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Review Article

Genetic Variability and Heritability in Ethiopian Mustard (*Brassica carinata* A.Braun)

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ABSTRACT

Ethiopian mustard (2n=34), is one of the six economically important species. It was natural cross between *Brassica nigra* and *Brassica oleracea* in north-eastern Africa, most likely on the Ethiopian plateau. Even though, the crop has high economic importance, production is limited by lack of high-yielding early maturing varieties, high erucic acid (C22:1) concentration in seed oil, and high glucosinolate content in the meal. In Ethiopia, mustard is grown largely in the 500-1200 mm annual rainfall zone of the Central and Southeastern Plateaus' mid- to high-altitude (1700-2800 m asl) locations. B. napus is the most ancient amphidiploid, followed by B. juncea and B. carinata. Ethiopian mustard is an erect annual, biennial, or perennial crop used for oilseeds or as a leafy vegetable in Ethiopia. *Brassicas* are economically important species by supplying vitamins, minerals, trace elements, dietary fiber, protein and oil for human use and raw materials for industry, as well as fodder and condiments. Interspecific hybridization has increased the gene pool of *Brassica* crops by transferring beneficial features from one species to another. A hexaploid hybrid (AABBCC) produced from an interspecific cross between B. carinata and B. rapa (AA, 2n=20) was shown to be suitable as a bridge hybrid. High heritability combined with high genetic progress is an important tool for selecting the finest people and successfully improving mustard genetics. High heritability combined with high genetic advance indicated additive while high heritability combined with low genetic advance indicated dominance and epistatic effects. In Ethiopian mustard, different variables like days to flowering, days to maturity, plant height, and 1000 seed weight have a high heritability.

Keywords: Ethiopian mustard; Heritability; Genetic advance; Variability

INTRODUCTION

Ethiopian mustard (*Brassica carinata*) is a significant oil crop of Ethiopian origin that has been used as an oilseed and vegetable crop in Ethiopia since antiquity. The crop thrives at higher altitudes (2000-2600 m) on more fertile, well-drained soil, which is often near to the homestead. *Brassica carinata*, also known as Ethiopian mustard, is one of the six economically important species. It arose as a natural cross between *Brassica nigra* and *Brassica oleracea* in north-eastern Africa, most likely on the Ethiopian plateau, where wild forms of *B. nigra* have co-existed with cultivated forms of *B. oleracea* since ancient times.

Ethiopian mustard, also known as "Gomenzer" in Amharic, is traditionally used to grease a bread baking clay pan used for baking traditional Ethiopian dish "enjera," as well as to treat certain maladies and stomach disturbances and prepare specific beverages. The biggest mustard growing areas in Ethiopia are Arsi, Bale, Gonder, Gojam, Wello, Shewa Sidamo, and Wellega, with 550,000-750,000 quintals produced in areas ranging from 30,000 to 45,000 hectares in the last five years (CSA 2011/12-2015/16). The leaves of Ethiopian mustard plants are high in vitamin C and K, beta carotene, and cancer-fighting anti-oxidants, as well as being low in bitterness. Vegetable relish can be found in the leaves of immature plants. Furthermore, it is utilized as a break crop for the production of cereals with comparable ecological amplitude in farming systems, particularly in large-scale farms [1-3].

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Ethiopian mustard ranks third in overall production and area among highland oilseeds in Ethiopia, after niger seed and linseed (CSA, 2013/2014). At the level of private peasant holdings, its area and production are projected to be 44041.34 hectares and 62450.266 tons, respectively, with an average productivity of 1.418 tons/ha (CSA, 2013/14). It thrives in soils that are well-drained and high in organic matter. Ethiopian mustard thrives in locations with cool, lengthy growing seasons and high rainfall, such as those between 2200 and 2800 meters above sea level. During the growth season, temperatures and rainfall in these places range from 12 to 18^{0}C and 500 to 1200 mm, respectively (i.e., June to December). It thrives in both heavy sandy loam and light clay soils with adequate drainage.

The Ethiopian mustard's main production limits, according to (EARO) are a lack of high-yielding early maturing varieties, high erucic acid (C22:1) concentration in seed oil, and high glucosinolate content in the meal. Improvements in seed oil and meal quality to fulfill Canola quality standards, as well as the production of high yielding early maturing varieties, are key concerns in Ethiopian mustard breeding.

