Genetic Variability, Heritability and Genetic Advance in Garlic (Allium Sativum L.) Genotypes in Ethiopia

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Garlic is the second most important bulbous allium species in the world after onion. It is also a popular vegetable in

percent of the mean. A high genetic advance in fresh bulb yield per hectare, clove number per bulb, and bulb diameter

future advantages aimed at improving garlic breeding.

Bulb; Clove; Trait; Variation; Weight

I d c

A er onion, garlic is the most ancient vegetable to be produced, and it is the second-largest allium species worldwide. Besides onion, garlic is highly valued for its production, commercial use, medical properties, and culinary seasoning. It is also essential for cash as an income source, local medicine for health treatment, and spices as a avoring agent in Ethiopia. Identifying crucial garlic genotypes in simple clonal selection and germplasm collection is important based on morphological diversity. Genotypic and phenotypic coe cients of variation, heritability, and genetic advance are essential way of tools for measuring the degree of variability in crop breeding programs. e selection of suitable genotypes in garlic depends on the genetic variability, heritability, and genetic advance among various traits [1].

Garlic production and productivity were declining year to year in many parts of Ethiopian garlic-growing regions due to variable weather conditions, including rainfall, wind, temperature, humidity, and edaphic factors, contribute to fungal diseases and soil-borne pathogens, including white root rot, leaf rust, aphids and lady bugs. Ethiopia's garlic production and productivity in 2020 and 2021 were 18,344.46 and 15,979.54 hectares respectively, with 1,525,946.34 and 1,149,446.97 quintals harvested. In Ethiopia, garlic breeding improvement is weak due to the nature of the crop propagation method. Garlic can only be propagated via clonal methods since it is di cult to create new genetic variations.

Ethiopia's garlic breeding program aims to release high-yielding varieties through clonal selection by utilizing collected garlic germplasm based on yield-wise characterizations to address production issues. e Ethiopian Institute of Agricultural Research introduced new cultivars like Holeta, Chefe, Chelenko, Kuri u, Qericho, Bisho u Netch, and Tseday for Ethiopian growing environments, but their performance is lower than local planting material from this trial study areas of Libokemikem and Fogera districts. Further information is mandatory for garlic yield enhancement on genetic variability among garlic genotypes for variety development. erefore, the study emphasizes the importance of estimating the entire genetic variability in garlic germplasm to enhance its production and productivity [2].

Ma e a a d Me d

O e e f e e ea c a ea

e study was carried out in the main rainy season on 2020/2021 on aTin rmatiChe nti maHimpAgriculens.
Fogera district of Woreta. e Station is Located at 11° 58′ N latitude and 37° 41′ E. It receives 1230 mm of rainfall annually and is located 1819 meters above sea level. e typical area temperatures are 12°C at the lowest and 28°C at the highest points. With a pH of 5.48, the soil is red clay [3].

P a a e a a d e e e a de a c a a e e

Forty-nine (49) genotypes of garlic were collected from garlic growing areas of Ethiopia. e study was set up using two replications of a 7x7 simple lattice design. Before planting, the trial area was completely tilled and leveled. Ridges of 20 cm width and 15 cm height with a 40 cm furrow width were prepared. e spacing between double rows, rows, and plants was 60 cm, 20 cm, and 10 cm respectively.

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Healthy medium sized cloves were planted with the tip in an upright position and the basal part of the clove down to the soil surface. Cloves were planted on both sides of the ridge with 10 cm between plants (Table 1).

e plot size was 1.8 m2 (1.8 m x 1 m), and a plot had 60 plants on the three ridges (6 rows). NPS fertilizer as a source of nutrients (N = 38, P = 19, S = 7) was applied at a rate of 242 kg ha^{-1} during planting time, and Urea at a rate of 100 kg ha^{-1} was applied in two splits, the rst half at complete emergence (10-15 days a er planting) and the second at one and a half months a er planting (45 days). All other recommended agronomic activities such as weeding, hoeing were handled uniformly at all experimental units based on the national recommendation [4].

Da a c ec ed

Data on growth morphology, phenological stages, yield, and yield-related parameters were collected during the cropping and post-harvest periods. Observations on bulb yield and yield-related traits were recorded on both at plot and plant basis, viz., plant height (cm), number of leaves per plant, pseudo stem length (cm), leaf width (mm), leaf length (cm), bulb diameter (mm), bulb weight (g), number of cloves per bulb, clove length (mm), clove diameter (mm), neck diameter of

= 2 (6)

Where GA = Genetic advance; SDp = Phenotypic standard deviation on mean basis; H2= Heritability in the broad sense and K = the standardized selection di erential at 5% selection intensity (K = 2.063).

Ge e c ad a ce a e ce ea (GAM)

Genetic advance as percent of the mean was calculated to compare the extent of the predicted advance of di erent traits to select genotypes based on the breeding objective. Genetic advance as percent of mean is categorized as low (0-10%), moderate (10-20%) and high (20% and above) [8].

$$GAM = \frac{GA}{X} x\ 100\ \% \quad (7)$$

Where GAM = Genetic advance as percent of mean; GA = Genetic advance and X = Mean value of the trait.

