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Intergeneric Hybridization Between Two Wheat and Two Barley Species

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Abstract: The present study was executed for intergeneric crosses reciprocally among four species of *Triticum* and *Hordeum* at the first step. Chemical treatment with GA_3 yielded better result regarding seed setting. On an average 7.91% seeds were found to set and 68.24% seeds were found to germinate. Most of the hybrid seeds were shriveled, weak, smaller in size, sometimes intermediate and few of them resembled to that of their respective female parent. Seedling viability ranged from 45.45-58.33%. The F_1 plants were vegetatively weak and resembled morphologically somewhat to their female parent. The spikes were very weak and the spikelets were found to arrange themselves on the rachis very laxly. All the hybrid plants were found to be sterile in nature.

Key words: Intergeneric hybrids, morphological features, *Triticum*, *Hordeum*

INTRODUCTION

Hybridization is one of the most important techniques for crop improvement. Crop plant species are different from their wild relatives; mostly weed species, from which they originated. Genetic change of crop plants have been brought about by man through plant breeding and the extent of these changes are often very much difficult to realize the cultivated plants. Today, it is clear that the crop plants were virtually reconstructed by man from weedy wild plants. Intergeneric hybridization commonly have great potential for crop improvement by widening the genetic base from which plant breeder can select the desirable traits for high lysine content, yellow dwarf resistance, drought tolerance, salt tolerance and scab resistance. In many crop species the genes for disease resistance transferred from the wild species are extremely useful.

The hybrid was made between *H. jubatum*×*S. cereal* cv. (Brink *et al*., 1944; Wagenaar, 1959). Similarly, the intergeneric hybrid were produced by four species of *Hordeum* and two species of *Agropyron* (Fedak, 1985). Moreover, artificial and spontaneous intergeneric hybrid of *Elymus* and *Hordeum* species had been reported by Bowden (1958). Dewey (1971) also reported the self-sterile hybrid obtained from the crosses between *E. Canadensis* L. and *H. bogadanii*. The present study as undertaken to produce intergeneric hybrids and studied their morphological features.

MATERIALS AND METHODS

The experimental materials for the present study were two wheat *(Triticum)* species and two barley (*Hordeum*) species as follows: *Triticum aestivum* (2n = 42), *Triticum durum* (2n = 28), *Hordeum vulgare* (2n = 14) and *Hordeum nudum* (2n = 14). To conduct the different experiments of the present study reciprocal crosses among the mentioned species were made for obtaining the hybrid in the growing seasons of 1998-1999, 1999-2000 and 2000-2001.

The intergeneric crossing programme was made following the schedule of (Kruse, 1973), with certain modifications. The plants of all the parental species were grown in pots and were kept under ambient condition up to their heading stage. After complete emergence of spike they were allowed to acclimatize with the controlled conditions of 15-18°C under fluorescent light for 16 h and at approximately 45% relative humidity. Emusculation was done just prior to anthesis and the florets were treated with 2-4 dichlorophenoxy acetic acid immediately as suggested by Kruse (1974). Pollination was made 2-3 days after emusculation and the pollinated florets were injected with 75 ppm GA_3 by microsyringe 2/3 times in 2 days. On day after the pollinated florets were protected by white paper bags. After 15-20 days of pollination the plants were brought under open environment gradually. The shrivel and weak crossed seeds were cultured on MS medium for emerging the root and shoot properly. The plantlets were then transferred to small plastic pots and

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after 7-10 days, the young seedlings were transplanted into large size potted soil. Somewhat healthy crossed seeds were allowed to germinate in laboratory on moistened filter paper. Then very young seedlings keeping under controlled conditions as mentioned earlier were transplanted in the potted soil and they were used as F_1 plant in this study.

A keen observation was made on the following characters of different hybrids for characterizing them morphologically and also comparing them with that of their respective parents. Production of hybrids, seed morphology, seedling morphology and morphology of spike and spikelets were considered characters in the present study.

