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Genetic Erosion of Common Bean (*Phaseolus vulgaris L.*, Fabaceae) Landraces in Southeastern Ethiopia

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Abstract: Losses of landrace diversity are believed to generate erosion and this has enormous influence on agricultural biodiversity. This study was undertaken to determine the genetic erosion of common bean landraces and ways of seed management in south eastern Ethiopia. Data collection was conducted using semi-structured interview guide and field observation. The mean genetic erosion in Loka Abaya was significantly different ($p<0.05$) from other districts showing the highest mean genetic erosion while it was the lowest in Silti District. The mean genetic erosion in districts ranged from 31.85-78.13% showing ongoing genetic erosion in common bean. Agricultural extension system was a major cause of landrace loss linking it with the escalating promotion of improved varieties. Landraces considered late-maturing types and having relatively low market demands and values are becoming increasingly vulnerable to replacement by early-maturing and those having high market demands and values. Farmers need to be encouraged and supported by stakeholders to consciously monitor the conservation of common bean landraces for all their worth which include use values, agroecological intensification income generation potential, role in breeding and other domestic purposes.

Key words: Common bean, conservation, genetic erosion, landrace, agricultural extension, encouraged

INTRODUCTION

From the beginning of agriculture, farmers have domesticated hundreds of plant species and due to migration, natural mutations and crosses and unconscious or conscious selection, genetic variability has increased within species gradually (Hammer *et al*., 1996). Diversity of crops and varieties are created and maintained through seed exchange among farmers and the scales and strengths of these pathways have enormous influence on agricultural biodiversity. Continuous expansion of genetic diversity within crops went on for several millennia, until scientific principles and techniques influenced the development of agriculture (Scarascia-Mugnozza and Perrino, 2002). With growing technology, population, production and consumption rates, the impact of humans upon biodiversity has gradually increased (Hammer *et al*., 1996). The quest for increasing food production and the resulting success achieved in several crops has begun to replace landraces by improved varieties (Scarascia-Mugnozza and Perrino, 2002).

The concept of genetic erosion emerged forcefully between 1965 and 1970 in a period when crop improvement had clearly demonstrated its power to transform local crop populations in industrialized countries and in certain less developed regions (Brush, 1995) and the term gene erosion was coined (Bennett, 1968). Brush (1995) defined genetic erosion in crops as the loss of variability from crop populations. Variability refers to heterogeneity of alleles and genotypes with their attendant morphotypes and phenotypes. Genetic erosion is the main threat to landraces. It is the loss of a crop, variety or allele diversity as well as the reduction in richness and evenness (Maxted and Guarino, 2006). Genetic erosion implies that the normal addition and disappearance of genetic variability in a population is altered, so that, the net change in diversity is negative.

A consequence of decrease in genetic diversity of landrace availability usually means that the genes will not be available for breeders to develop improved varieties and cultivars grown by farmers become genetically homogenous. Agro-ecosystem functioning and its provision of services (pest and disease control, pollination, soil processes, biomass cover, carbon sequestration and prevention of soil erosion) as well as potential innovation in sustainable agriculture are each likely to be seriously impacted (Hajjar *et al*., 2008).

Several approaches have been employed to estimate the degree of genetic erosion that a particular taxon faces in a certain region over a given time. Methods usually rely

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on either the analysis of molecular data (Proven *et al*., 1999) and allozyme analysis (Akimoto *et al*., 1999) or molecular markers (Barry *et al*., 2008; Van De Wuow *et al*., 2010) or DNA-marker techniques have also provided tools to directly measure genetic diversity and hence, test for genetic erosion at the allelic level (Almanza-Pinzon *et al*., 2003) or comparison between the number of species/landraces still in use by farmers at present time to those found in previous time (Hammer *et al*., 1996). The most widely used figures in estimating genetic erosion are indirect which is the diffusion of modern crop varieties released from crop breeding programs.

