Maintenance of Sorghum (*Sorghum bicolor*, Poaceae) Landrace Diversity by Farmers' Selection in Ethiopia[1]

A. Teshome, L. Fahrig, J. K. Torrance, J. D. Lambert, T. J. Arnason and B. R. Baum

A. Teshome, L. Fahrig *(International Plant Genetic Resources Institute (IPGRI), Via delle Sette Chiese 142, 00145 ROMA, ITALY, Ottawa, ON, Canada, K1S 5B6)* **J. K. Torrance** *(Geography Department, Carleton Univ, Ottawa, ON, Canada, K1S 5B6)* **J. D. Lambert, T. J. Arnason, and B. R. Baum** *(Ottawa-Carleton Institute of Biology, Ottawa, ON, Canada, K1S 5B6)* Maintenance of Sorghum (*Sorghum bicolor*, Poaceae) Landrace Diversity by Farmers' Selection in Ethiopia. *Economic Botany 53(1):79–88, 1999. We quantitatively examined the relationships between* Sorghum *landrace diversity at the field level and environmental factors and farmers' selection practices in north Shewa and south Welo regions of Ethiopia. Surveys were conducted on 260 randomly selected farmers' fields. The altitude and size of each field were recorded.* Sorghum *plants at 5 m intervals along transect lines spaced 10 m apart over each field were identified by the farmers and the owner of each field was asked why she/he decided to grow each plant. Soil samples were collected from all of the fields and analyzed for pH, organic content, and sand, silt and clay content. Simple and polynomial regressions and multiple regression analyses showed that* Sorghum *landrace diversity at the field level had significant relationships with the number of selection criteria used by the farmers, field altitude, field size, pH and clay content. As the number of selection criteria increased, landrace diversity in the fields increased. This relationship was not a result of the correlation between selection criteria and the environmental factors, because it was significant after statistically correcting for the effects of the environmental variables. This study quantitatively confirms the role of traditional farmers in the maintenance of sorghum landrace diversity in north Shewa and south Welo regions of Ethiopia.*

Wir untersuchten quantitative Zusammenhänge zwischen der Diversität von Sorghum *(Anzahl der Getreidevariationen) im Feld sowie Umweltfaktoren und Auswahlkriterien von Farmern im nördlichen Shewa und im südlichen Welo in Äthiopien. Die Untersuchung wurde an einer Stichprobe von 260 Feldern durchgeführt. Für jedes Feld wurden Höhenlage und Größe erfaßt.* Sorghum *Pflanzen wurden an den Schnittpunkten eines 5 × 10 Meter Rasters über jedes Feld von Farmern identifiziert und jeder Eigentümer wurde nach dem Grund des Anbaus der Pflanze befragt. Wir entnahmen Bodenproben von jedem Feld, welche auf PH Wert, Gehalt von organischem Material, Sand, Schlick und Lehm analysiert wurden. Einfache, polynomische und mehrfache Regressionsanalysen zeigten signifikante Beziehungen zwischen der Diversität von* Sorghum *und der Anzahl von Auswahlkriterien der Farmer—Höhenlage, Feldgröße, PH und Lehmgehalt. Mit Zunahme der Auswahlkriterien erhöhte sich die Diversität von* Sorghum *im Feld. Dieser signifikante Zusammenhang war nicht das Ergebnis der Korrelation zwischen den Auswahlkriterien und Umweltfaktoren, da wir vorher den Effekt der Umweltfaktoren ausgeglichen hatten. Diese Studie quantifiziert die Bedeutung traditioneller Farmer für die Diversität von* Sorghum *im nördlichen Shewa und im südlichen Welo in Äthiopien.*

Key Words: *Sorghum* landrace diversity; farmers' selection practices; Ethiopia; multiple regression analysis; field size; altitude; soil attributes.

Biological diversity provides humans with a wide array of materials essential for food, fiber, medicine and industry. Because of human reliance on biological diversity, scientists and policy makers (at all levels) must come to understand the factors involved in the generation and maintenance of diversity in order to reduce the risk of degradation of diversity and extinction of valuable genetic resources. This paper elucidates the critical role of traditional farmers in one of the world centers of biological diversity, Ethio-

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pia, in developing and maintaining the diversity of the major cereal crop, sorghum.

