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Research Article

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Variability Assessment of Hot Pepper (*Capsicum annum* L.) Genotypes in Ethiopian for Qualitative Traits

Flagote Alemu [1*]

[1] Ethiopian Institute of Agricultural Research (Pawe Agricultural Research Center), P.O.Box: 25, Pawe, Ethiopia

*Corresponding author: *flagotea4@gmail.com*

Abstract

The present study was conducted on hot pepper (*Capsicum annum* L.) genotypes collected from Ethiopia's Metekel, Awi, and W/gojame Zones. The objective of the study was to assess the degree of diversity and their qualitative traits among the hot peppers at Pawe Research Center during the rainy season of 2017. The results showed that the hot pepper genotypes collected from different Zones, of Ethiopia, had a wide variation in growth habits, stem, leaf, fruit, and flower in their qualitative traits, namely, shape, pubescence, and other quality factors like color which is a determinant factor in preference of the consume. Therefore, the result of this study is an indicator of the presence of a higher chance to develop hot pepper varieties highly preferred by domestic and foreign markets through selection/crossing of hot pepper genotype collected from W/gojame, zones; as an example, genotypeBR30 had brown color for mature fruit color which is preferable by consumers. However, the genotypes showed greater variability for plant habits that has their e ect mainly related to competition for growth factors and are used for different production practices where intermediate and erect types are suitable for open field production. Finally, it is better if molecular characterization is to be followed by the current morphological characterization and evaluation work.

Keywords: Diversity, Qualitative Traits, Hot pepper

Introduction

Capsicum species are grown in tropical and temperate regions across the continents. They are generally considered together in Africa as *C. annuum* L. (Grubben and Tahir, 2004). *C.* annuum hasgrown widely in tropical agro climate conditions of Ethiopia (Berhanu *et al.*, 2011). In the world, it is the most important crop used as spice and vegetables (Amare, 2013). In Ethiopia, it is a high-value crop due to its high pungency which serves in the preparation of local flour called “Berberie” and it is used as food for consumption and a source of cash earning for smallholder farmers/or producers in both green and dry form (Amare, 2013).

Ethiopia is one of a few countries that produce capsicum oleoresin (red pigment) for the export market and ground powder (Berbere). It is important to the processing industries (coloring agents) and in the local dishes (Karia and Berber) (Shimeles, 2018). Moreover, the powder from the dry fruits is used as a spice to yield the desired color, flavor, and pungency to everyday culinary preparations (Rehima, 2006).

The productivity of the crop is low due to many limiting factors such as shortage of adapted high-yielding varieties, using unknown seed sources and poor-quality seeds, poor irrigation system, lack of information on soil fertility, the prevalence of fungal and bacterial as well as viral diseases. However, Ethiopia has less benefited from research activities although some research centers are working on hot pepper variety development which mainly focused on the adaptation and release of locally adapted varieties. Hence, generating information on the degree and pattern of genetic diversity of the hot pepper genotypes was less evaluated scientifically either using molecular or morphological studies in Ethiopia. Diversity studies are an essential step and pre-requisite in plant breeding and could produce valuable knowledge for crop improvement programs (Pujar *et al.*, 2017). Genetic diversity studies are also useful for the conservation, evaluation, and utilization of genetic resources and for determining the uniqueness and distinctness of genotypes (Saleh *et al.*, 2016). The presence of genetic variability in crops is essential for its further improvement by providing options for the breeders to develop new varieties and hybrids (Shimeles, 2018). In Ethiopia, farmers usually save their seeds and transfer them from one generation to the next. However, proper seed production methods including isolation techniques are not in practice within and among farmers, giving chance to outcross and introgression forces to take place. In addition, seed exchange across the border with Eritrea, Kenya, and Sudan has been active for a long period and numerous exotic varieties have been introduced. This is the reason why local pepper is sold in the market in mixed pods containing a wide range of fruit size, color, pungency, etc., reflecting the rich genetic variation existing in the local genotypes.

Knowledge of Ethiopia's diversity of hot pepper landraces would be highly important. Morphological and molecular markers could be used in the characterization and diversity study of landraces to predict their potential as a source of novel genes for future breeding programs. In Ethiopia, systematic investigation of the geographic pattern of diversity in hot pepper genotypes and knowledge of their useful traits is important for conservation (protecting genetic erosion) and utilization of genetic resources for the future breeding program. However, limited information is documented regarding the genetic diversity of the existing gene pool and the association of physiological and quality parameters of hot pepper in the country that are easily available for use in selection programs for different purposes (Shimeles, 2016).

