all crosses in both directions.

The percentage of seed set was higher (32%) in the Chinese Spring - Machmudy progeny than in the Chinese Spring - Carleton (17%) progeny (Table 3).

The relative success of disomics and monosomics is also indicated in Table 3. In Chinese Spring x Machmudy progeny, monosomics gave a higher seed set (34%) than disomics (26%).

Monosomics also crossed well with other pentaploids (Siddiqui 1964). These results are summarised in Table 4. The seed set with monosomics (21%) was more than double the seed set (9%) obtained from the disomics and seven times as much as was given by other varieties of *T. aestivum* (3%).

The greater success of monosomics as pollen parents in all these crosses may be ascribed to the fact that most crosses with monosomics were made during September and October, which are suitable months for crossing. Most of the disomics were used during November and December, when the conditions are less suitable for crossing.

Eleven monosomic lines were used in crosses during September and October, five of which (XVII-XXI) were the monosomics of the D genome (Table 5). There are differences in the success of crosses even when all the results from fewer than 150, or even 300 crosses, are excluded. Monosomic XIX gave the highest seed set (46%) which is double the percentage obtained from monosomic XXI (23%) and more than double the average seed set from all monosomics in the first backcrosses (17% of 1558 florets). Monosomic XVII gave only 7% seed set, which was lower than the average.

It may be summarised that in the first crosses, the combination Chinese Spring Machmudy was most favourable (48% seed; Siddiqui 1964). In the first backcross also the combination involving Chinese Spring and Machmudy was most successful (32% seed set; Table 3).

The details of the recovery of the fertile pentaploids including 34-chromosome plants obtained from the first backcross are given in Table 6. Twenty-four of the 126 pentaploids recovered from the first backcross progeny failed to survive, and of those which did, 17 were sterile and did not produce seed either by self- or cross-pollination (Table 6). The differences in survival and sterility among plants having the same chromosome number were probably the result of recombination between the genotypes of the tetraploid and hexaploid parents.

Discussion

The F_1 pentaploids were backcrossed to varieties of *T. aestivum* in both directions. The results were in agreement with those reported by Thompson (1930) and by Alston (1963). Three per cent of the pollinated flowers set seed when the hexaploid was used as female in contrast to 16% in the reciprocal crosses (Table 1). Thompson (1930) suggested that the difference was due to abortion and non-functioning of pollen in the F_1. Opeke (1961) compared the pollen and seed fertility of a number of F_1 pentaploid hybrids. He concluded that, before any of the F_1 pentaploid hybrids could produce a reasonable number of seeds, the pollen fertility by staining should be well above 50%. The present work also supports these suggestions. The backcross in which the F_1 pentaploid (Koga x Iumillo) was used as pollen parent (pollen fertility 80%) gave a seed set of 18% compared with an average seed set of 3% from all the backcrosses in which the F_1 pentaploids were used as male parents.

The difficulty arising from the variation in time of flowering can be overcome by growing the hexaploids continuously so that the pollen and florets for emasculation are always available. Another facility with the hexaploid is that the number of plants which can be grown is almost unlimited, and there is no need to determine their chromosome numbers.

It is easier to work with a hexaploid which not only has a high crossability and produces a high frequency of pentaploids but is also adaptable to a wider range of environmental conditions, so that, for example, it can produce fertile pollen throughout the year. In Chinese Spring these attributes are more pronounced than in any other variety that was used.

TABLE 1

Results of the first backcross of F_1 pentaploid* hybrids with varieties of *T. aestivum*

Recurrent parent	*No. florets pollinated*	*No. seeds obtained*	*% seed set*
I. 6 *x* ** x 5 *x**			
1. Chinese Spring disomic	332	9	3
1*a*. Chinese Spring monosomics	548	16	3
2. Peko	88	0	0
3. Koga	68	12	18
4. Svenno	50	0	0
5. A. T. 38	146	1	1
6. '*T. aestivum* (general)'	226	1	0.4
Total or mean	1458	39	3
II. 5 *x* * x 6 *x* **			
1. Chinese Spring disomic	454	70	15
1*a*. Chinese Spring monosomics	1010	248	25
2. Peko	84	0	0
2*a*. Peko***	170	35	21
3. Koga	130	0	0
3*a*. Koga ***	116	16	14
4. Svenno	88	17	19
4*a*. Svenno ***	50	1	2
5. C. 518	196	1	1
6. '*T. aestivum* (general)'	626	68	11
Total or mean	2924	456	16
Total or mean for *T. aestivum*	4382	495	11
7. (*T. durum* var. Carleton x *Ae. squarrosa*)	424	34	8
Grand total	4806	529	11

* Including 34-chromosome plants

** Including monosomics

*** Backcrossed to the plants obtained from the selfed seed of F_1 pentaploids

TABLE 2

Results of the first backcrosses using F_1 pentaploid* hybrids as male parents with disomics and monosomics of Chinese Spring