The Ethiopian federal ministry of agriculture has been encouraging farmers to grow high yielding improved commercial varieties of this and other important crops to fulfill food security demands (Katungi *et al*., 2010). Dependency on few commercial varieties is however, leading to loss of varietal diversity (Gouveia *et al*., 2011). The crop is also a victim of intermittent droughts of the past decades that eroded considerable amount of crop diversity in the country. Knowledge about the causes and the degree of genetic erosion of the local varieties and what remain to date is unavailable to a satisfactory level. Information on the list of currently cultivated landraces of *Phaseolus vulgaris* in Ethiopia is not certainly known (Asfaw *et al*., 2009). Loss of genetic variation may decrease the potential of species to persist in the face of abiotic and biotic environmental changes (Martinez-Castillo *et al*., 2011). Such loss of genetic variations may as well diminish the ability of the farming community to cope with short-term challenges caused due to damages by pathogens and herbivores. Detecting and assessing genetic erosion has been suggested as the first priority in any major effort to arrest loss of crop genetic diversity. Understanding the causes of genetic erosion is equally important for devising doable conservation measures. Quantification of genetic erosion is not given the high priority it deserves though it gives a good early warning signal for the degree of threat and measures to be considered in order to avoid possible extinction of landraces (FAO, 2010). Therefore, the main purpose of this study was to estimate and assess the genetic erosion of common bean landraces in selected zones of Southeastern Ethiopia.

MATERIALS AND METHODS

The study was conducted in major common bean growing zones of Oromia Region such as West Hararge, Arsi and Bale zones and zones of SNNP region such as Sidama, Wolayita and Siltie in Southeastern of Ethiopia Fig. 1.

Six administrative zones located in the two regional states encompassing 12 districts and 24 kebeles (sub-districts) were purposively selected as sampling sites and ethnobotanical data retrieved focusing on common bean landrace diversity and their utilization. Data were collected also on environmental factors including soil type, soil pH and elevation while secondary sources were consulted for rainfall and temperature. A total of 96 informants (4 per sub-district = 4×24 = 96) were selected

