Utilizing diverse gene pool from synthetic hexaploids for improving bread wheat (*Triticum aestivum* L.)

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ABSTRACT

Bread Wheat (*Triticum aestivum* L) is the most widely cultivated and consumed cereal crop globally. India recorded the highest wheat production of 76.37 million tons during 1999-2000 but since then production figures of wheat are hovering around 70 million tons. Production has therefore not increased in line with population growth of the country, which is a matter of concern. Therefore, wheat researchers will therefore need to accelerate the pace in productivity per year to achieve 109 million tons of wheat grain by the year 2020. In India, all possible and feasible efforts are being attempted for creating and harnessing the genetic diversity and trait specific variability for economic traits particularly yield attributes.

A set of 90 synthetic hexaploid wheats (AABBDD) obtained from CIMMYT, Mexico, was evaluated in augmented design for yield contributing traits, quality attributes and biotic and abiotic stresses. It was observed that most of the synthetic hexaploid lines showed more tillers per meter length, ear length and better grain size as compared to best available aestivum (PBW 343) and durum (HI 8498) checks, respectively. Besides, a number of synthetics showed superiority for quality and tolerance to various biotic and abiotic stresses. The breeding lines have been developed through intercrossing synthetics and agronomically superior wheat varieties. A number of lines selected from the segregating populations showed great promise with respect to multiple diseases (leaf rust, karnal bunt and spot blotch) resistance, tolerance to heat stress and some quality attributes namely protein content, sedimentation value and grain hardness. However, the material developed showed some undesirable traits such as tall stature, hard threshability, longer duration and red grains. To overcome these problems, 2-3 doses of backcrosses with agronomic parents were given. The present paper highlights the potentials of synthetics and their role in development of model wheat genotypes.

INTRODUCTION

Wheat (*Triticum aestivum*) is the staple food of above 40% human population across the globe and during the last decade, emphasis has been to further accelerate the pace of productivity per year by utilizing novel genetic diversity. During the last few decades, interspecific and intergeneric hybridization have been widely used to develop wheat cultivars with improved agronomic performance, pest tolerance and high yields (Friebe *et al.* 1996, Jauhar and Chibber 1999, Jauhar 2003). Wheat (*Triticum aestivum* L., 2n=6x=42, AABBDD) is an allo-hexaploid which evolved from the hybridization of a tetraploid wheat (AABB) with *Aegilops tauschii* (2n =2x =14, DD), syn. *T. tauschii; Ae. squarrosa*. This hybridization event is thought to have occurred more than once, but the exact number is not clear. The small number of hybridization events and the restricted geographic origin of these events have resulted in a narrow genetic diversity for hexaploid wheat. The D genome of wheat has remained largely unchanged from that of its wild relative *Ae. tauschii*, so much so that *Ae. tauschii* can be considered as an extension of the wheat gene pool. Therefore, *Ae. squarrosa* can be used as a source of genes for various traits still unexplored. More than 25% of all new wheats that CIMMYT has distributed in recent past to wheat improvement programme have been synthetic wheat derivatives. China has crossed CIMMYT synthetic wheat with local wheats and derived two varieties having 20 to 35% higher yields. Var. Chuanmai-42 had yield of 6 tons/ha in trials and was released in Sichuan in 2003. It is well documented that synthetic hexaploid germplasm can also be exploited for resistances and tolerances for leaf rust, stripe rust, mineral toxicities, drought, salinity (Pritchard *et al.* 2001), heat, cold, sprouting, water logging (Villareal *et al.* 2001), powdery mildew, loose smut, cereal cyst nematode (CCN) and are better for yield and its components. The present paper highlights the genetic variability available for yield attributes and scope for making disruptive selection for the traits that make direct influence on grain yield in wheat.

