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# CIMMYT-selected derived synthetic bread wheats for rainfed environments: Yield evaluation in Mexico and Australia

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**Abstract**

Synthetic backcrossed-derived bread wheats (SBWs) from CIMMYT were grown in the Northwest of Mexico at Centro de Investigaciones Agrícolas del Noroeste (CIANO) and sites across Australia during three seasons. During three consecutive years Australia received ‘‘shipments’’ of different SBWs from CIMMYT for evaluation. A different set of lines was evaluated each season, as new materials became available from the CIMMYT crop enhancement program. These consisted of approximately 100 advanced lines (F7) per year. SBWs had been top and backcrossed to CIMMYT cultivars in the first two shipments and to Australian wheat cultivars in the third one. At CIANO, the SBWs were trialled under receding soil moisture conditions. We evaluated both the performance of each line across all environments and the genotype-by-environment interaction using an analysis that fits a multiplicative mixed model, adjusted for spatial field trends. Data were organised in three groups of multienvironment trials (MET) containing germplasm from shipment 1 (METShip1), 2 (METShip2), and 3 (METShip3), respectively. Large components of variance for the genotype $\times$ environment interaction were found for each MET analysis, due to the diversity of environments included and the limited replication over years (only in METShip2, lines were tested over 2 years). The average percentage of genetic variance explained by the factor analytic models with two factors was 50.3% for METShip1, 46.7% for METShip2, and 48.7% for METShip3. Yield comparison focused only on lines that were present in all locations within a METShip, or ‘‘core’’ SBWs. A number of core SBWs, crossed to both Australian and CIMMYT backgrounds, outperformed the local benchmark checks at sites from the northern end of the Australian wheat belt, with reduced success at more southern locations. In general, lines that succeeded in the north were different from those in the south. The moderate positive genetic correlation between CIANO and locations in the northern wheat growing region likely reflects similarities in average temperature during flowering, high evaporative demand, and a short flowering interval. We are currently studying attributes of this germplasm that may contribute to adaptation, with the aim of improving the selection process in both Mexico and Australia.


*Keywords:* Synthetic wheat; Drought; Breeding

## 1. Introduction

Wheat is Australia’s largest crop and most valuable agricultural commodity (Australian Bureau of Statistics, 2005). The crop is grown under rainfed conditions and water limitation frequently reduces grain yield. A lack of useful genetic diversity in traits conferring adaptation to moisture stress potentially limits genetic gain in dry environments. The production of synthetic bread wheats (SBWs), through interspecific hybridisation of the original donors of the wheat genome, is one of the strategies employed at CIMMYT (International Maize and Wheat Improvement Centre) to address this issue (Trethowan, 2004). Briefly, SBWs are obtained by crossing modern durum wheat (*Triticum turgidum* L.), donor of the AB genome, with the wild progenitor goat grass (*Aegilops tauschii* L.), donor of the D genome, and backcrossing this amphiploid to locally adapted wheat cultivars. This approach has been mainly aimed at broadening the restricted variation in the D genome present in modern wheats, since only a few accessions of *A. tauschii* (L.) were

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likely involved in the hybridisations that lead to the original bread wheats 8000–10,000 years ago (Appels and Lagudah, 1990). In addition, this methodology capitalises on the fact that *A. tauschii* L. has evolved and continued to thrive in marginal, water scarce environments ever since.

The CIMMYT wheat breeding program in Mexico has contributed to yield gains in the Australian wheat industry since the 1960s, when the first semi-dwarf wheats were introduced (Brennan and Quade, 2004). Since 2001, SBWs have been systematically introduced into Australia from Mexico. The SBWs, either in CIMMYT or Australian backgrounds, are screened at an arid location in Northwestern Mexico, at the Centro de Investigaciones Agrícolas del Noroeste (CIANO) under terminal water stress (Trethowan, 2004). Those lines yielding 10% or more than the designated Mexican or Australian check varieties are sent for evaluation in the Australian wheat belt (Richard Trethowan, personal communication).

