PROCEEDINGS OF THE SEVENTH ASSEMBLY

WHEAT BREEDING SOCIETY OF AUSTRALIA

The University of Adelaide, Adelaide, 25-30 September 1994

Edited by: J Paull, I S Dundas, K J Shepherd and G J Hollamby

IBSN 0 86396 234 3

The relevance to Australia of CIMMYT international locations for testing bread wheat

IH DeLacy[a], M Cooper[a], DR Woodruff[b], PN Fox[c] & WGA Ratnasiri[a]
[a]Department of Agriculture, The University of Queensland, Qld 4072, Australia.
[b]Queensland Wheat Research Institute, PO Box 2282, Toowoomba, Qld 4350, Australia.
[c]CIMMYT, Apdo. Postal 6-641, 06600 México, D.F., México.

INTRODUCTION

Australian wheat breeders currently evaluate and use advanced breeding lines developed from the International Centre for Maize and Wheat Improvement (CIMMYT). These lines may be used as parents or in some cases released as cultivars. The value of this germplasm has differed between states, estimated as ranging from a 0.3% yield improvement in Western Australia to a 7.2% improvement in Queensland with a national average of 3.6% up to 1983 (Brennan 1986) when CIMMYT germpalsm had proved particularly successful in the north eastern wheat belt of Australia. However, the area sown to CIMMYT-derived materials in Western Australia grew from 9% in 1983 to 67% in 1990 (Romagosa and Fox, 1993). If current advanced breeding lines produced by CIMMYT provide potential for further genetic improvement of grain yield, Australian wheat breeders require an efficient process for identifying useful germplasm from CIMMYT. There are two complementary projects underway. The first is a retrospective analysis of genotypic adaptation in the International Spring Wheat Yield Nurseys (ISWYNs), and the second an analysis of indirect response to selection for yield in Australian environments from selection on yield in the International Bread Wheat Screening Nurserys (IBWSNs).

1. Retrospective analysis of yield adaptation in the ISWYN

The ISWYNs have been distributed annually by CIMMYT since 1964. Entries in the ISWYNs have represented the major types of spring bread wheat grown in many parts of the world and the results provide a base for investigating relationships among locations for testing. The mean yield of entries in the 184 locations (research stations) reporting data for three or more years in the first 26 ISWYNs were analysed (DeLacy et al. 1994). An environment standardised squared Euclidean distance (esSED) dissimilarity matrix was calculated among the 184 locations for each of the first 26 ISWYNs on the phenotypic standard deviations of entry means within each location. The matrices calculated for each ISWYN had an empty row or column for locations which were not used or did not report data for that nursery. The matrices were pooled over years, locations contributing empty cells were eliminated, and a long-term esSED matrix for the remaining 74 locations was defined. None of the few participating Australian locations survived this process. This matrix was used to conduct a pattern analysis; the 74 locations were classified using Ward's method and ordinated using principal co-ordinate analysis. Groupings of locations were compared with the composition of "mega-environments", groupings of locations defined by CIMMYT from climatic factors and perceptions of major biotic and abiotic stresses. The CIMMYT definition of mega-environments (MEs) for spring wheat consists of 6 major divisions. The first 5 MEs are low latitude, autumn sown zones whereas ME6 is high latitude, spring sown. ME1 environments have high input, irrigation and low rainfall, ME2 and ME6 have adequate rainfall, ME3 are the same as ME2 but with acid soils, ME4 has water stress and ME5 has heat stress. Each ME has a characteristic disease spectrum. The ME4 environments are separated into ME4A (those with winter dominant rainfall, Mediterranean regions, terminal water stress, relevant to the southern Australian wheat belt) and ME4B types (those with summer dominant rainfall, relevant to the northern Australian wheat belt). No ME3 environments survived the elimination process described above.

Two major spring wheat environments, typified as Asian and European, were found with the key environmental discriminators being latitude and the presence or absence of stress from disease. Group One comprises locations for which leaf and stem rust were the diseases which had received the most attention from breeders. This group, an "Asian" type, occupies a low latitude band from South-East Asia, through the Indian Subcontinent, West Africa and North Africa, northern Mexico and south-western USA. Group Two locations are generally not irrigated and have combinations of long growing cycles, high disease stress or mid to high latitudes. This group, a "European" type, occupies high latitudes, or high altitudes (such as southern Mexico). CIMMYTs two main spring bread wheat breeding stations are in Group One (Obregon) and Group Two (Toluca).