RESULTS

To obtain these intergeneric hybrids attempts were made in several ways. But only under controlled environmental condition and with chemical manipulation results regarding these preliminary but significant studies have been achieved.

The seed set expressed as percentage of pollinated florets in different crosses were found to be lowest (6.21%) in *H. vulgare*×*T. aestivum* and highest (9.45%) in *H. vulgare*×*T. durum*. Average seed set percentage in the crosses reciprocally as found to be 7.92% (Table 1).

Seed germination percentage in different crosses were found to be vary and it ranged from 75.0 (*H. nudum* ×*T. durum* and *T. aestivum*×*H. vulgare*.) to 61.90% (*H.nudum*×*T. aestivum*). Average seed germination percentage was 68.24 (Table 1).

Table 1 indicates that seedling viabilities in different cresses were also found to vary and it ranged from 58.33 (*H. nudum*×*T. aestivum*) to 45.45% (*T. durum*×*H. nudum*). Average seedling viabilities were found to be 52.74%. It is mentionable that none of the F_1 plants was found to set seed. Morphology of hybrids is presented in Fig. 1A-E. Hybrid seeds of *T. durum*×*H. vulgare* and *T. durum*×*H. nudum* were found to be very weak, shriveled and smaller in size. The weak and small sized seeds were found in the crosses *T. aestivum*×*H. vulgare* and *T. aestivum*×*H. nudum*. Rest of the crosses showed hybrid seeds to be intermediate in size and shape compared to that of the parents. Very few of the hybrid seeds resembled somewhat their respective female parent. At the age of 60-65 days, morphologically F_1 plants resembled their maternal parents predominantly. Their heights were found to be intermediate in the most of the cases. Somewhat normal seeds of the crosses *H. vulgare*×*T. aestivum*, *H. nudum*×*T. aestivum* and *H. vulgare*×*T. dunum* produced healthy plants to some extent. But vigorous growth was not observed in any of the hybrid seedling, even at their adult stage.

The F_1 plants of the crosses *T. aestivum*× *H. nudum*, *T. dunum*×*H. vulgare* and *T. dunum*×*H. dunum* were found to be weak with light green foliage, ill healthy and different from their respective parents. On the other hand *H. vulgare*×*T. aestivum*, *H. nudum*×*T. aestivum*, *H. vulgare*×*T. dunum* and *T. dunum*×*H. dunum* crosses showed F_1 plants to be green in colour, long and flat leaved, which were more or less similar to that of their maternal parent in the crosses *T. dunum*×*H. vulgare* and *T. dunum*×*H. nudum* few seedling of different ages were found to show ill growth, dying and declining stage gradually. Most of them could not be managed to survive. Spike and spikelets in F_1s plants from different crosses were found to be different from their parents. Small and weak spikes containing very weak spikelets were found in the crosses of *T. aestivum*×*H. vulgare*, *T. aestivum*×*H. nudum* and *T. durum*×*H. nudum* which differed from their respective parents. Rest of the crosses (*H. vulgare*×*T. aestivum*, *H. nudum*×*T. aestivum*, *T. durum*×*H. vulgare*, *H. vulgare*×*T. durum* and *H. nudum*×*T. durum*) were found with F_1 plants to show intermediate spikes and spiklets. Spikelets were found to be arranged laxly. Spikelets density was not prominent and awn development was very poor in all the cases. All the F_1 plants in different crosses were found seedless.