Therefore, it is imperative to study the variability among the collected accessions. Hence, the objective of the study was to assess the degree of diversity and qualitative traits among the hot pepper collection with the ultimate goal of providing input for hot pepper variety improvement.

Materials and Methods

Description of Study Area. The study was conducted at Pawe Agriculture Research Center (PARC), Ethiopia, in the 2017 main rainy season. Pawe is located at 11°38′ N latitude and 36°24′ E longitude by having a distance of around 575 KMfrom Addis Ababa in the North West direction at an altitude of 1120m.a.s.l. The area is characterized by a long season of rainfall in which the main rainy season falls primarily from early May to late October with a mean annual rainfall of 980-1587mm. The dominant soil type of the center is vertisol with moderately acidic (pH 6.5). The monthly mean minimum and maximum temperatures are 16°C and 32°C, respectively.

Experimental Materials and Design. A total of 28 genotypes were evaluated, of which all genotypes were collected from different areas of the Metekel, Awi, and W/gojame Zones, of Ethiopia. Genotypes were evaluated on the field in Randomized Complete Block Design (RCBD). Each plot had 2.8 m × 3 m (8.4 m^2) consisting of 40 plants per plot. The spacing between plant and row was 0.3,and 0.7 m, respectively. seedlings were raised on nursery beds and transplanted to the open fields when the seedling attained 15-20 cm height. Fertilizers were applied DAP at the rate of 200 kg ha^{-1} during planting and Urea at the rate of 100 kg ha^{-1} in splits, half during transplanting and the rest as side-dressing at 45 days after transplanting. Hand weeding and all other agronomic practices were applied uniformly to the entire plots as recommended by EIAR (2016) for hot pepper production during the growing season to raise a healthy seedling.

Data Collections. International Plant Genetic Resources Institute's IPGRI (1995) descriptor list and published documents for capsicum species were used to record data on qualitative traits. Qualitative traits were recorded on five randomly selected plants in the middle two rows of all plots.

Plant growth Habit and Stem Related Traits. Plant growth habit, branching habit, and stem pubescence were measured when 50% of the plants bear ripe fruits in the plot.

Leaf- and Flower-Related Traits. Leaf color, leaf shape, and leaf pubescence, and were recorded at the full foliage stage whereas flower position was recorded at anthesis, and calyx pigmentation and calyx margin were recorded during the full flowering stage.

Fruit-Related Trait. Fruit shape at pedicle attachment and blossom end fruit shape was recorded at the near maturity stage whereas fruit color at maturity was recorded on mature fruits in the first harvest.

Data Analysis.

Shannon Waver Diversity Index is a commonly used diversity index that takes into account both the abundance and evenness of species or a character present in the community(Shannon and Weaver, 1963). It is explained by the following formula:

$$H' = 1 - \sum_{i=1}^{n} Pi \log_e Pi$$

Where, H' = Shannon-Weaver Diversity Index; pi = the proportion of genotypes in theith class of an n–class character; n= the number of phenotypic classes of traits.