Sorghum landrace diversity for this research is defined as the number of types of sorghum grown on a farm, as named by the farmers. A landrace is a plant population with a limited range of genetic variation, which is adapted to local agroclimatic conditions and which has been generated, selected, named and maintained by traditional farmers. Farmers can distinguish landraces (Harlan 1975:137–138), and each landrace named by the farmer can be considered a separate taxon (Berlin, Breedlove, and Raven 1973; Harlan, De Wet, and Price 1972). Numerical taxonomy, used to test the consistency of farmers' naming of the more common sorghum landraces (Teshome et al. 1997), indicated that identification and naming of sorghum landraces is consistent among farmers, and, as found by Berlin, Breedlove, and Raven (1973), and Quiros et al. (1990), approximates the accuracy of standard scientific taxonomic approaches.

Landraces have been used by plant breeders as the source for specific characteristics in the development of the modern High Yielding Varieties (HYV's) (Frankel 1974). Conventional plant breeders employ very few selection criteria and seek to develop varieties for widespread production in favorable agricultural habitats. In contrast, farmers use a range of selection criteria when breeding crops for adaptation to specific agricultural habitats, particularly in heterogeneous and marginal environments. HYVs have caused genetic erosion as they have displaced landraces in areas of the world where modern agricultural methods have been adopted; this genetic erosion is at the point of becoming particularly serious as the HYVs are beginning to displace the landrace populations in the centers of origin and diversification of cultivated plants (Altieri 1995; Brush, Bellon, and Taylor 1992; Frankel 1974; Harlan 1975; Hawkes 1983; Oldfield and Alcorn 1987). According to Chambers (1983), HYVs are also causing the loss of traditional knowledge of cropping patterns and management practices and the ecological rationale behind them.

The HYVs have a narrow genetic base and, as a consequence, are almost uniformly vulnerable to a host of environmental risks, such as diseases, pests, and extreme weather conditions. The risks associated with monoculture farming which almost invariably accompanies HYV introductions are evident from the Irish potato famine (Fowler and Mooney 1990), the southern corn leaf blight, and the Californian barley yellow dwarf virus (Adams, Ellingboe, and Rossman 1971; Brown 1983; Wilson 1985). The barley yellow dwarf virus was controlled by a single gene from the Ethiopian barley collections (Qualset 1975). Such experiences of the vulnerability of HYVs to diseases and pests are the main reasons for rising global interest in the maintenance of the genetic variation of cultivated plants.

An important step in conserving genetic diversity is to determine the role of farmers' selection in generating and maintaining crop diversity. The association between farmers and the maintenance of crop varieties has been described for potatoes in the Andes (Bellon 1991; Brush, Carney, and Huaman 1981; Brush, Bellon, and Taylor 1992; Zimmerer 1996), maize in the Americas (Bellon and Brush 1994; Galinat 1992; Zimmerer 1996), beans in central Africa (Martin and Adams 1987; Voss 1992), and manioc and cassava in the Amazon basin in Peru (Boster 1985; Salick, Cellinese, and Knapp 1997).

In north Shewa and south Welo regions of Ethiopia, both sorghum HYV's and sorghum landraces are grown. Studies are currently underway to document the distribution and potential effects of the HYV's on sorghum landrace diversity. In this paper we quantitatively examine the relationship between sorghum landrace diversity at the field level, and environmental factors and farmers' selection criteria. Environmental factors are included in the study in order to statistically control for their effects and thereby determine the unique role of farmers' selection practices on sorghum diversity. The environmental variables included field size, altitude, soil texture (sand, silt, and clay), soil organic matter, and soil pH. The farmer's role is measured as the number of selection criteria that a farmer used in choosing the landrace(s) growing on his/her farm. We hypothesized that sorghum landrace diversity at the field level would increase as the number of farmers' selection criteria increases.

