Indian J. Genet., **48**(3): 377–381 (1988)

GENE TRANSFER FROM WILD TETRAPLOID *AVENA MAGNA* TO THE CULTIVATED HEXAPLOID *A. SATIVA*. I. BC_1 PROGENY

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(Received: October 19, 1985; accepted: February 11, 1988)

ABSTRACT

Five *Avena sativa* (2n = 42) genotypes, JHO-801, UPO-94, IGO-500, OS-6 and OS-7 were used as female parents and crossed with *A. magna* (2n = 28). The pentaploid self-sterile hybrids obtained were backcrossed to *A. sativa*. Out of 1507 florets pollinated with *A. sativa* pollen, only six seeds developed, four of which germinated giving rise to BC_1 plants. The morphology, cytology and fertility of these plants were studied. Some of the *A. magna* characters, viz., strong awns, grey and pubescent lemma and high tillering expressed themselves in these plants. The chromosome number varied from 2n = 33 to 2n = 40 with high frequency of bivalents. Further backcrossing to *A. sativa* was successful in two BC_1 plants. Some selfed seeds were obtained from three plants. It is expected that subsequent backcross and selfed progenies will give rise to stable hexaploid lines with gene introgression from *A. magna*.

Key words: *Avena sativa*, *Avena magna*, interspecific hybridization, oats, backcrossing.

The gene transfer from wild relatives is of great importance for improvement of oat (*Avena sativa* L.) because the cultivated germplasm pools of this crop are quite restricted and the cultivated types have remained isolated from their wild relatives for several thousand years [1]. Many useful genes in the wild *Avena* species have been identified and some have been successfully transferred to *A. sativa* [2–4]. Recently, the tetraploid species, *A. magna* Murph. et. Terr., has been utilized by Ladizinsky and Feinstein [5] and Thomas et al. [6] for introgression of wild genes into the cultivated hexaploid oats. Choubey et al. [7] observed significantly higher proportion of bivalent formation when this species was crossed with an *A. sativa* strain JHO-801, indicating better chances of introgression from *A. magna* to *A. sativa* JHO-801 than to other strains of the cultivated species used. The present studies confirm this hypothesis and in the following text, the cytology, morphology and fertility of some first backcross derivatives of *A. sativa* × *A. magna* hybrids have been described.

MATERIALS AND METHODS

During February 1982, a strain of *A. sativa* JHO-801, was successfully crossed to *A. magna* utilizing the tetraploid species as the pollen parent [7]. In the subsequent

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year, four more strains of *A. sativa* viz. UPO-94, IGO-500, OS-6 and OS-7 along with JHO-801 were again used as female parents for the production of pentaploid hybrids which were raised during rabi (winter) 1983-84 and subjected to extensive backcrossing with *A. sativa*. In all, 1507 florets were pollinated with *A. sativa* pollen, out of which six BC_1 seeds were obtained. Four of these seeds germinated, giving rise to BC_1 plants during rabi 1984-85.

These BC_1 plants were observed for days to panicle emergence, final plant height, number of nodes, tiller number, peduncle length, rachis length, spikelets per panicle, lemma hairiness and colour, awns per spikelet, and spikelet separation, along with the parental lines.

For cytological analysis, young panicles were fixed in ethanol–acetic acid (3:1) solution. Pollen mother cells were studied from acetocarmine smear preparations.

Pollen stainability and diameter were scored from freshly dehisced anthers by dusting the pollen on a drop of acetocarmine-glycerol (1:1) and observing after 1 h. Attempts were also made to further backcross these plants with *A. sativa*.