Results and Discussion

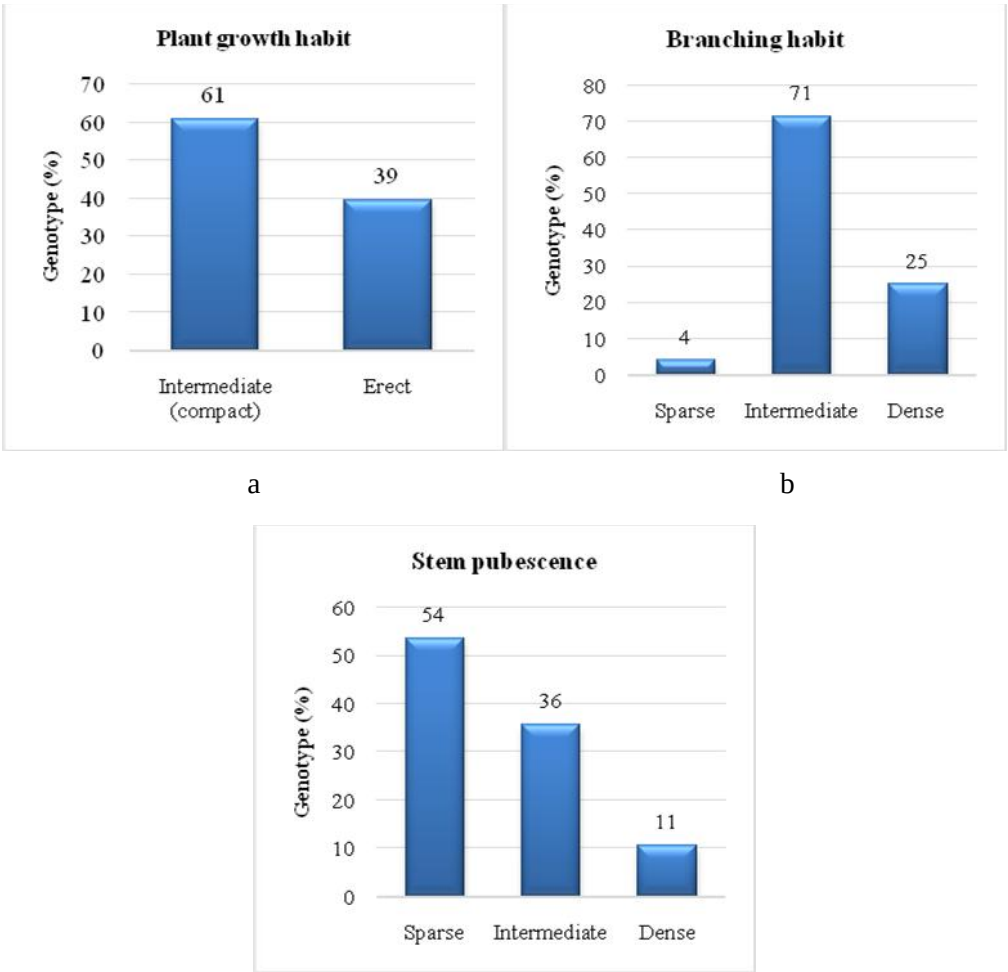
Qualitative Traits of Hot pepper Genotypes

Plant Growth Habit and Stem-Related Traits

A total of 17(61%), and 11 (39%) genotypes had plant growth habits of the intermediate (compact) and erect, respectively. All genotypes under study showed a large proportion of 20 (71%) hot pepper genotypes had intermediate while 7 (25%) and 1 (4%)genotypes had branching habits dense and sparse, respectively. The study also revealed three distinct stem pubescence 15 (54%) were sparse, 10 (36%) were intermediate, and 3 (11%) were dense (Figure 1). The hot pepper genotypes collected from di erent regions and countries may be distributed into varied categories of plant growth habit, plant branching habit, and stem pubescence and the proportion of genotypes in each category may vary due to either inherent characteristic di erences and environmental di erences where the genotypes are grown or selection of genotype di erences by a human being. Evolutionary forces like selection, mutation, migration, and genetic drift are the basis of crop genetic diversity (Bhandari *et al.* 2017).

Pepper genotypes with intermediate and erect growth habits, with compact and dense canopy shapes, are preferred for good yield under field conditions and are suitable for intercropping with maize or sorghum crops. Shimeles, 2018 reported

That 47% of them showed an erect growth habit, 36.7%, and 16% showed prostate and intermediate growth habits, respectively and the proportions of genotypes for dens, sparse, and compact branching habits were35.4%, 31.3%, and 33.3%, respectively. Gurung, *et al.* 2020 reported that the stem pubescence of20 accessions was sparse, and seven accessions had intermediate stem pubescence.



a b

c

Figure 1: The number of hot pepper genotypes as distributed into categories of plant growth habit (a) branching habits (b) and stem pubescence (c) evaluated at Pawe

Leaf and Flower-Related Traits.

The tested genotypes had great variations for leaf-related qualitative traits, namely, leaf color, leaf shape, and leaf pubescence (Figure 2). Out of 28 genotypes, 20 (77%), 6 (21%), and 2 (7%) genotypes showed dark green, green, and light green leaf colors, respectively. The leaf shape of 28 genotypes was observed as lanceolate 18 (64%) and ovate 10 (36%) among evaluated genotypes. The leaf pubescence traits observed among 28 genotypes were as follows: 24 (86%) had sparse leaf pubescence and 4 (8.33%) had intermediate leaf pubescence. Shimeles, 2018 reported that three distinct leaf colors are predominantly dark green (63.3%), light green (25%), and green (12%). Similar, results were reported by Gurung *et al.* 2020 stating that among 27 accessions, 19 accessions had green leaves, six had light green leaves, and two had dark green leaves. Leaf shapes were ovate (13 accessions), lanceolate (12accessions), or deltoid (two accessions).

