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Genetic gains with genomic versus phenotypic selection for drought and waterlogging tolerance in tropical maize (*Zea mays* L.)

Reshmi Rani Das [a], Madhumal Thayil Vinayan [a], Kaliyamoorthy Seetharam [a], Manish Patel [b], Ramesh Kumar Phagna [c], Shyam Bir Singh [c], Jai Prakash Shahi [d], Akashi Sarma [e], Nagendra Sarma Barua [e], Raman Babu [a], Pervez Haider Zaidi [a,*]

[a] International Maize and Wheat Improvement Center (CIMMYT), ICRISAT Campus, Patancheru 502324, Hyderabad, India
[b] Main Maize Research Station, Anand Agriculture University, Anand 388001, Gujarat, India
[c] ICAR-Indian Institute of Maize Research, Ludhiana141001, Bihar, India
[d] Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005, Uttar Pradesh, India
[e] Assam Agricultural University, Jorhat 785013, Assam, India

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ABSTRACT

Erratic rainfall often results in intermittent drought and/or waterlogging and limits maize (*Zea mays* L.) productivity in many parts of the Asian tropics. Developing climate-resilient maize germplasm possessing tolerance to these key abiotic stresses without a yield penalty under optimal growing conditions is a challenge for breeders working in stress-vulnerable agro-ecologies in the region. Breeding stress-resilient maize for rainfed stress-prone ecologies is identified as one of the priority areas for CIMMYT-Asia maize program. We applied rapid cycle genomic selection (RCGS) on two multiparent yellow synthetic populations (MYS-1 and MYS-2) to improve grain yield simultaneously under drought and waterlogging conditions using genomic-estimated breeding values (GEBVs). Also, the populations were simultaneously advanced using recurrent phenotypic selection (PS) by exposing them to managed drought and waterlogging and intermating tolerant plants from the two selection environments. Selection cycles *per se* (C_1, C_2, and C_3) of the two populations developed using RCGS and PS approach and their test-cross progenies were evaluated separately in multilocation trials under managed drought, waterlogging, and optimal moisture conditions. Significant genetic gains were observed with both GS and PS, except with PS in MYS-2 under drought and with GS in MYS-1 under waterlogging. Realized genetic gains from GS were relatively higher under drought conditions (110 and 135 kg ha^{-1} year^{-1}) compared to waterlogging (38 and 113 kg ha^{-1} year^{-1}) in both MYS-1 and MYS-2, respectively. However, under waterlogging stress PS showed *at par* or better than GS as gain per year with PS was 80 and 90 kg ha^{-1}, whereas with GS it was 90 and 43 kg ha^{-1} for MYS-1 and MYS-2, respectively. Our findings suggested that careful constitution of a multiparent population by involving trait donors for targeted stresses, along with elite high-yielding parents from diverse genetic background, and its improvement using RCGS is an effective breeding approach to build multiple stress tolerance without compromising yield when tested under optimal conditions

1. Introduction

Maize is largely grown as a rainfed crop in the Asian tropics and is prone to the vagaries of monsoon rains. As such, maize production is affected by an array of abiotic and biotic constraints. Climate variability, together with erratic/uneven distribution of monsoon rainfall, has been identified as one of the key factors responsible for year-to-year fluctuations in maize production in the tropics [1,2]. Developing and delivering improved maize cultivars that can withstand drought and waterlogging stress without yield penalties under optimal moisture conditions is critical for attaining resilience in maize-based system [3].

While there is a vast amount of research focusing on breeding for tolerance to individual stress, maize crops are occasionally subjected to a combination of stresses. Breeding programs often run

* Corresponding author.
E-mail address: phzaidi@cgiar.org (P.H. Zaidi).

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