Table 1. Morphological features of BC_1 plants and parental lines

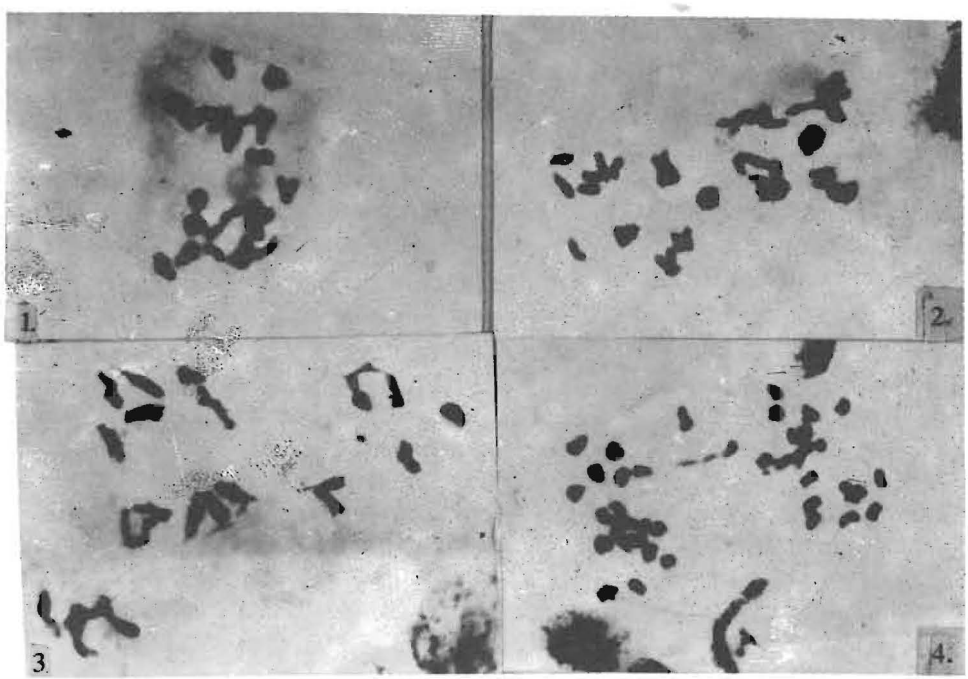
Strain or hybrid	Days to panicle emergence	Height (cm)	No. of nodes	No. of tillers	Peduncle length (cm)	Rachis length (cm)	Spikelets per panicle	Lemma hairiness	Lemma colour	Awns per spikelet	Spikelet separation
A. magna	130	135	5	82	50	30	18	Dense	Grey	2, strong, hairy	Abscission
A. sativa JHO-801	92	136	6	25	34	40	141	Glabrous	Yellow white	1, weak, nonhairy	Breakage
A. sativa UPO-94	115	165	6	33	43	37	75	–do–	–do–	Absent	–do–
A. sativa OS-7	108	208	7	21	45	49	105	–do–	–do–	1, weak nonhairy	–do–
(JHO-801 × *A. magna*) × UPO-94	121	147	7	69	44	41	138	–do–	–do–	–do–	–do–
(JHO-801 × *A. magna*) × JHO-801 Plant No. 1	108	148	7	36	40	31	97	Dense	Grey	2, strong nonhairy	–do–
–do– Plant No. 2	106	136	7	55	35	32	89	Glabrous	Yellow-white	1, rare, weak, nonhairy	–do–
(OS-7 × *A. magna*) ×UPO-94	112	144	6	41	40	30	96	Dense	Grey	1, strong, nonhairy	Semi-abscission

RESULTS

All the F_1 hybrids were completely self-sterile. The attempt to backcross these hybrids with *A. sativa* resulted in 0.4% seed set. Maximum success was observed in case of the F_1 hybrid JHO-801 × *A. magna* backcrossed to the parental *A sativa* strain JHO-801 where 1.1% artificially pollinated florets set seeds. However, the efforts to backcross the F_1 hybrids involving UPO-94, OS-6, and IGO-500 as the *A. sativa* parents were unsuccessful.