All genotypes under study showed a large proportion of 23 (82) hot pepper genotypes had intermediate while 4 (14%) and 1 (4%) genotypes had flower position erect and pendent, respectively. The study also revealed two distinct calyx pigments25 (89%) were present, and 3 (11%) were absent. The study also revealed two distinct calyx margins21 (75%) were intermediate, and 7 (25%) were dentate (Figure 2). Brhan *et al.*, 2016 showed three different flower positions erect (34.7%), Intermediate (53.7%), and mixed (11.6%) also, showed with the predominant character (100%occurrence) was dentate calyx margin.

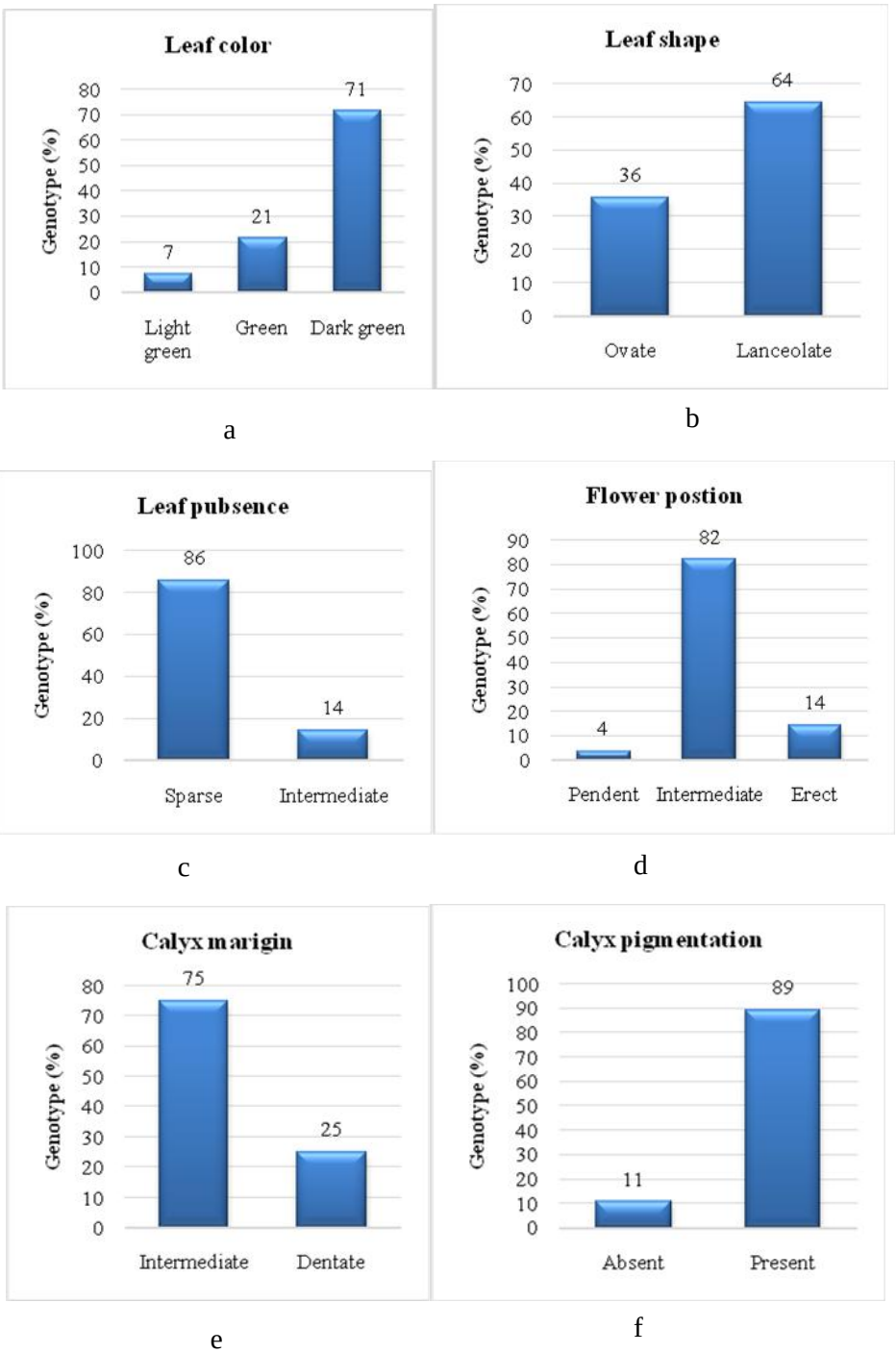
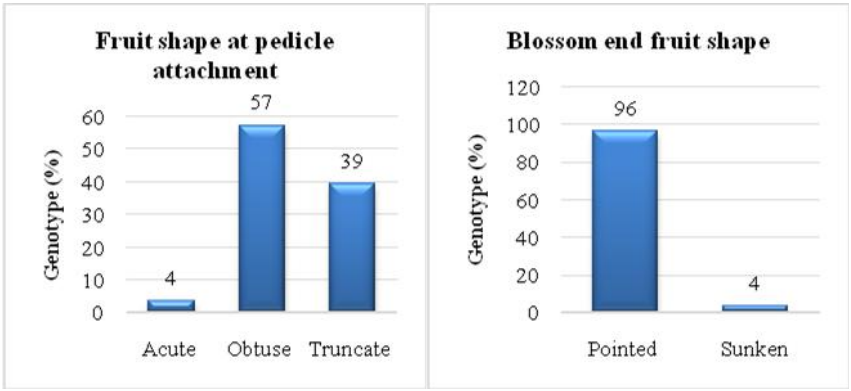