Table 1: Seed set, seed germination, seedling viabilities and seed set in F_1 plants of eight different wheat-barley crosses

Cross No.	Cross combinations	Pollinated florests during 1998-99, 99-2000 and 2000-2001	Total seed set	Seed set (%)	Seed germination (%)	Seedling viabilities (%)	Total F_1s plants obtained during 1999-2000, 2000-2001 and 2001-2002	Seed set in F_1 plants
C1	*T. a*×*H. v*	310	24	7.74	62.5	50.0	12	Nil
C2	*H. v*×*T. a*	322	20	6.21	65.0	50.0	10	-
C3	*T. a*×*H. n*	316	21	6.64	61.90	52.38	11	-
C4	*H. n*×*T. a*	279	24	8.60	75.0	58.33	14	-
C5	*T. d*×*H. v*	276	23	8.33	69.0	52.17	12	-
C6	*H. v*×*T. d*	296	28	9.45	75.0	57.14	16	-
C7	*T. d*×*H. n*	258	22	8.52	63.63	45.45	10	-
C8	*H. n*×*T. d*	292	23	7.87	73.91	56.52	13	-
				$\bar{x}$ = 7.92	$\bar{x}$ = 68.24	$\bar{x}$ = 52.74		

* T = *Triticum*; A = *Aestivum*; D = *Durum*; H =*Hordeum*; V = *Vulgare*; N = *Nudum*