MATERIAL AND METHODS

A set of 90 synthetic hexaploids obtained from CIMMYT, Mexico, was evaluated at Directorate of Wheat Research, Karnal in a 5-row plot of 2.5 length having 30 cm distance between the rows. This material was planted under normal sown situation (second week of November) and recommended dose of fertilizer and other agronomic package of practices were followed to have proper expression of different traits. To maintain the purity of seeds, individual plants were harvested and threshed. Passport data on 13 metric traits including plant, grain and spike attributes were recorded at appropriate crop stage. However, in this paper genetic variability of five traits and disruptive selection made for only three major yield attributes namely tillers/m, spike length (cm) and 1000-grain weight (g) are discussed in detail. In addition, a set of these lines has been given to GRU, DWR for inventorying purposes. The statistical analysis was carried out following Panse and Sukhatme (1967). The synthetic lines were compared with checks taking into account the critical difference and coefficient of variation for these traits.

RESULTS AND DISCUSSION

The data recorded on various agronomic traits in 90 synthetic lines were analysed and the results showed a wide range of variation for yield contributing traits (Table 1). The estimates of parameters such as range, mean and critical difference revealed that synthetic wheat lines possess good amount of genetic variability. The magnitude of range for spike length (9.0-16.8), spikelets/ spike (13.8-24.6), grains/spike (11.4-64.0), tiller/m (50-222) and 1000-grain weight (20.0-50.4) is the indicative of wide range of variability present in synthetics for these traits.

The highest coefficient of variation was noted in tillers per plant followed by the traits tillers/m and seeds per spike. The highest CV was recorded for spikelets/spike followed by spike length. For efficient and effective selection in any breeding program, the high SD and CV are the pre-requisites and not actually the mean *per se*. In cases with a high range of CV, disruptive selection for higher values can be performed, which will result into the higher mean in selected population.

Table 1: Genetic variability available for yield components in 90 lines of synthetic wheats.

Parameters	Major Attributes				
	Spike length (cm)	Spikelets \ Spike	Grains\ spike	Tillers\ m	1000-grain wt. (g)
Range	9.0-16.8	13.8-24.6	11.4-64.0	50-222	20-50.4
Mean	12.73	17.79	35.03	125.36	38.40
S.D	1.68	1.89	8.49	39.28	7.92
C.V	13.24	10.67	24.25	31.34	20.61
Check (mean)	11.60	19.10	46.00	70	41.50
Lines selected	14	9	7	13	14

In the present study we carried out the disruptive selections for three characters viz; tillers per meter spike length and thousand grains weight. For this purpose the mean of the check as minimum limit and selection was utilized. It was found that some of the genotypes had longer spikes than the best existing varieties (Table 2). Synthetic 64 had the longest spike of 15.5 cm. As many as 10 lines were selected which exhibited longer spikes (>14 cm) in comparison to the check variety PBW 343 (12 cm). However, many of these except Synthetics 5 and 39 produced red grains. A large number of synthetic hexaploids developed at CIMMYT have been reported to show genetic richness for high grain weight, delayed senescence (stay green), HMW glutenins, resistance to KB and yellow rust (Mujeeb-Kazi 1995a, 1995b, and 2001; and Rajaram et al, 1983).

The information on most promising lines for each of the three traits, along with other agronomic attributes is presented in Table 2. Effective tillers per unit area directly contribute to the yield potential. The tillers/meter length was recorded even upto 222 in synthetic numbers 88 and 93 in compassion to the check 87 (PBW 343). Some of the synthetics even showed good kernel size and spike length. Lines were selected with about 15cm spike length as compared to the PBW 343. Synthetic 66 showed high tillering with maximum spike length (15.8), but it flowered late and produced smaller kernels. Based on higher kernel weight, eight synthetics were selected with 1000-grain weight above 47g. Although some of the synthetics (31, 33 & 38) are good for tilling and spike length also, but flowered 12 days later then the check PBW 343 and hence were not found very suitable for hybridization programme.

These promising synthetics can be used as genetic stocks for many yield contributing characters in crossing programs. In general synthetics are late flowering, hard threshing and have red grains that have poor acceptance among farmers and consumers in India. On the other hand the lines are resistant to disease and biotic stresses and thus contribute traits for combining with yield enhancement of the modern cultivars (Mamluk O F and Van Slageren M W 1997).