Materials and Methods

Surveys were conducted on 260 randomly selected farmers' fields in north Shewa and south Welo regions of Ethiopia. The altitude and size

TABLE 1. SUMMARY STATISTICS (N = 260 FIELDS). SELECT = NUMBER OF SELECTION CRITERIA/FIELD; SIZE = FIELD SIZE (ha); ALTITUDE = FIELD ALTITUDE (M ABOVE SEA LEVEL); SOIL pH; PERCENTS OF ORGANIC MATTER, AND SAND, SILT, AND CLAY PARTICLES IN THE SOIL SAMPLES COLLECTED FROM EACH FIELD; AND DIVERSITY = NUMBER OF SORGHUM VARIETIES REPRESENTED BY THE PLANTS SAMPLED IN THE FIELD.

	Mean	Std Dev	Minimum	Maximum
Select	5.24	1.55	2	9
Size	2.14	1.28	0.4	8.1
Altitude	1716	261.1	1290	2390
Soil pH	6.54	0.33	5.7	7.5
Organic Matter	4.98	1.66	1.18	9.27
Sand	28.96	14.85	0	73.6
Silt	50.34	12.33	5.77	84.56
Clay	18.87	6.52	0	36.3
Diversity	9.75	5.01	1	24

of each field were recorded. Three to 5 soil samples per field were collected and analyzed for pH (Jackson 1967), organic matter content, and sand, silt and clay content measurement by the falling drop method (Moum 1965).

Sorghum plants were sampled by walking along parallel transect lines, stopping at 5 m intervals on each transect and selecting the nearest plant. The transect lines were spaced 10 m apart over each field. Therefore, there were 50 plants sampled for approximately every 50 m^2 of field, resulting in a sample size of about 200 plants in a typical 1 ha field. The farmer was asked to identify each plant, and was simply asked why she/he decided to grow it. The interviews were conducted by A. Teshome in the local language, Amharic. In all cases, the person interviewed was the farmer responsible for planting decisions. Both men and women farmers were therefore involved in the study. The farmer's answers were entered in the data sheets as one or more selection criteria, and after the whole field was sampled the total number of selection criteria for that field were summed.

Simple and polynomial regressions (SAS 1992) were carried out to examine the relationship between each individual variable (field size; altitude; sand, silt, clay, and soil organic matter contents; soil pH; and number of farmers' selection criteria) and sorghum diversity. *Sorghum* diversity was measured as the number of distinct sorghum landraces identified on each field (i.e., landrace richness). The individual predictor variables, including significant higher order polynomial terms, were then included in a stepwise multiple regression analysis (SAS 1992) which generated our best model for predicting sorghum diversity. In all models, sorghum diversity was square root transformed in order to meet the assumptions of analysis of variance. An alpha value of 0.05 was set for all statistical tests. Type III sums of squares were used in the significance tests so that the effect of each variable was examined after accounting for the effects of all the other variables in the model.

RESULTS

The selection criteria identified by farmers were grain yield, total plant biomass, insect/pest resistance, market value, suitability for beverages, milling quality, time to maturity, drought resistance, threshability, and bird resistance. The total number of these selection criteria applied to individual landraces ranged from 1 to 6, and the number of selection criteria used per field ranged from 2 to 9. Altogether 60 landraces were identified by the farmers, and the number of landraces per field ranged from 1 to 24.

The mean, standard deviation, and minimum and maximum values for each predictor variable (Table 1) indicate that farmers' fields in the study area are heterogeneous. Pearson correlations among the predictor variables are given in Table 2.

Based on single variable regressions, sorghum landrace diversity at the field level showed significant relationships with altitude (Fig. 1), field size (Fig. 2), and the number of farmers' selection criteria (Fig. 3). The multiple regression analysis (Table 3) shows that sorghum landrace

TABLE 2. PEARSON CORRELATIONS AMONG THE PREDICTOR VARIABLES. $^*P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

	Size	Altitude	pH	Organic	Sand	Silt	Clay
Select	0.17**	−0.32***	0.08	0.17**	−0.009	0.05	−0.04
Size		0.09	0.13*	0.02	−0.05	0.05	0.01
Altitude			−0.12*	−0.15*	−0.04	0.03	0.03
pH				0.22**	−0.15*	0.17**	0.04
Organic					−0.49***	0.37***	0.34***
Sand						−0.88***	−0.63***
Silt							0.24***

diversity at the field level had significant relationships with pH(-) and clay(-), along with the terms that were significant in the single variable regressions (selection criteria, altitude and field size).