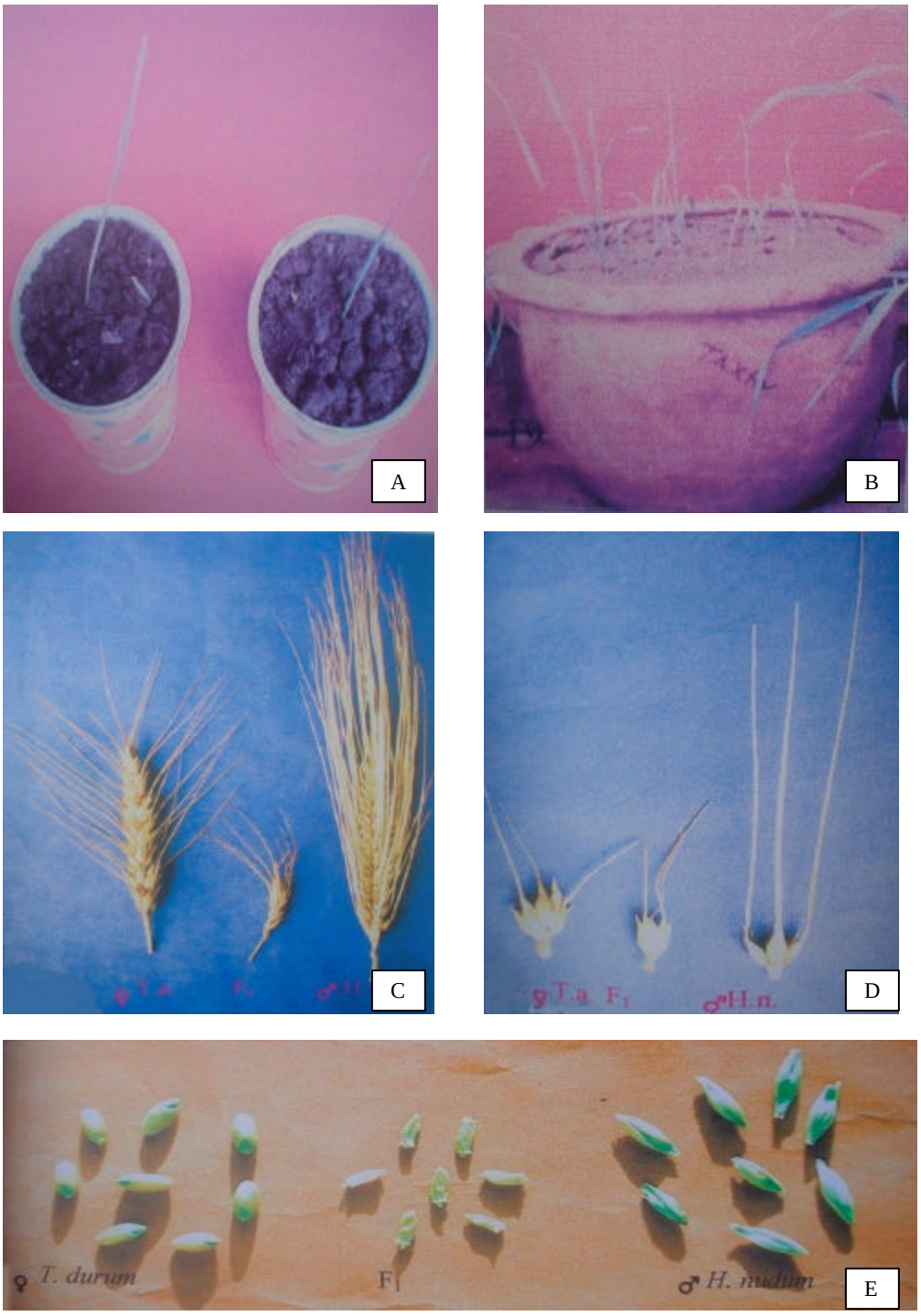

Fig. 1A-E: Morphology of *Triticum-Hordeum* hybrids
A) Transplanted plantlets in plastic pots, B) Morphology of the hybrid seedlings, C) Morphology of the spikes of F_1s along with their parents, D) Morphology of the spikelets of F_1s along with their parents, E) Seed morphology of the F_1s and their respective parents

DISCUSSION

In the present study many more intergeneric crosses between four species of *Triticum* and *Hordeum* were made reciprocally for producing hybrids in the successive four growing seasons. The crosses were made under both ambient condition and chemical treatment. Under ambient condition no seed was found to set in any of the crosses but the floret cup injected with giberrellic acid (GA_3) gave better result regarding seed setting. However, Kimber and Sallee (1976), obtained Wheat×barley intergeneric hybrids without using any chemicals. Some workers (Kruse, 1973; Bates *et al*., 1974), produced wheat barley hybrid seeds by treating the pre-pollinated ovary with GA_3 particularly Kruse (1973), pioneered the role of growth hormones in facilitating intergeneric hybridization and his contributions have been successfully utilized by Fedak (1977) and Martin and Chapman (1977).

Seed set percentages were found to range from 6.21-9.45 with the mean value of 7.92%. Martin and Chapman (1977), reported seed set of *Hordeum chilense* and *Triticum aestivum* with very low percentage Fedak (1980), stated that the wheat (*Triticum aestivum* cv. Chinese spring) and barley (*Hordeum vulgare* cv. Betez) hybrids resulted at a frequency of 0.80% pollinated florets In the present study a total of 98 hybrid plants were obtained in the successive three growing season. When seed germination was found to range from 61.90-75.00% with the mean value of 68.24%. However, Abdulaeva and Kurkiev (1991), found 65.50 and 45.25% caryopses to set and their 45.20 and 33.30% germinability when crosses were made between *Triticum boeticum* (2n = 4x = 28) with rye (2n = 14) and *triticale* (2n = 28), respectively. Besides, Gupta and Fedak (1986), studied the hybrids of *Hordeum procerum* (6x) with *H. parodii* (6x) and *Elymus virginicus* and they reported that the hybrids of *H. procerum*×*H. parodii* and that of *H. procerum*×*E. virginicus* were found to produce at the rate of 7.9 and 14.3%, respectively. Moreover, Fedak (1978), also obtained the viable hybrids of *Hordeum vulgare* and secale cereal, when they injected GA_3 to the pollinated florets.

In the present study highest and lowest seedling viability were found to be 58.33 45.45%, respectively. Fedak and Armstrong (1986), found a total of 16 seeds from 250 pollinating florets of *Secale cereal*×*Thinopyrum* intermedium and only 5 (five) of them contained embryo strikingly only two germinated to produce seedlings. Similarly Abdulaeva and Kurkiev (1991) found less seedling viability compared to total seed setting of the intergeneric hybrid in the cross of *Triticum boeticum*×rye and in the cross of *T. boeticum*×*Triticum*. Almost similar results were found in the present study and it might be due to apparent incompatibility at several stages of reproductive process and immaturity of the embryo.