In Northwestern Mexico, under managed stresses generated using limited irrigation, synthetic wheats in Australian background can yield up to 50% more than the recurrent parent (Trethowan, 2004). However, in Australia wheat is grown under a wide range of agroecological conditions. The average annual rainfall in the wheat growing region ranges from 275 to 700 mm, with a winter dominant distribution in the west (Western Australia) and south (Victoria and South Australia) and primarily summer rainfall in the north (Queensland and Northern New South Wales) (Fischer, 1999). In the face of this environmental diversity, it is important to assess if imported germplasm performs consistently in Mexico and Australia or displays specific adaptation to particular regions. Cooper et al. (1993) previously showed that sites in Mexico ranked advanced breeding lines similarly to sites in Queensland, in the northern portion of the Australian wheat belt. The authors indicated that Australian breeders could rely on selection for yield in Mexico to import lines for local breeding programs. However, their study did not include sites in the southern and western regions of Australia. Recent evidence from the International Adaptation Trial, a spring wheat nursery distributed by CIMMYT worldwide, confirmed that CIMMYT germplasm is well suited for the Northern Australian wheat belt; however, its performance is relatively poorer in southern areas (Matthews et al., 2004). The two synthetic lines included in the International Adaptation Trial did not contain Australian parentage, and it remains unclear whether lines derived from crosses between Australian and CIMMYT wheats will improve yield performance in the southern and western regions of Australia. In addition, it is not clear if lines selected under drought stress in Mexico will express tolerance to drought stress under Australian conditions.

This study assesses the yield performance of SBWs in Mexico and Australia in relation to local benchmark cultivars and common checks. The association among test locations for environmental characteristics (e.g. temperature, radiation and water balance) was also analysed, to provide a basis for the interpretation of the relative performance of SBWs across sites. Strategies to optimise selection in CIMMYT for the diversity of Australian environments are discussed.

## 2. Materials and methods

### 2.1. Germplasm and trial description

During three consecutive years, Australia received ‘‘shipments’’ of different SBWs from CIMMYT for evaluation. They consisted of approximately 100 advanced lines (F7) per year. SBWs had been top and backcrossed to CIMMYT cultivars in the first two shipments and to Australian wheat cultivars in the third one. Bacanora, Kauz, Opata, Pastor and Weaver were among the CIMMYT cultivars chosen for top and backcrossing. Australian recurrent parents were representative of breeding progress in different regions of Australia, e.g. Kulin for the western region, Kennedy and Cunningham for the northern region, and Janz, Silverstar, RAC710 and RAC655 for the southern region.

CIMMYT's drought screening of the SBWs was carried out in an arid location in Northwestern Mexico at CIANO, Obregón (Table 1). The methodology has been described elsewhere (Trethowan, 2004; Trethowan et al., 2005). Briefly, primary synthetic wheats were backcrossed once (and in the case of the CIMMYT parents sometimes top-crossed) to the above-mentioned cultivars, and the progeny were selected under alternating cycles of drought stress and irrigation during segregation. Populations were advanced to F6 using the selected bulk strategy (Wang et al., 2003) and then head-rowed to F7. These advanced materials were first exposed to ample water supply, to ensure that they have a high yield potential. Selected lines with high yield potential were then grown in the drought nursery, on raised-beds that had been gravity irrigated 2 weeks before planting. The trials were grown on receding moisture and no further irrigation was applied.

Each shipment of SBWs was sown at CIANO and in different locations in Australia in field experiments, plot size varied from 4.8 $m^2$ at CIANO to 9.6 $m^2$ in Australia. Trials were fertilised and maintained free from weeds, insects and diseases. In Australia, fields with non-cereal predecessor crops were chosen to minimise the risk of incidence of root pathogens and soil chemical analyses were done to ensure the absence of constraints such as salinity, high boron concentrations, extreme pH, etc. in the trial sites (data not presented). Table 1 summarises the trial locations and average yields. Trials in Queensland (Qld) and Northern New South Wales (NSW) are generally dependent on summer rainfall; the average annual rainfall in the past 45 years was 599 mm at Roma (Qld), 687 mm at Biloela (Qld) and 654 mm at Narrabri (NSW). Locations in Western Australia, such as Merredin and Wongan Hills, have a distinctive Mediterranean climate, with historic average annual rainfall of 366 and 304 mm, respectively. In Horsham (Vic), winter rainfall is also predominant and the average annual rainfall is 448 mm.

The majority of the crops were grown under rainfed conditions. However, tactical irrigations were applied to trials at Biloela and Roma before or soon after planting, to ensure