Despite the lack of solid statistical data on mustard distribution and production in Ethiopia, the crop has been widely grown in various parts of the nation with low yields. This could be because mustard has been largely ignored by research and development programs, and its genetic resources are being depleted by physical and biophysical causes. As a result, the country has been experiencing significant genetic degradation in recent decades. Any breeding program's main raw materials are determined to be genetic diversity. For genetic improvement and crop conservation, determining the level of variation and identifying variants within the collected species is crucial [3-9].

The interplay of evolutionary forces (mutations, selections, migrations, and random genetic drift) with the impact of man through selection and domestication results in genetic diversity in crop plants. Genetic variation within a taxon is not equally distributed over the geographic area where it is expanding, and populations from far away are predicted to accrue more genetic diversity than those from close proximity. In plant breeding and population genetics, detecting and quantifying the degree of dissimilarity among species, subspecies, populations, and elite breeding materials is critical. As a result, the goal of this review is to evaluate genetic variability, heritability, and genetic progress in Ethiopian mustard (*Brassica carinata* A.Braun).

LITERATURE REVIEW

Morphology description of ethiopian mustard

Ethiopian mustard is an erect annual, biennial, or perennial crop used for oilseeds or as a leafy vegetable in Ethiopia. The crop seedling emerges *via* epigeal germination, in which the cotyledons sprout above ground, allowing them to be photosynthetically active and counteracting the detrimental effects of a lack of reserve food within the seed. *B. carinata* has a long, extended taproot with multiple laterals that can reach a length of one meter or more. The stem and leaves are both green and dark green, with numerous branches and a short petiole.

B. carinata's inflorescence is an elongated raceme that grows at the end of the main stem and branches. The flowers are usually bright yellow; however they can also be orange or creamish white. The fruit is a long, slender pod known as a silique (pl=siliqua), which is made up of two carpels separated by a false septum. The seeds are mostly embryonic and small, with brown and yellow as the predominant colors.

Economic importance of ethiopian mustard

Brassicas are economically important species that supply oil for human use and raw materials for industry, as well as fodder and condiments. They are grown as leaf and root vegetables and used as fodder and condiments. In the mid-altitude and highland parts of Ethiopia, Ethiopian mustard is important as a source of oil and as a green vegetable (1700 to 2800 meters a.s.l). The leaf is used as a vegetable, either by thinning or topping, and the seed for oil extraction, greasing traditional bread baking clay pans (Mitad), healing certain maladies, and preparing beverages at an early stage of development. The protein-rich meal that remains after oil extraction can be used as a high-protein feed supplement (provided the glucosinolate level is decreased) or as organic fertilizer. In industry, it is used in the tanning of leather, the production of varnishes, the production of diesel fuel, soap, and lighting.

Ethiopian mustard is a nutritious vegetable that may be added to any meal. It contains vitamins, minerals, trace elements, dietary fiber, and protein. It also adds zing and spice to meals.

Genetic variability in ethiopian mustard (*Brassica carinata* A. Brun)

As a result of the interaction of evolutionary forces (mutations, selection, and random genetic drift) and the influence of man through domestication and selection, genetic diversity emerges during the course of evolution. Individual variety is measured by genetic diversity, which indicates the frequency of distinct types in a community. It helps to analyze genetic variability of cultivars, select parental materials for hybridization for making new gene recombination, select inbred parents or testers for maximizing heterotic response and identify materials that should be maintained to preserve maximum genetic diversity in germplasm sources.

Populations from far away are predicted to accrue more genetic variety than populations in close proximity. The level of genetic variety between parents determines the genetic improvement achieved through hybridization and selection. One of the most important biometrical tools for determining genetic divergence in a population is the D2 statistic. The D2 is a measure of genetic divergence between genotypes, both within and between clusters. Crosses between genotypes belonging to clusters separated by the largest generalized distance and showing the greatest divergence are logical.

Interspecific hybridization has increased the gene pool of *Brassica* crops by transferring beneficial features from one species to another. A hexaploid hybrid (AABBCC) produced from an interspecific cross between *B. carinata* and *B. rapa* (AA, 2n=20) was shown to be suitable as a bridge hybrid. It was feasible to develop a pentaploid hybrid by crossing the hexaploid hybrid with *B. napus* (AABCC). The DNA from this pentaploid hybrid was subsequently used to construct a *B. napus* variation with half of the A genome of *B. rapa* and half of the C genome of *B. carinata*. Several interspecific crosses involving *B. carinata* have been carried out, with certain beneficial features from *B. carinata* being transferred to other *Brassica.*

Morphological and agronomic features differed across *B. carinata* accessions. Young stems and leaves had different colors, especially along the major leaf vein. Some plants were purple in hue, making them easy to distinguish from the green vegetation. The accessions' bolting and blooming periods ranged from 90 to 212 days. When the plants sprang in the early winter, some of the accessions were severely damaged by frost. Abebe found that genotypes of *B. carinata* obtained from different locations of Ethiopia have a wide range of morphological and agronomic features. Furthermore, Alemayehu investigated 36 genotypes of Ethiopian mustard for agronomically relevant features and discovered a large level of genetic variability.

