ABSTRACT

Wheat (*Triticum* L.) is an extraordinary annual crop that plays a crucial role in feeding the ever-increasing world population. This versatile crop serves as a crucial source of carbohydrates, proteins, edible dry matter and daily caloric intake, especially in many developing countries. Despite its critical importance, the production of wheat encounters numerous challenges stemming from biological, environmental and socio-economic factors. Notably, among the biological factors, stem rust disease, which is attributed to *Puccinia graminis* f. sp. *tritici,* has rendered nearly 90% of the world's improved wheat varieties susceptible to its destructive impact. Utilizing disease-resistant varieties as a strategy for disease management is a notably practical approach that garners easy adoption and holds greater environmental compatibility and therefore, the objectives of this study were to: (i) identify new sources of resistance to stem rust, (ii) investigate the effect of GEI on yield and rust resistance stability of selected wheat genotypes, and (iii) determine the mode of inheritance of resistance to stem rust, yield and yield related traits. The study commenced with the evaluation of 120 bread wheat genotypes for seedling resistance to stem rust under a controlled screenhouse condition using a complete randomized design (CRD) with three replications. Subsequently, 60 genotypes lacking major gene (race-specific) resistance were selected and subjected to further evaluation for their adult plant resistance and agronomic traits performances across Adet, Kulmsa and Debrezeit environments using an alpha lattice design (5 x 12) with three replications. Genotypes exhibited variation in response to stem rust disease indicating the presence of high genetic diversity, which offers a valuable resource that can be used in breeding programs to produce varieties resistant to stem rust. Genotypes G12, G60, G31 and G52 exhibited the highest levels of resistance, suggesting that they could serve as donor parents/ sources of resistance to stem rust in the wheat improvement programs. To investigate the effect of genotype-environment interaction (GEI) on the stability of yield and rust resistance, twenty-one wheat genotypes with robust adult plant resistance and favorable grain yield performance were selected from a screening experiment and evaluated across Adet, Debrezeit, Kulmsa, Lay-Gaint, Welela-Bahir and Simada areas using randomized block design with three replications. The results revealed that genotypes G12 and G60 were the most stable genotypes displaying consistent rust resistance reactions across the three testing environments, while G52 and G31 exhibited specifically good resistance performance in Kulmsa and Debrezeit testing environments. Furthermore, the GGE biplot analysis categorized the testing environments into two distinct mega environments: Mega Environment 1 encompassed Adet, Lay-Gaint, Welela-Bahir and Sali, while Debrezeit and Kulmsa were grouped into Mega Environment 2. In terms of grain yield, G58, G12 and G60 showed stable performance across diverse conditions, whereas G52 was identified as the least stable genotype. In the determination of the mode of inheritance of resistance to stem rust, yield and yield-related traits, nine genetically diverse genotypes comprising three resistant, three moderately resistant and three susceptible but high-yielding wheat genotypes were crossed in a half diallel mating design (Griffing's method 2, Model 1). Subsequently, 36 F_2 progenies and their parents were evaluated against stem rust using an alpha lattice design with three replications at the Debrezeit and Kulmsa environments. The results revealed that general combining ability (GCA) and specific combining ability (SCA) effects were significant for area under disease progress curve (AUDPC), coefficient of infection (CI), final rust severity (FRS), grain yield (GY), hectoliter weight (HLW), thousands kernel weight (TKW), spike length (SL), plant height (PH), days to maturity (DM), days to heading (DH) and number of spikelets per spike (NSPS), signifying the crucial role of both additive and non-additive gene actions for governing the inheritance of these traits. However, the high values of Baker's ratio (BR) (> 0.5) for FRS, AUDPC, CI, DH, DM, SL, PH, TKW and GY indicated the predominant role of additive gene action in the control of these traits. Parents G12, G31 and G60 exhibited significant negative GCA effects for FRS, AUDPC and CI, suggesting that these genotypes were suitable for wheat breeding programs to develop varieties resistant to stem rust disease. Likewise, crosses G12×G58, G31×G58 and G60×G11 exhibited negative significant SCA effects for FRS, AUDPC and CI, indicating that these crosses could be used as optimal starting materials for the stem rust resistance breeding program. For yield and yield-related traits, G8 and G58 showed significant positive GCA effects for GY, TKW, HLW, NSPS and SL, suggesting them as the best parental genotypes for improving grain yield. Similarly, crosses G8×G31, G52×G60 and G46×G60 showed significant positive SCA effects for TKW and GY, implying their usefulness as starting material for improving the GY and TKW of wheat genotypes.