Female parent		*Male parent*	*No. florets pollinated*	*No. seeds obtained*	*% seed set*
I. *Chinese Spring* x *Carleton progeny*					
C S** disomic	x	5*x*	54	0	0
C S disomic	x	5*x*—1	132	4	3
C S monosomics	x	5*x*	210	5	2
C S monosomics	x	5*x*—1	132	0	0
		Total or mean	528	9	2
II. *Chinese Spring* x *Machmudy progeny*					
C S disomic	x	5*x*	146	9	6
C S monosomics	x	5*x*	206	7	3
		Total or mean	352	16	5
Summary of crosses					
C S disomic	x	5*x*	200	9	5
C S disomic	x	5*x*—1	132	4	3
C S monosomics	x	5*x*	416	12	3
C S monosomics	x	5*x*—1	132	0	0
		Total or mean	880	25	3

Chinese Spring monosomics used. (Seeds obtained/florets pollinated)
I (1/146): III (1/58): IV (4/30): VII (1/18): VIII (0/18): XII (0/80): XIV (4/84): XV (0/40): XVI (1/54): XX (0/20).

* Including monosomics

** CS = Chinese Spring

TABLE 3

Results of the first backcross using F_1 pentaploid* hybrids as female parents with the disomics and monosomics of Chinese Spring

Female parent		*Male parent*	*No. florets pollinated*	*No. seeds obtained*	*% seed set*
I. *Chinese Spring* x *Carleton progeny*					
5*x*	x	C S** disomic	94	13	14
5*x*—1	x	C S disomic	42	10	24
5*x*	x	C S monosomics	322	55	17
5*x*—1	x	C S monosomics	118	22	19
		Total or mean	576	100	17
II. *Chinese Spring* x *Machmudy progeny*					
5*x*	x	C S disomic	136	35	26
5*x*	x	C S monosomics	290	100	34
		Total or mean	·426	135	32
III. *Chinese Spring* x *Nursi progeny*					
5*x*	x	C S disomic	56	5	9
5*x*	x	C S monosomics	186	57	31
		Total or mean	242	62	26
IV. *Chinese Spring* x *Samra progeny*					
5*x*	x	C S disomic	44	1	2
5*x*	x	C S monosomics	68	13	19
		Total or mean	112	14	13
V. *Chinese Spring* x *T* 1 *progeny*					
5*x*	x	C S disomic	50	3	6
5*x*	x	C S monosomics	26	1	4
		Total or mean	76	4	·5
VI. *Chinese Spring* x 33 *D* 1 *progeny*					
5*x*	x	C S disomic	6	2	33
5*x*—1	x	C S disomic	26	1	4
		Total or mean	32	3	9

Summary of Crosses

Female parent		*Male parent*	*No. florets pollinated*	*No. seeds obtained*	*% seed set*
5*x*	x	C S disomic	386	59	15
5*x*—1	x	C S disomic	68	11	16
5*x*	x	C S monosomics	892	226	25
5*x*—1	x	C S monosomics	118	22	19
		Total or mean	1464	318	22

* Including 34-chromosome plants
** CS = Chinese Spring

TABLE 4

Result of the first 'general' backcrosses with *T. aestivum*

Female parent		*Male parent*	*No. florets pollinated*	*No. seeds obtained*	*% seed set*
I. 6*x** x 5*x*					
C S **disomic	x	5*x*	128	1	1
C S monosomic	x	5*x*	46	0	0
Other varieties	x	5*x*	52	0	0
		Total or mean	226	1	0.4
II. 5*x* x 6*x**					
5*x* x C S disomic			200	18	9
5*x* x C S monosomics			200	43	21
5*x* x Other varieties			226	7	3
		Total or mean	626	68	11

* Including monosomics
** CS = Chinese Spring

TABLE 5

Results of the first backcross using Chinese Spring monosomics and disomics as male parents

Monosomic lines and disomics used	*No. seeds No. / florets pollinated obtained*					*Total*		
						No. florets pollinated	*No. seeds obtained*	*% seed set*
(*a*) Monosomic lines								
I	7/22	5/22	1/26	4/24		94	17	18
II	3/24	0/14	0/20	0/16	15/38	112	18	16
IV	2/26					26	2	8
XI	0/24					24	0	0
XII	0/24					24	0	0
XIII	0/18		21/64			82	21	26
XVII	0/24		1/16	4/32		72	5	7
XVIII	29/98		7/32	22/60		190	58	31
XIX	13/26		52/112	12/30		168	77	46
XX	5/24		13/68			92	18	20
XXI	1/20		16/56	1/44	27/46			
			13/68	9/40	8/52	326	75	23
(*b*) Disomics						654	88	13

TABLE 6

Recovery of fertile pentaploids* from the first backcross

Recurrent parent	*No. seeds sown*	*No. plants with known chromosome numbers*	*No. pentaploid plants*	*No. pentaploid* plants dead*	*No. pentaploid* plants sterile*	*No. fertile pentaploids**
Chinese Spring	295	164	78	10	13	55
Peko	35	14	5	2	1	2
Koga	24	12	7	2	0	5
Svenno	18	8	6	1	0	5
'*T. aestivum*' (general)	58	32	14	6	1	7
Total	430	230	110	21	15	74
T. durum var. Carleton x *Aegilops squarrosa* (Synthetic hexaploid)	34	24	16	3	2	11
Grand total	464	254	126	24	17	85

*Including 34-chromosome plants

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