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An analysis of wheat yield and adaptation in India

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ABSTRACT

Multi-environment wheat trials provide valuable information on the extent of genotype x environment interaction, the stability of genotypes and define and confirm agro-ecological regions through associations among sites. The All India Coordinated Crop Improvement Project on wheat evaluates candidates for release across the wheat growing regions of India. To facilitate this process the wheat area is divided into six agro-ecological zones; the northwestern plains zone (NWPZ), the northeastern plains zone (NEPZ), the central zone (CZ), the peninsular zone (PZ), the northern hills zone (NHZ) and the southern hills zone (SHZ). Factor analytic (FA) models were used to analyze the genotype x environment interaction for yield of 813 wheat genotypes evaluated at 136 locations across the six agro-ecological zones in 1307 individual advanced variety trials between 2008/09 and 2012/13.

Genotype x environment interaction was firstly assessed separately within each of the six established agro-ecological zones. Key locations with a high genetic correlation with all other locations within each zone were identified. Predicted genetic values of important cultivars that were represented in a wider range of environments within each zone were estimated and highly stable genotypes were found.

Genotype x environment interaction was subsequently assessed across agro-ecological zones. Only those environments where the models accounted for > 99% of the genetic variance were retained for further analysis and two smaller zones (NHZ and SHZ) with little or no genotype congruence with other agro-ecological zones were removed. Thus 476 genotypes from 488 environments were included in the analysis. Fifteen clusters of environments with similar patterns of adaptation were found. These clusters were then characterized based on zonal classification, sowing time, irrigation regime, latitude and year and three regions broadly representing the main wheat growing areas of India were identified. These regions represent a combination of the NWPZ and NEPZ defined by latitude, a central region that combines CZ locations with northern PZ locations and a southern region comprised of southern PZ sites. Further stratification of these zones was then possible based on sowing time and irrigation practice.

One cluster of 29 environments had a high average genetic correlation (r = 0.75) with most other environments and production zones. These represent key locations where larger numbers of entries might be grown in future seasons as they are the best predictors of yield across cropping zones.

1. Introduction

Yield evaluation of new candidate crop genotypes in multi-environment trials is a key component of most varietal release systems globally. These multi-environment experiments also provide estimates of genotype x environment interaction, genotype stability and the genetic relationships among varieties and environments (Cooper and DeLacy, 1994). However, large multi-environment data are rarely

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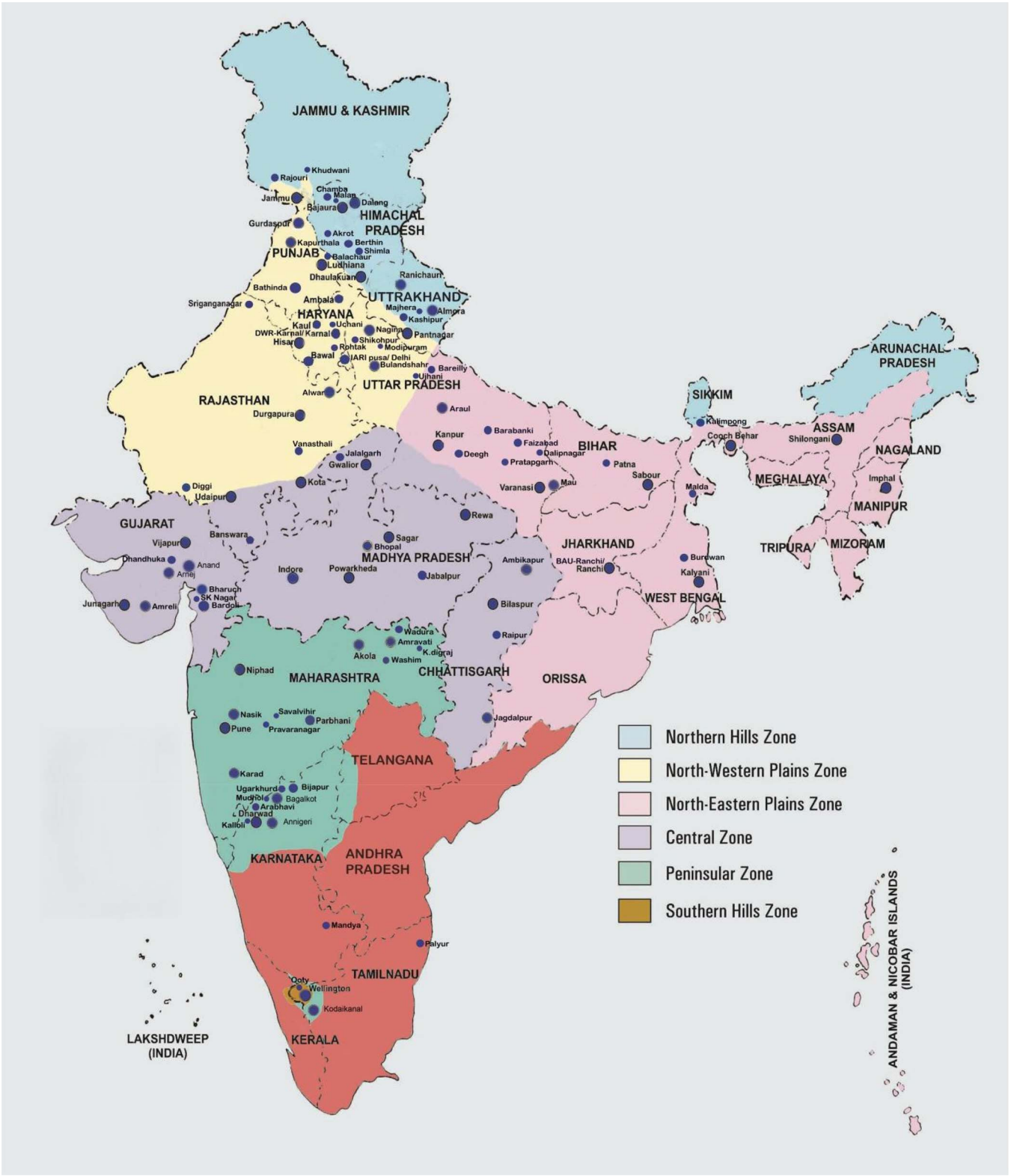

Fig. 1. Indian cropping zones and the location (blue dots) of AVT trials, 2008–2013. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

balanced. Factor analytic (FA) models have been used to estimate genotype x environment interaction in large unbalanced multi-environment data (Smith et al., 2015). The most general model for estimating the between environment genetic variance matrix is an unstructured form that estimates a genetic variance for each environment and covariance between each pair of environments. However, as the