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Response to selection for grain and biological yield in early segregating generations of spring x winter wheat.

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The wheat grown in India is of the spring type mainly guided by agro-geographic factors. Winter wheats possess a wide diversity for yield and other traits associated with high yield *per se* and resistance to major biotic and abiotic stresses. In order to enhance the productivity of spring wheats, winter types can be a great source of variability. Because there is no crossability barrier between the two ecotypes, hybridization is easily carried out by synchronizing the flowering time.

The higher productivity associated with winter wheats is due to the larger quantity of biomass they produce. Because the major area under wheat worldwide is occupied by spring wheats, one way to obtain yield enhancement in spring wheat is through introgressing traits for higher biomass production from winter wheats. CIMMYT, Mexico, has successfully utilized 'winter x spring' hybridization for yield enhancement in spring wheats. Furthermore, the recent spring wheat cultivars, which have been released in different countries have higher biomass in comparison to the cultivars of the 1980s and 1990s.

Two, exotic, winter wheat lines (EC 609401 and EC 609402) obtained from the Germplasm Unit at the Directorate of Wheat Research (DWR), Karnal, India, were sown in first week of October, 2010, to synchronize heading with early maturing, spring wheat cultivars that were sown in late December. These winter wheat lines were used as female parents in crosses with the advanced spring wheat lines PBW658, HD3059, WH1125, PBW672, DBW71, and DBW92 to generate F_1s. Five spikes were used as the female parent for each cross. Cross seed was grown in an open field during the winter of 2011 at Karnal and the seed harvested from the F_1 plants was divided into two lots; half was planted in an off-season nursery located at DWR Regional Station, Dalang Maidan (Himachal Pradesh), during May 2012. From the

F_2 plants grown during the off season, only spring type plants were selected. The harvested seed was bulked for generation advancement. During the 2012–13 crop season, seed of the previous season's F_1 plants (F_2 generation seed) and the bulked F_2 seed obtained from off season nursery (corresponding to F_3 generation seed) were planted together. In all, eight F_2s and eight F_3s were space planted at Karnal, in plots of six 5-m rows with row spacing of 20 cm. The seed was placed 5 cm apart in all rows of each plot. All recommended agronomic practices were adopted to raise the crop.

Biological yield (kg/plot) was measured as the total aerial biomass on dry weight basis produced for the inner four rows plus the biomass of individual plants selected in each cross. The grain yield (gm/plot) of the whole plot and selected plants was measured after threshing. The response to selection was determined as the difference between the phenotypic value for the traits biological yield and grain yield in selected population (F_3) and base population (F_2).

The realized gain under selection varied from –1.18 kg (EC609401/PBW658) to 2.95 kg (EC609402/DBW71) for biological yield (Table 1). For grain yield, response to selection ranged from –589.60 g (EC609401/WH1125) to 1,025.00 g (EC609402/PBW672). All eight crosses except one (EC609401/PBW658) showed a positive response to selection for biological yield. In most of the crosses, the positive response for biological yield was associated with a negative response with grain yield. The negative response in grain yield in crosses may be due to rejection of winter types in the F_2 generation in the segregating population grown at off season. However, in segregating populations of 'EC609402/PBW672' and 'EC609402/DBW71', we observed a positive response to selection for both biological and economic yield. These populations will further be subjected to selection pressure for spring types and, hence, used to study the response to selection in advanced generations. We concluded that biological yield could be used as selection criterion in early filial generations in winter x spring hybridization programs.

Table 1. Response to selection for biological (kg/plot) and grain yield (g/plot) in early segregating generations of spring x winter wheat.

	Biological yield			Grain yield		
Pedigree	F_2	F_3	Response to selection	F_2	F_3	Response to selection
EC609401/PBW658	6.42	5.24	–1.18	821.4	1,692.7	871.3
EC609401/HD3059	6.30	7.02	0.72	2,117.2	1,707.7	–409.5
EC609401/WH1125	4.56	6.84	2.28	1,636.3	1,046.7	–589.6
EC609402/PBW672	5.24	5.77	0.53	1,581.4	2,606.4	1,025.0
EC609402/DBW71	4.68	7.63	2.95	1,472.5	1,737.0	264.5
EC609402/HD3059	6.74	6.78	0.04	2,299.5	1,781.4	–518.1
EC609402/PBW658	6.00	6.33	0.33	1,876.1	1,787.4	–88.7

Increasing water productivity through matriconditioning and seed sprouting in wheat.

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The wheat crop is mainly grown under irrigated conditions. Future projections estimate that by 2050 per capita water availability will decrease to 1,190 M^3/year from present 1,545 M^3/year. In India, 90 % area of the wheat is irrigated, which also includes the area with restricted irrigation; only 10% of the area is rain-fed. In the future, the major challenge will be to produce more food with less water as share of water for agriculture decreases. Therefore, the biggest challenge is to improve water productivity in existing systems. The present water productivity of wheat is 800–1,000 L water/kg wheat grain, which needs to be decreased in order to improve the water use efficiency. This investigation was undertaken to reduce the presowing irrigation requirement of the wheat crop and understand the effect of matriconditioning (seed priming with distilled water) and seed sprouting on crop establishment under different soil moisture regimes.