DISCUSSION

The results indicate that *Sorghum* landrace diversity at the field level is influenced by many factors, including the farmers' decision making processes, through their selection criteria. Below we discuss the effects of individual factors, and how they may interact.

ENVIRONMENTAL VARIABLES

Altitude

In the study area, sorghum landrace diversity is greatest between approximately 1500–1700 m, where sorghum is well adapted to the temperature, precipitation and growing season conditions, and decreases towards both higher and lower elevations (Fig. 1).

The main reason that sorghum landrace diversity decreases towards higher elevation (above 1700 m) is undoubtedly due to its being a C_4 plant, not adapted to cool conditions (Nor-

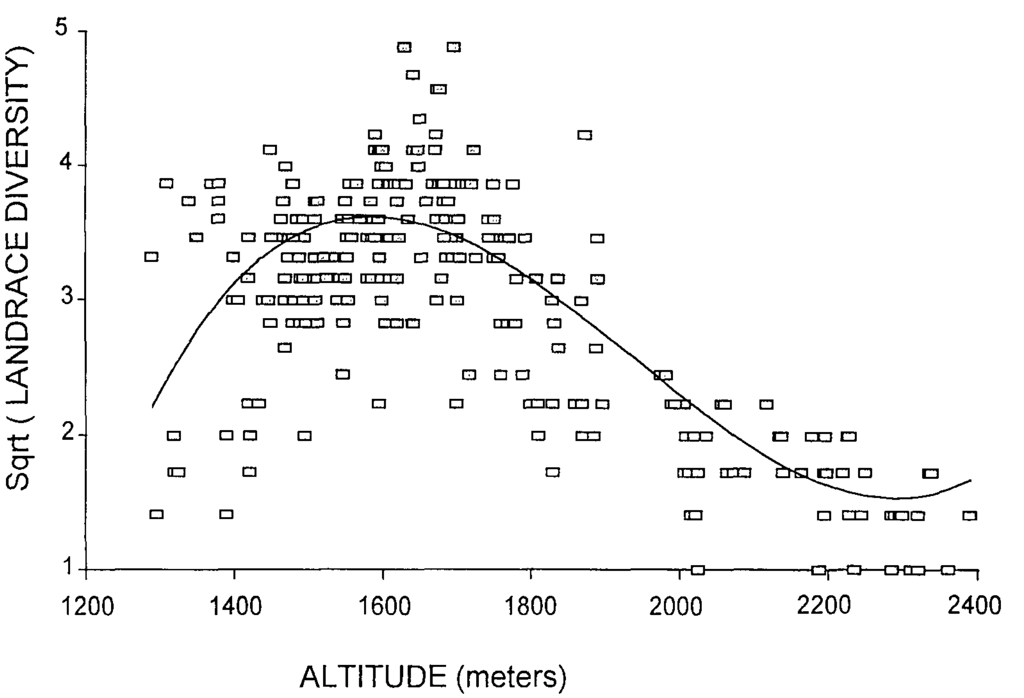

Fig. 1. Relationship between field altitude and sorghum landrace diversity based on polynomial regression analysis ($R^2 = 0.63$; $P < 0.0001$). Sqrt (Diversity) = 0.13Alt − 000069Alt^2 + 0.00000001Alt^3 − 75.74. All terms are significant at $\alpha = 0.05$, based on Type III sums of squares.