Wide cross programmes are generally not designed for developing the varieties but are structured for incorporating novel gene sources, thereby enhancing their potential of already available genetic variability (FAO 1996). With a high selection pressure for few agronomic traits only, the diversity in the germplasm available particularly genetic stocks is shrinking slowly.

Table 2: Promising synthetics entries selected for tillers/m, spike length and high thousand-grain weight.

Syn #	Tillers /m	Syn #	Spike length (cm)	Syn #	1000-grain wt. (g)
Syn. 27	170	Syn. 98	15.7	Syn. 72	50.0
Syn. 93	186	Syn. 40	15.0	Syn. 31	48.1
Syn. 3	200	Syn. 97	15.1	Syn. 51	49.1
Syn. 55	200	Syn. 8	15.5	Syn. 36	48.0
Syn. 66	210	Syn. 64	15.8	Syn. 44	50.0
Syn. 57	214	Syn. 45	15.1	Syn. 38	48.7
Syn. 88	222	Syn. 66	15.8	Syn. 50	50.4
HI 8498 ©	72	-	9.8	-	50
PBW 343 ©	87	-	12.0	-	38

In certain situations, existing variability for breeding purposes is negligible and efforts need be made to use more and more diverse sources for widening the genetic base. Plant breeders are finding less and less appropriate germplasm with desired traits among cultivated crops themselves with which to make needed improvements. Fortunately, useful genetic resources (important traits) are found in uncultivated wild species. Now it is a challenge to breeders to incorporate this new germplasm regularly into existing well adapted varieties. Several reports on such issues have been presented (Muzeeb Kazi 1996, Rajaram et al, 1983, Sharma and Gill 1983 and Villareal et al, 2001) for highlighting the importance of synthetics in future wheat improvement programmes globally. In conclusion, it can be stated that synthetic hexaploids with desirable traits that were identified through the present study have their utility for future wheat improvement programmes and are being used at DWR, Karnal. The pedigree details of the promising lines identified as genetic stocks for three major yield attributes are given in Table 3.

Table 3: Pedigree details of selected synthetics for yield traits.

Synthetic #	Pedigree
Synthetic 3	ALTAR 84/ Ae sq.
Synthetic 6	CROC 1/ Ae sq.
Synthetic 7	ALTAR 84/ Ae sq.
Synthetic 8	CPI/GEDIZ/3/GOOJO 69/../4/Ae sq.
Synthetic 27	GARZA/BOY// Ae sq.
Synthetic 31	68112/WARD// Ae sq.
Synthetic 36	DOY 1/ Ae sq.
Synthetic 38	FGO/USA 2111// Ae sq.
Synthetic 40	68-111/RGB-U//WARDRESEL/3/ STIL/4/ Ae sq.
Synthetic 44	68.111/RGB-U//WARD/3/FGO/4/ RABI / 5/ Ae sq.
Synthetic 45	68-111/RGB-U//WARD /3/FGO/4/ RABI /5/ Ae sq.
Synthetic 49	68-111/RGB-U//WARD /3/FGO/4/ RABI /5/ Ae sq.
Synthetic 50	CROC 1/ Ae sq.
Synthetic 51	PBW 114/ Ae sq.
Synthetic 55	GAN/ Ae sq.
Synthetic 57	LCK 59.61/ Ae sq.
Synthetic 64	BOTNO/ Ae sq.
Synthetic 66	BOTNO/ Ae sq.
Synthetic 72	GAN/ Ae sq.
Synthetic 88	CPI/GEDIZ/3/GOOJO..CRA/4/ Ae sq.
Synthetic 93	DEVERD 2/ Ae sq.
Synthetic 97	RASCON/ Ae sq.
Synthetic 98	DOY1/ Ae sq.
HI 8498	Check (Durum wheat)
PBW 343	Check (Bread wheat)

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