Figure 2: The number of hot pepper genotypes as distributed into categories of leaf color (a),leaf shape (b), leaf pubescence (c), flower position (d),calyx margin (e), and calyx pigmentation (f)evaluated at Pawe

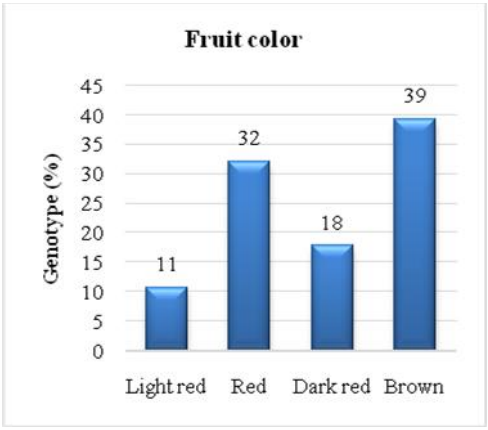
Fruit-Related Trait.

The current research reveals the presence of variation among tested genotypes for fruit shape at pedicle attachment, blossom end fruit shape, and fruit color at maturity (Figure 3). The fruit shape at the pedicle attachment of 16 (57%) genotypes was obtuse, 11(39%) had truncated and one (4%) had acute fruit shape at pedicle attachment. All genotypes had a pointed blossom end fruit shape except one genotype which had a sunken blossom end fruit shape. In addition to this, 11 (39%), 9 (32%), 5 (18%) and3 (11%) genotypes show brown, red, dark red, and light red fruit colors at maturity, respectively (Figure 4).This result shows the presence of variation among genotypes studied which may be due to the distribution of genotypes and an environmental di erence that indicates the possibility of improving fruit qualitative traits through the selection and/or crossing of genotypes from the regional state.

A wide range of variability in fruit shapes and colors in Capsicum species has also been reported by other researchers (Lannes *et al.*, 2007). Brhan *et al.*, 2016 showed a wide range of variability in fruit colorat the mature stage; light red (57.9%), dark red (23.2%), light brown (7.4%), and brown (9.5%).Also, Adetula and Olakojo 2006 reported that Characters such as fruit positions calyx margin shape, fruit shape at pedicel as well as fruit length, and fruit width were significantly different from one another.



a b



c

Figure 3: The number of hot pepper genotypes as distributed into categories of Fruit shape at pedicle attachment (a), Blossom end fruit shape (b), and Fruit color (c) evaluated at Pawe

A **B**

Figure 4: Dry red (A) and brown (B) pepper fruits after harvesting

Conclusion

The current study concluded that the hot pepper genotypes collectedfrom the regional state had a wide variation for leaf, fruit, flower,shape, growth habit,and other quality factors like color which is a determinant factor in the preference of the consumer. Therefore, the result of this study is an indicator ofthe presence of a higher chance to develop hot pepper varieties highlypreferred by domestic and foreign markets through selection/crossing of hot pepper genotype collected from W/gojame, zones; as an example, genotypeBR30 had brown color for mature fruit color which is preferable byconsumers. However, the genotypes showed greater variabilityfor plant habits that has their e ect mainly related tocompetition for growth factors and are used for different production practices whereintermediate and erect types are suitable for open field production.

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