Different phenotypic features of Ethiopian mustard were described, including leaf shape, leaf apex, leaf color, petiole length, chlorophyll content, primary branch, plant height, and leaf area. The most common leaf shape was elliptic, although there were also obovate orbicular, ovate, and a variety of shapes. Light green, green, purple green, and deep green were the colors of the Ethiopian mustard accessions. Acute, moderate, rounded, and a variety of leaf apex types were found.

According to the report, different traits in Ethiopian mustard, such as date of flowering, date of maturity, seed yield per plot, oil content, oil yield, number of seed per plant, thousand seed weight, number of primary branches, number of secondary branches, plant height, palmitic, stearic, oleic, linoleic, linolenic, and erucic acid, show a lot of variation. Nigussie and Adefris both found differences in fatty acid contents across Ethiopian mustard germplasm accessions.

Heritability in ethiopian mustard (*Brassica carinata* A. Brun)

A measure of genetic gain under selection is genetic advance, which expresses the direct link between heredity and response to selection. Understanding heritability and genetic progress (as a percentage of the mean) is necessary for effective selection. The most effective condition in breeding programs is thought to have high genetic progress combined with high heritability estimates for a certain trait.

High heritability combined with high genetic progress is an important tool for selecting the finest people and successfully improving mustard genetics. High heritability combined with high GAM for secondary branches per plant, number of pods per plant, harvest index, and oil output per plot, according to Tesfaye, showing the presence of additive gene effects for these traits. Plant height and secondary branches per plant only had high GAM values, whereas the number of seeds per pod, the number of pods per plant, and the length of pod all had low GAM values. Panse stated that high heritability combined with high genetic advance indicated additive gene effects, while high heritability combined with low genetic advance indicated dominance and epistatic effects; Variation in the species' locally adapted population is useful for identifying relevant features and developing agronomically viable variations.

Selection is more effective in improvement endeavors when heritability is combined with genetic progress. High genetic progress and heritability are crucial selection strategies. Heritability provides information on how qualities are passed down from parents to offspring, which aids in selection. Plant breeders can utilize heritability evaluation to forecast genetic development below assortment, allowing them to be optimistic about success from various types and intensities of selection.

Tesfaye calculates genetic progress for biomass yield per plot based on the number of primary branches and seeds per plot. The biggest genetic advance was found in plant height with high heritability, whereas grain filling period and days to maturity exhibited a similar pattern in heritability and genetic advance.

Days to flowering, plant height, 1000-seed weight, and days to maturity have strong heritability, according to Yared. In Ethiopian mustard, Delesa found that variables like days to flowering, days to maturity, plant height, and 1000 seed weight have a high heritability. Other *brassica* species have similar findings of strong heritability for days to flowering, plant height, and 1000-seed weight.

DISCUSSION AND CONCLUSION

There is enough evidence in Ethiopia for the existence of several genotypes of Ethiopian mustard to optimize the conservation and utilization of mustard genetic resources, which could have major impacts on the diverse needs of growers and consumers in light of future climatic, edaphic, and biotic challenges. Ethiopian mustard has a low grain yield despite its genetic diversity and favorable agro-ecological conditions for production. This is due to a lack of knowledge about the crop, which makes it difficult to improve its genetic make-up through different breeding techniques, as well as a lack of breeding facilities and the use of classical breeding/conventional breeding methods in Ethiopia, which limit Ethiopian mustard's production potential. The crop is used for both fresh consumption and oil production. Because Ethiopia has such a complex agro-ecology, intercrossing distant mustard varieties can lead to genetic advancement. As a result, selection can easily occur in a variety of genetic variations.

Rather than employing conventional/classical breeding, Ethiopian mustard should be supported by current agricultural research technology such as biotechnology, marker assisted selection of characteristics, molecular markers, genomic mapping, and alternative culture techniques. Farmers and breeders should be well-versed on the importance of crops. It is better if the crop is for oil to create cash income rather than for fresh cooking consumption to make the crop more essential.

CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

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