Mean yields of Group One exceeded Group Two for ISWYNs-1 to 14, neither showed consistent superiority from ISWYNs-15 to 19 and were lower in ISWYNs-20 to 26. Group Two yield superiority in later ISWYNs may be due to a higher yield potential for wheat in these environments which could not be realised until resistance to pathogens was addressed after major yield advance was achieved in ME1 environments.

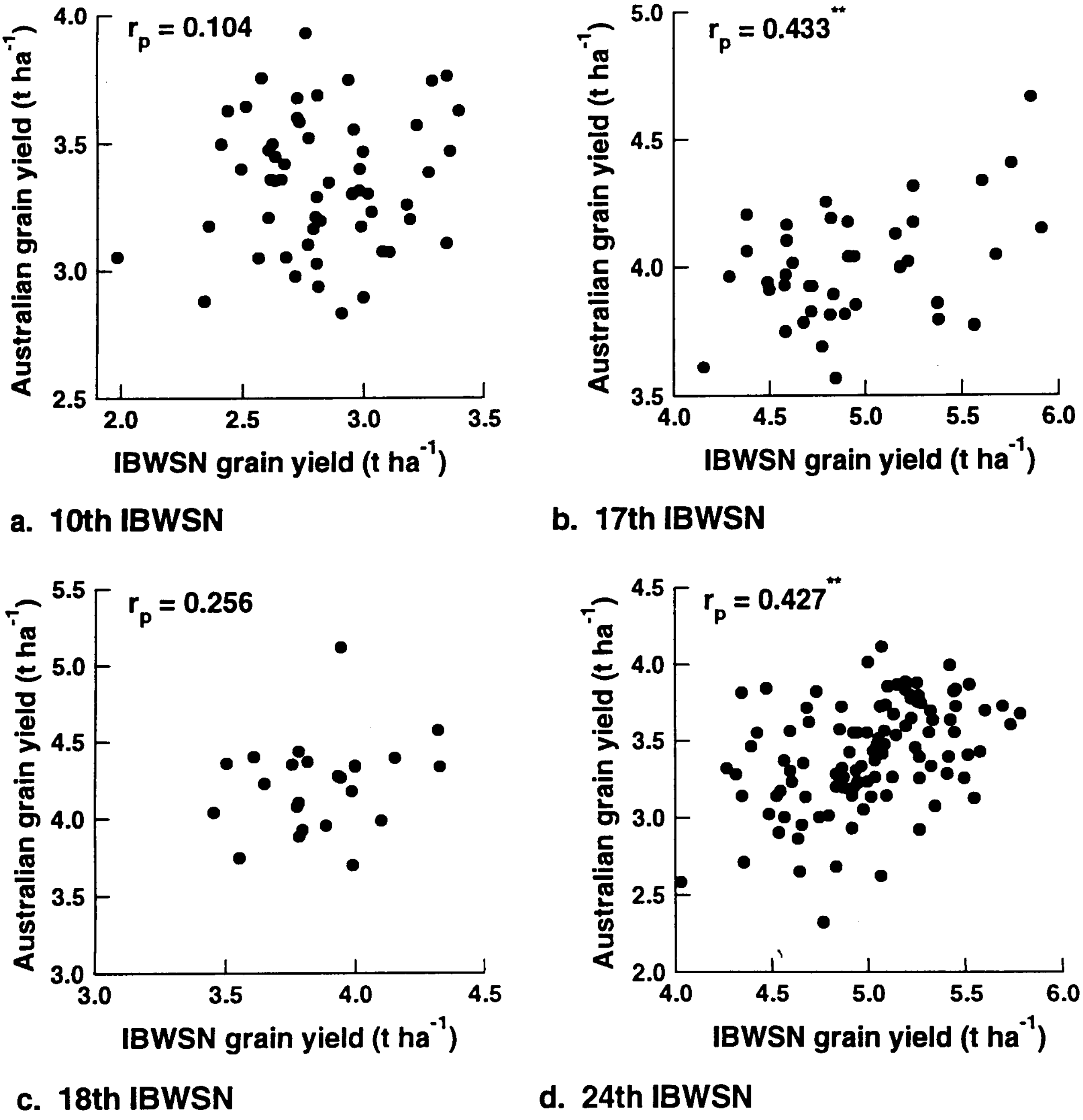
ME4 environments included in the analysis were not separated, but rather distributed across the whole range of environments. There was little evidence for repeatable interactions between entries and moisture availability, suggesting that advance for resistance to drought stress may be elusive and difficult to achieve through field screening alone.