MORPHOLOGY

The morphological features of the four BC_1 plants and the parental lines are presented in Table 1. The BC_1 plants flowered later than the respective *A. sativa* parent and were intermediate in height. Three of these plants exhibited more number of nodes on the main tiller than either of the parents and all had higher tiller number than any of the *A. sativa* lines. The number of spikelets per panicle was comparable to *A. sativa* but markedly greater than in *A. magna*. Two BC_1 plants had densely hairy and grey lemma similar to *A. magna* and the primary spikelets exhibited strong nonhairy awns. In the other two BC_1 plants, the spikelets were similar to *A. sativa*. In all the BC_1 plants, the spikelets were persistent and did not disarticulate by abscission.



Figs. 1–3. Diakinesis: 1) 1 VI + 1 IV + 15II in (JHO-801 × *A. magna*) × JHO-801 plant No. 1.; 2) 1 IV * 1 III + 16 II +1I in (JHO-801 × *A. magna*) × JHO-801 plant No. 2; and 3) 3 IV + 12 II +2 I in (JHO-801 × *A. magna*) × UPO-94.

Fig. 4. Anaphase-I showing a bridge and a laggard in (JHO-801 × *A. magna*) × JHO-801 plant No. 1.

CYTOLOGY

The chromosome number of these plants was 2n = 33, 38, 40 and 40. Bivalent frequency was very high (Figs 1–3). The average chromosomal associations in one plant with 2n = 40 were observed to be 0.15 VI + 1.15 IV + 0.70 III + 15.05 II + 2.30 I. At anaphase I laggards and bridges were observed in PMC of all the plants (Fig. 4).

FERTILITY

The BC_1 plant (OS-7 × *A. magna*) × UPO-94 with 2n = 33 showed no stainable pollen. The two BC_1 plants of the backcross (JHO-801×*A. magna*)× JHO-801 with 2n = 40 had 40.5 and 52.4% fully stainable pollen, whereas the plant with 2n = 38, (JHO-801 × *A. magna*) × UPO-94, had 86.0% pollen stainability. The pollen diameter of the BC_1 plants, *A. sativa* lines, and *A. magna* ranged from 39–66, 48–60, and 48–54 μm, respectively.

Two BC_1 plants involving JHO-801 as the *A. sativa* parent were successfully backcrossed, giving BC_2 seeds. Selfed seed from three BC_1 plants, with the exception of the one with 2n = 33, were also obtained.

DISCUSSION

The presence of *A. magna* characters like strong awns, lemma colour, pubescence, and high tillering potential in BC_1 progeny indicates that introgression of genes from *A magna* to *A. sativa* is possible. Such observations for morphological traits were also reported by Ladizinsky and Feinstein [5] and Thomas et al. [6]. In BC_1F_3 and BC_2F_2 progenies of *A. sativa* Sun II × *A. magna*, Thomas et al. [6] observed introgression of higher groats size and protein content from *A. magna*. Although the material of the present studies is in an early stage, there are indications of obtaining lines with high tillering potential in the subsequent generations.

Recovery of BC_1 plants with chromosomal complement nearing the 6x level and success in obtaining BC_1F_2 and BC_2 seeds indicate possibility of isolating plants with stable chromosome number. The present studies also confirm our earlier results [7] that JHO-801 is a better genotype than the other four *A. sativa* strains used in this programme of gene transfer from *A. magna* to *A. sativa*, since higher seed set by backcrossing was obtained in the JHO-801 × *A. magna* F_1 hybrid than in the other F_1 hybrids where it was very low or nil. Further, BC_1 plants involving JHO-801 had chromosome number close to the hexaploid level, indicating that the higher bivalent formation in the F_1 played an important role in obtaining BC_1 plants with higher chromosome number.

The results reported here and our earlier observations [7] clearly indicate that valuable introgression from *A. magna* to *A. sativa* JH-801 is possible. The studies also confirm the results of Ladizinsky and Feinstein [5] Thomas et al. [6] and show the possibility of generating genetic variation from *A. sativa* × *A. magna* hybridization.

ACKNOWLEDGEMENT

Thanks are due to Dr. S. N. Zadoo, Scientist (Genetics and Cytogenetics) for valuable suggestions.

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