Another striking feature was found in the present study that none of F_1 plants was found to set seed i.e., all the hybrids plants were sterile. However, Dewey (1971) found that the hybrid plants were partially self-sterile and produced shrunken seeds in the crosses between *E. Canadensis* and *H. bogadanii*. Almost in the same way Kimber and Sallee (1976), produced an amphiploid of *T. timopheevi* (2n = 28)×*H. bogadanii* (2n = 14), which were meiotically stable and fertile. A hybrid of *H. chilense* (2n = 14) and *T. asetivum* obtained by Martin and Chapman (1977), 2n = 42 was reported to seed set in one year of a colchicines treated clone of the hybrid. *Triticum aestivum* and *Hordeum vulgare* shows phylogenetic affinity and few successful crosses have been made earlier and in the present study also. But production of viable seeds from the crosses of the two of these two species is really in scarcity. This might be due to many cytogenetic reasons although morphology of the hybrid seeds at the first glance indicates their shriveled nature, intermediate or parental conditions. In the present study such behaviour of hybrid seeds from morphology point of view was distinct. In almost all the cases the hybrid seeds were found to be shriveled and weak. They were smaller in size, sometimes intermediate in size and shape and few of them resembled to their respective female parent. But their overall features were not suitable and promising. Charpenter and Feldman (1986), obtained the hybrid seeds of *T. aestivum* and *A. junceum* but most of the seeds were shriveled and in all the cases endosperm was poorly developed or sometimes absent altogether. Low percentage of seed set, shriveling and weak condition and poor germinability of the hybrid seeds clearly indicates the existence of significant intergenric genetic barriers between wheat and barley. In the present study hybrid plants were found to be vegetatively weak. However, a few plants resembled the material parents in overall morphology except for growth, awn characters and complete sterility. Mujeeb and Rodriguez (1982), found *E. canadenis* and *H. vulgare* hybrids to be phenotypically resembled to the material parents more than *H. valgare*. In the present study *T. aestivum* was found sometimes to show its dominant nature and it might be due to its polyploid condition. Some cases, the characteristics of *Hordeum* were marked by *Triticum* to such an extent that the biparental phenotype was expressed. Almost all the F_1 plants of the crosses between *Hordeum* and *Triticum* species showed green coloured long and flat leaves, which were more or less similar to the maternal parents

Hordeum. Fedak (1980) found all reciprocally crossed barley and wheat hybrids to show intermediate height, light green foliage and the wheat like pubscent auricles were evident at the early seedling stage. When *Triticum* species was considered as the maternal parent in the present investigation the hybrid showed light green foliage character. Jiang and Liu (1990), found the hybrids of wheat x barley crosses to be more similar to wheat parents. However, both types of hybrids possessed more maternal characters and it might be due to low female to become ill, dying and declining gradually. Spike and spikelets in F_1 plants of all the crosses in the present study were found to be different from their parents. The spikes as a whole were very weak and the spikelets were found to arrange themselves on the rachis very laxly. Schooler and Anderson (1980), found spikelets to be arranged alternately on the rachis, but in general more closely resembled the barley parent then *Elymus*. The spikes of F_1 plants were larger and more shriveled than those of autotetraploid barley. However, in the present investigation the spikes were small and weak compared to both the parents. Mujeeb and Rodriguez (1984), found hybrid spike phenotypes of *H. vulgare*×*T. aestivum* to be influenced by the phenotype of *T. aestivum* parent. No such behaviour was noticed in any hybrid of the present study. Spikelets were less in number and their florets were not prominent. However, Fedak (1982), found compact spikes with much larger glumes and lemmas in barley-wheat hybrid. Fedak (1980), also found spikes of reciprocally crossed barley-wheat hybrids to be different from wheat by being more lax and awnletted lemmas.

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