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Ga c e ., e a ab

e analysis of variance (ANOVA) indicated highly signi cance (P < 0.01) di erence among the traits of plant height, days to maturity, leaf number, leaf length, pseudo stem height, plant neck diameter, bulb length, bulb diameter, clove length, clove diameter, clove number, total soluble solid, bulb weight, clove weight, and total bulb yield. A signi cant di erence at the p < 0.05 probability level was observed in leaf width (Table 2). ese ndings showed the presence of genetic variability among genotypes. A similar result was reported on leaf width. Similarly, highly signi cant (p <0.01) variability was reported on plant height, days to physiological maturity, leaf number, leaf length, pseudo stem height, neck diameter, bulb length, bulb diameter, clove length, clove diameter, clove number, bulb weight, clove weight, and total bulb yield. Similar results on plant height, leaf number, maturity date, pseudo stem height, neck diameter, bulb weight, clove number, total bulb yield per hectare, and total soluble solids were reported [9].

Mea e a ce e e

Genotypes showed a wide range of variability in all traits. e mean values indicated signi cant variation among traits. A range of variability was recorded in bulb diameter (24.3 to 42.78 mm), plant height (36.2 to 53.8 cm), bulb weight (6.48 to 22.64 g), and pseudo stem height (12.05 to 26 cm). On these traits, similar results have been reported by. ese high ranges of variation among di erent genotypes can have a high contribution to breeding values for further improvement of desired traits.

Minimum and maximum mean values were recorded for all studied traits and genotypes. For example, genotype G37-3 has the most leaves (11.3), $G50^{-1}$ has the smallest leaves (7.25), and genotypes 009/04 and G16-1 have the longest and shortest leaves, respectively [10,11]. e latest and earliest maturity dates were observed among genotypes. Genotype 009/04 had the highest bulb length (39.54 cm), while genotypes G-067/18 and G36-1 had the lowest. e largest bulb diameters were found in genotypes 009/04 and G36-1. e highest clove diameters were found in genotypes G-011/18 and G44-1. e G10-2 and G-028/18 genotypes had the highest and lowest total soluble solid values, respectively. G5-2 had the highest bulb weight and clove weight, while G5-2 and G36-1 had the highest and lowest bulb yields per hectare. Similar results were reported on the traits of highest leaf number for G49 was 10.63, the highest plant height for G29 was 74.6cm and leaf length for G49 was 43.57cm by from twenty ve genotypes in the spring season [12,13].

e range of genotypic coe cients of variation was 1.97% to 27.84%. Since the highest genetic coe cient of variation recorded in bulb yield (27.84%), clove weight (26.41%), clove number (24.71%), and bulb weight (21.12%) [17]. Moderate genetic variation was observed in pseudo stem height (14.42%) and plant neck diameter (13.71%). While low magnitudes were observed in clove diameter (9.75%), clove length (8.66%), bulb diameter (8.35%), leaf length (6.91%), leaf width (6.68%), plant height (5.61%), and maturity date (1.97%). Similar results were reported in high estimates of phenotypic and genotypic coe cients of variation for bulb yield per hectare. Similarly, high estimates of phenotypic and genotypic coe cients of variation for clove weight, total bulb yield, bulb weight, and clove number were observed [18,19].

He ab . a d e e c ad a ce

e range of most traits of heritability percentage in broad sense was 17.27% for leaf width and 81.42% for bulb yield, followed by clove number (78.71%), consistent results reported by. Moderate heritability was observed in plant neck diameter, leaf number, bulb length, clove length, total soluble solid, bulb weight, pseudo stem height, leaf length, clove weight, plant height, and maturity date, while Low heritability in the broad sense was estimated in leaf width (17.27%). High heritability for the above traits were least a ected by environmental variations and that selection based on phenotypic performance would be reliable [20,21].

e range of genetic advance as a percent of the mean was 2.35% (maturity date) to 51.74%, (bulb yield) followed by clove number per bulb (45.17%), clove weight (34.93%), bulb weight (26.06%), and plant neck diameter (21.35%) [22]. e magnitude of moderate genetic advancement in various traits such as pseudo stem height (19.72%), clove diameter (13.99%), and clove length (12.43%), bulb diameter (11.88%), leaf number (11.60%), total soluble solid (14.77%), leaf length (10.83%), and bulb length (10.13%). A low genetic advance was observed for leaf width (5.72%), plant height (7.52%), and physiological maturity date (2.35%). A similar nding was reported by on total bulb yield, clove weight, and clove number and bulb weight [23].

e mean of high heritability with high genetic advance is more reliable indicator than heritability alone for genotype selection. Bulb yield (81.42% in heritability and 51.74% in genetic advance), clove number (78.71% in heritability and 45.17% in genetic advance), and clove weight (43.62% in heritability and 35.93% in genetic advance) all showed high heritability and high genetic advance as percent of the mean, with similar ndings reported. us, High genetic advancement and high heritability make successful selection strategies, governed by additive gene action and further improved through mass selection [24,25].

C c .

For this study, signi cant variability was observed in the range and mean of traits across garlic genotypes. e result indicated a signi cant range among existing genotypes. High heritability and genetic advance were recorded for bulb yield, clove number, and clove weight. is result aids plant breeding researchers in understanding the genetic background of genotypes for further breeding improvement programs.

Ac ed e e

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24. *(Allium sativum L.)*

25. Collection *(Allium sativm L.)* germplasm for growth and bulb