The ME classification does not explain all significant associations among locations. There were discrepancies between mega-environments and location groups distinguished by pattern analysis, especially in West Asia. The analysis indicates that there are major stresses affecting wheat in these areas which are yet unidentified. Recommendations from the study include: (1) analysis of performance data be conducted on a regular basis to refine classification of target environments, (2) breeding for broad adaptation be continued and (3) initiate research to elucidate unknown stresses suggested by the analyses.

2. Indirect selection for Australia using IBWSN data

Cooper et al. (1993a, b) and Cooper and Woodruff (1993) have discussed the opportunity for exploiting indirect selection for Queensland environments based on data from the 17th IBWSN. Grain yield data on wheat lines included in the 10th, 17th, 18th and 24th IBWSNs were used from international and Australian environments. Line mean grain yield over the international environments was compared with that over the Australian environments to examine the association between broad yield adaptation observed in the international and Australian trials (Figure 1).

Figure 1 Association between line mean grain yield over International and Australian environments for the 10th, 17th, 18th and 24th IBWSNs.



For the 10th and 18th IBWSNs there was no association (P>0.05), however for both the 17th and 24th IBWSNs there was a positive (P<0.01) association. Therefore, in the case of the 17th and 24th IBWSNs, there was scope for achieving an indirect response to selection for broad yield adaptation to Australian environments based on selection for broad yield adaptation in the International trials but not for the 10th and 18th IBWSNs. While there was not a consistent positive association across all IBWSN series examined, no negative associations were observed. It is anticipated that in any IBWSN some of the international environments may be more relevant than others to the Australian environments. For example, an international environment affected by a pathogen not present in Australia is unlikely to provide a relevant selection environment for Australian conditions. Therefore, strategies for relating the international and Australian environments are being examined. One such strategy is the use of "probe genotypes" (Cooper et al. 1994) to provide a bioassay for the incidence of particular environmental factors. The objective is to identify more relevant subsets of the international environments for Australian conditions. It can be concluded that there is scope for selection for broad yield adaptation for Australian conditions using the results of international trials co-ordinated by CIMMYT. The extent to which the indirect response to selection can be increased by excluding international environments considered to have no relevance for Australian conditions is being examined.

ACKNOWLEDGMENTS

This work was conducted with support from the Grains Research and Development Corporation of Australia.

REFERENCES

Brennan JP 1986 Impact of wheat varieties from CIMMYT on Australian wheat production. Agricultural Economics Bulletin 5, Division of Marketing and Economic Services, Department of Agriculture, New South Wales.

Cooper M, Byth DE, DeLacy, IH & Woodruff, DR 1993a Predicting grain yield in Australian environments using data from CIMMYT international wheat performance trials. 1. Potential for exploiting correlated response to selection. Field Crops Research 32: 305-322.

Cooper M, DeLacy IH, Byth DE & Woodruff DR 1993b Predicting grain yield in Australian environments using data from CIMMYT international wheat performance trials. 2. The application of classification to identify environmental relationships which exploit correlated response to selection. Field Crops Research 32: 323-342.

Cooper M, Fox PN & Woodruff DR 1994 Environmental characterisation based on probe and refernce genotypes (This Volume).

Cooper M & Woodruff DR 1993 Predicting grain yield in Australian environments using data from CIMMYT international wheat performance trials. 3. Testing predicted correlated response to selection. Field Crops Research 35: 191-204.

DeLacy IH, Fox PN, Corbett JD, Crossa J, Rajaram S, Fischer RA & van Ginkel M 1994 Long-term association of locations for testing spring bread wheat. Euphytica, 72: 95-106.

Romagosa I & Fox PN 1993 Genotype x environment interaction and adaptation. In Hayward MD, Bosemark NO & Romagosa I, eds, pp. 373-388. Plant Breeding. Chapman & Hall, London.