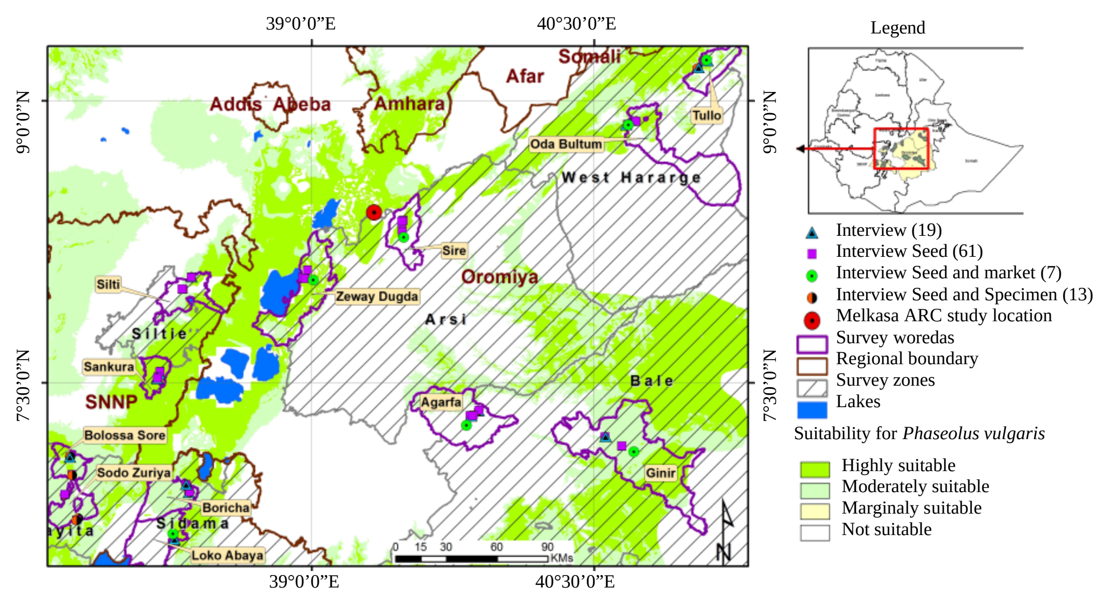

Fig. 1: Map of the study area with crop ecological suitability

randomly from the registry of farmers obtained from the agriculture offices of each sub-district. Secondary, archival material which included information on common bean production status of the districts and overall description of the study area were collected from the zonal administrative centers and offices at other levels. Seed exchange systems and lost landraces were collected from farmers using semi-structured interview as discussed and described in standard ethnobotanical manuals and handbooks including Martin (1995), Alexiades (1996) and Albuquerque *et al*., (2014).

The collected data were analyzed using descriptive statistics and one-way ANOVA was used to analysis the genetic erosion landraces. The present status of on-farm genetic diversity (or genetic erosion) of common bean landraces was assessed using the formula given in Hammer *et al*. (1996) where GE = 100%-GI and GE and GI are respectively genetic erosion and genetic integrity and $GI = N_2/N_1 \times 100\%$ and N_1 the number of all landraces that the farmers said they cultivated 20-30 years ago while the number of landraces presently observed under cultivation is N_2.

RESULTS AND DISCUSSION

Genetic erosion of common bean landraces: The mean genetic erosion in Loka Abaya was significantly different ($p<0.05$) from other districts showing the highest mean genetic erosion while it was the lowest in Silti, although, there was high agricultural extension activity in the latter case where motivation in favor of using new varieties instead of landraces was high (Table 1). Furthermore, there is shortage of land in silti district where traditional varieties are intercropped with maize (Zea mays) or chat (Catha edulis), thus, indirectly creating favorable conditions for conservation of landraces. Table 2 shows cause for genetic erosion of landraces where multiple factors act together and they are well recognized by the farmers.

Farmer's recall the years of landrace loss: The majority of the farmers (61%) reported having lost a good number of their common bean landraces over the last 10 years while few landraces were lost in the past 20-30 (12.2%) years Fig. 2. This is because particularly in the last 10 years, new varieties were released vigorously by the agricultural extension system and non-governmental organizations giving wide options for farmers to try and choose the ones with preferable qualities.

The loss of variation in crops at least partly due to modernization of agriculture has been described as genetic erosion. Genetic erosion of cultivated plant taxa is reflected in what is termed as a modernization

Table 1: Mean on-farm genetic erosion (MGE)+SE (standard error) of *Phaseolus vulgaris* landraces in the study districts

District	MGE+SE	Maximum	Minimum
Loka Abaya	78.13+7.6^{a}	100.00	40.00
Ginnir	63.75+11.3^{abc}	100.00	0.00
Tullo	50.00+10^{bcd}	100.00	0.00
Silti	31.85+12.7^{d}	100.00	0.00
Sire	71.30+6.6^{ab}	85.71	40.00
Zuway dugda	70.83+2.7^{ab}	80.00	60.00
Boloso sore	65.83+5.8^{abc}	80.00	33.30
Agarfa	55.51+7.6^{abcd}	80.00	20.00
Sankura	63.54+6.3^{abc}	75.00	25.00
Sodo zuriya	57.29+7.1^{abcd}	75.00	25.00
Odabultum	43.13+8.7^{cd}	75.00	0.00
Boricha	42.71+10.1^{cd}	75.00	0.00

^{abcd}Significant

Table 2: Causes of genetic erosion/landrace loss according to farmer's perceptions

Causes of genetic erosion	Percentage
Climate change, influence of agricultural extension system favouring use of improved varieties combined with lack of market	35.4
Shortage of land, climate change, influence of agricultural extension system favouring improved varieties with lack of market	15.6
Influence of agricultural extension system favouring improved varieties	13.5
Shortage of land, climate change, influence of agricultural extension system favouring improved varieties and lack of market	10.4
Giving priority for more profitable crops	8.3
Lack of market	4.2
Shortage of land	3.1
Climate change	3.1
Climate change and lack of market	3.1
Shortage of land, influence of agricultural extension system favouring improved varieties and lack of market	2.1
Climate change, influence of agricultural extension system favouring improved varieties and giving more priority to crops that fetch more on the market	1.0