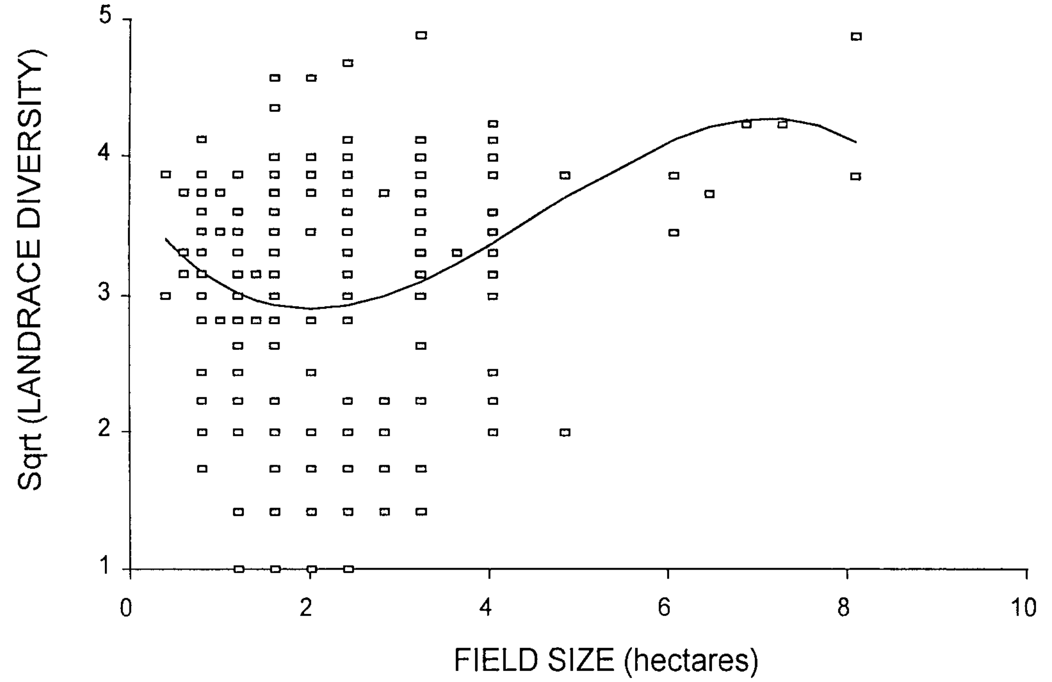

Fig. 2. Relationship between field size and sorghum landrace diversity based on polynomial regression analysis ($R^2 = 0.0.75$; $P < 0.0002$). Sqrt (Diversity) = $-0.36\text{Size} + 0.046\text{Size}^2 - 0.0014\text{Size}^3 + 3.73$. All terms are significant at $\alpha = 0.05$, based on Type III sums of squares.

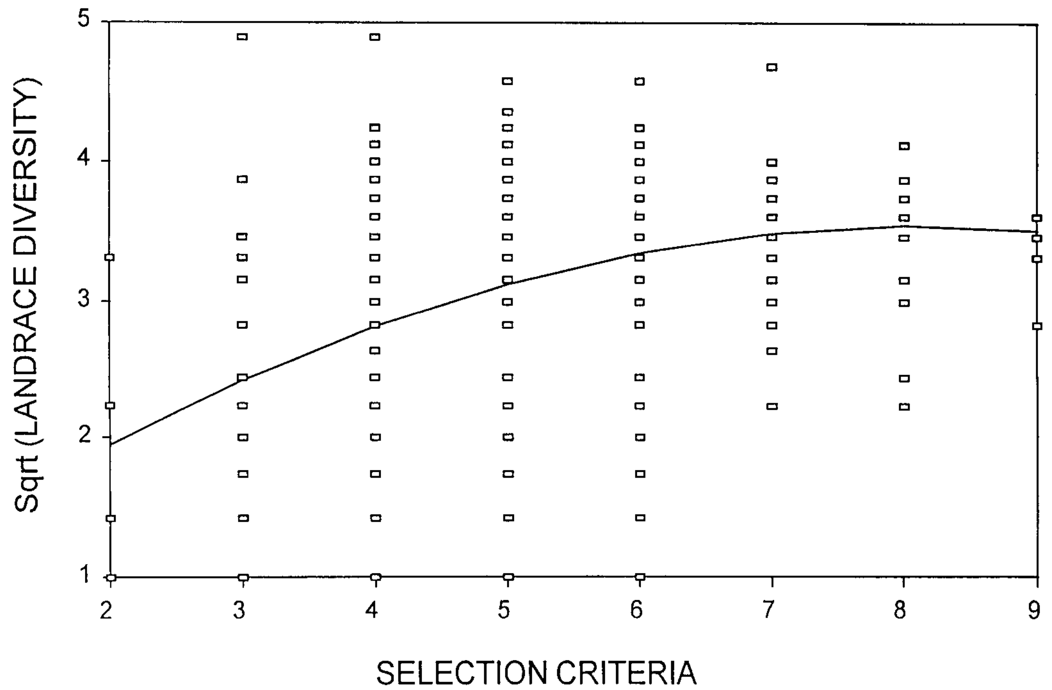

Fig. 3. Relationship between the number of farmers' selection criteria and sorghum landrace diversity based on polynomial regression analysis. ($R^2 = 0.21$; $P < 0.0001$). Sqrt (Diversity) = $0.69\text{Select} - 0.043\text{Select}^2 + 0.73$. All terms are significant at $\alpha = 0.05$, based on Type III sums of squares.