Materials and methods. A field experiment was conducted in a split-plot design with three replications during the winter of 2010–11 and 2011–12 at the Directorate of Wheat Research, Karnal (Haryana). The experiment was comprised of three main plot treatments; M1, seeding at optimum moisture level (17.5%), M2, seeding at suboptimal moisture (10.9%), and M3, seeding in dry soil followed by irrigation (6.2%); and three subplot treatments, S1, no seed priming, S2, matriconditioning seed priming, and S3, sprouted seed. Soil moisture content was estimated following a gravimetric method (Black 1965). Rainfall received at the experimental site was 129.7 mm during 2010–11 and 36.3 mm during 2011–12. The climate is subtropical, with the mean maximum temperature ranging in between 34–39°C in the summer and mean minimum temperature ranging in between 6–7°C in winter.

Matriconditioning was in gunny bags as described by Basra et al. (2003). The gunny bags were soaked overnight in distilled water and then spread on a perforated floor. After leaching excess water from the gunny bags, seed was uniformly layered between them. The gunny bags were kept moist for the whole treatment period, i.e., 12 hours. For sprouting, the required quantity of seed was soaked in water for 10 hours, and then they were spread uniformly on a wet bag and covered with another bag for 12–14 h. The soil in the experimental field was sandy clay loam with at pH 7.9 (1:2.5 soil to water). The soil had an organic carbon content of 0.4 %, available N was 190 kg/ha, P was 17.8 kg/ha, and K ws 165 kg/ha at beginning of the experiment. Recommended doses of fertilizer (150:60:30 kg N, P_2O_5, and K_2O/ha) were applied as part of nutrient management. Full doses of P and K and a one-third dose of N through urea and the NPK mixture (12:32:16) were applied at sowing, and the remaining N was applied equally in two parts at the first and second irrigations. The cultivar DBW17 was sown on 18 November, 2010, and 6 November, 2011. The seed was sown in rows 20 cm apart at a seeding rate of 100 kg/ha. For the treatment in dry soil followed by irrigation, a light irrigation (40 mm) was applied soon after seeding. The first irrigation (60 mm) was applied uniformly to all treatments at the crown root initiation stage (22 days after sowing). Subsequent irrigations were applied at all critical growth stages. Irrigation was done with the help of a water pump. Other management practices were adopted as per recommendations of the crop under irrigated conditions in North Western Plains Zone of India. The number of effective tillers/m^2 from the center of each plot was measured at maturity. Plant height (cm) was recorded by measuring the height of 10 random plants from each plot. A random sample of 10 spikes was taken from each plot to determine spike length at maturity. A net plot of size 6 m^2 was harvested manually to obtain biomass and yield data. Grain was randomly selected from each subplot to calculate 1,000-kernel weight. SAS version 10.3 was used to analyze the observations and differences; means were further grouped into significant classes by Duncan's New Multiple Range Test at P = 0.05.

Results. Sowing sprouted seed sowing produced significantly higher grain yield (54.87 q/ha) compared to matriconditioning (53.01 q/ha) and unprimed seeds (50.24 q/ha) (Table 2.). The effect of seeding method was statistically nonsignificant; seeding at optimum moisture level (52.77 q/ha), seeding at sub optimal moisture level (52.02 q/ha), and seeding in dry soil followed by irrigation (53.32 q/ha). Because seed germination is a major limiting factor in crop establishment under moisture-deficient conditions, matriconditioning (priming with plain water) and sprouted seed improved germination, seedling growth, and crop establishment. Priming with plain water and sprouted seed are simple and inexpensive and can increase crop establishment under suboptimal soil moisture conditions. Priming and sprouting can be successfully used in areas of water deficit. Sowing also can be done without presowing irrigation in the North Western Plains Zone.

Table 2. The effect of seed priming and seeding method on crop establishment, growth, and yield of wheat during crop years 2010–11 and 2011–12 (pooled analysis). Treatments were M1, seeding at optimum moisture levels; M2, seeding at suboptimal soil moisture levels; and M3, seeding in dry soil followed by irrigation. Subtreatments were S1, no seed priming; S2, seed priming; and S3, sowing sprouted seed.

Treatment	No. of tillers/M2	Spike length (cm)	Plant height (cm)	Biomass (q/ha)	Grain yield (q/ha)	1,000-kernel weight (g)
A. Seeding method						
M1	491.73	10.24	87.76	124.87	52.77	38.88
M2	456.94	10.15	88.37	124.17	52.02	38.42
M3	499.53	9.53	88.01	127.86	53.32	38.77
LSD (P = 0.05)	28.51	NS	NS	0.79	**NS**	**NS**
B. Seed priming						
S1	464.98	9.61	87.84	123.69	50.24	38.32
S2	482.48	10.13	88.34	125.81	53.01	38.67
S3	500.73	10.18	87.95	127.41	54.87	39.08
LSD (P = 0.05)	19.06	NS	NS	1.39	1.76	0.41

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