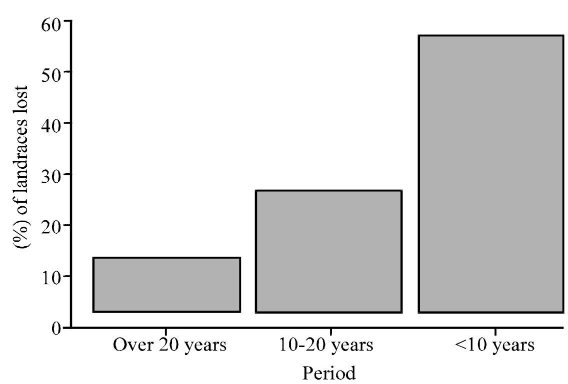

Fig. 2: Percentage of common bean landrace losses over the past 20 years

bottleneck in the diversity levels that occurred during the history of the crop. Replacement of landraces by modern cultivars and other more profitable crops and the trends in diversity reduction as a consequence of modern breeding practices has great impact on the diversity of landraces (Carovic-Stanko *et al.*, 2017). Climate change and environmental degradation can also result in changes in cropping patterns and loss of traditional varieties (Megersa, 2014).

Our findings also indicated that genetic erosion of common bean landraces is continuing in all districts of the study area. Study conducted on lima bean by Martinez-Castillo *et al.* (2012) in Mexico also indicated that there is genetic erosion in 2007 than 1979. In addition to this, Megersa (2014) attributed the current loss of genetic diversity to the changes in food preferences of a growing urban population and a decreasing demand for local products. Furthermore, natural disasters or human conflicts which result in a large-scale displacement of farmers, can lead to the loss of the agricultural diversity that was used by the farmers involved. The causes of the genetic erosion or loss of landraces could be attributed to a combination of replacing landraces by commercial improved varieties and giving priority to more expensive crops or more profitable crops. As a result, many farmers have shifted from landrace production to improved variety. We observed that farmers who adopt and grow improved varieties are considered model farmers by the government system and are rewarded to further encourage them while those who grow landraces are discouraged in various ways including indirectly. However, it must be known that cultivating only improved varieties would eventually lead to limitations. For example, in 2015 when this research was undertaken in Loka Abaya district the yield of maize was highly affected by shortages of rain and farmers had to depend on government handouts for replanting because many of the farmers had already exhausted all their seeds. The agriculture office of the district advised the farmers to use both improved and landraces together even though most farmers had done away with their landraces. In addition, early maturing landraces are preferred by farmers for drought tolerance. Worede (1992, 1997) asserted that local varieties are vulnerable to serious genetic erosion and irreversible losses due to replacement by new, genetically uniform crop cultivars. Other predisposing factors to genetic erosion include changes in agricultural development strategies and systems, land use, reduction in land size (cultivated area) and increase in population, destruction of habitats and ecosystems and reduction in rainfall (Megersa, 2014) and leading to drought. All these operate in Ethiopia such that the drought periods experienced in parts of the country are directly and indirectly leading to considerable genetic erosion. This situation has forced farmers to eat their own seed to survive the drought and often resulted in massivereplacement of native seed stocks by exotic seeds provided by relief agencies in the form of food grains (Worede, 1992).

CONCLUSION

Late-maturing and low income-generating landraces are becoming increasingly vulnerable to replacement by early-maturing and expensive ones. Considering the importance of common bean in local agriculture and tradition, farmers need to be encouraged and supported by stakeholders to consciously monitor the conservation of common bean landraces for all their worth which include use values, agroecological intensification income generation potential, role in breeding and other domestic purposes. In addition to this, governmental and non-governmental organizations should consider the conservation of common bean landraces under both in-situ and ex-situ strategies.

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