TABLE 3. STEP-WISE MULTIPLE REGRESSION ANALYSIS OF SQUARE ROOT (SORGHUM LANDRACE DIVERSITY) ON FIELD ALTITUDE, SIZE, SOIL pH, PERCENT OF SOIL ORGANIC MATTER, SAND, SILT, AND CLAY PARTICLES, AND NUMBER OF FARMERS' SELECTION CRITERIA (SELECT) [SAMPLE SIZE = 260 FIELDS; $R^2 = 0.635$; $P < 0.0001$]. ONLY SIGNIFICANT ($\alpha = 0.05$) TERMS ARE SHOWN.

Model Term	d.f.	Type III SS	*P*	Coefficient
Altitude	1	613.98	<0.0001	0.77
Altitude^2	1	578.23	<0.0001	−0.0042
Altitude^3	1	526.16	<0.0001	0.0000001
Size	1	321.50	<0.0001	0.148
pH	1	69.21	0.0072	−1.63
Clay	1	39.61	0.0414	−0.06
Select	1	92.80	0.0019	0.42

man, Pearson, and Searle 1984; Taiz and Zeiger 1991). The few sorghum landraces, such as Zengada, recorded at high elevation must be adapted to cooler conditions (Harlan 1975). A further factor is that the more cold-resistant C_3 crops, wheat, barley, and oats, are well adapted to the cooler conditions (Norman, Pearson, and Searle 1984; Taiz and Zeiger 1991). Their availability exposes sorghum to additional negative selection pressure by the farmers.

The decrease in sorghum landrace diversity below about 1500 m is most probably explained by precipitation decrease which makes the lowland areas more susceptible to water stress and drought (Tilman and El Haddi 1992). The sorghum landraces grown at lower elevations are reputed, by the farmers, to have good drought resistance. Whittaker and Niering (1975) also observed that increasing drought at lower elevations in natural systems is accompanied by a decrease in biomass production and biotic diversity.

Field Size

Sorghum landrace diversity increases as field size increases. This may be because larger fields have a greater range of microhabitats (Williams 1943) which farmers take advantage of to grow a greater range of sorghum landraces. Interestingly, the very small (<0.75 ha) fields had unexpectedly high landrace diversity (Fig. 2), almost certainly because their proximity to settlement areas led to the farmers being able to pay more attention to them in terms of more inputs of time and organic residues than fields located more distant from the home.

Soil Parameters

Sorghum landrace diversity at the field level showed negative relationships with soil pH and the percentage of clay particles (Table 3). The pH range of 5.7 to 7.5, encountered in the study area, is in the middle of the 4.3–8.7 range of tolerance for *Sorghum bicolor* indicated by Duke (1978) and, with sorghum being a semiarid region crop, one would expect it to be best adapted to the upper end of its pH range of tolerance. We have no explanation for the observed negative pH-diversity relationship.

Clay-rich soils are usually considered quite fertile due to the presence of high cation exchange capacity which retains nutrient elements, and their ability to retain relatively large amounts of available moisture which make them less susceptible to drought than coarse soils. Clay-rich soils may, however, pose operational constraints to subsistence farmers when they become sticky, waterlogged and untrafficable in wet seasons, and firm and hard to cultivate during the dry season. Our field observations indicate that, where Vertisols (clay-rich soils) predominate, most farmers plant quick-maturing sorghum landraces in late June and early July. These utilize the high soil moisture residuals and are ready for harvest at the same time as the longer-season landraces planted in February and March. By planting late on these soils, the farmers avoid the need to plough these heavy-textured soils during either dry or wet seasons and consequently are restricted to growing only the fast-maturing landraces, thereby limiting the diversity in these fields.

FARMERS' SELECTION CRITERIA

In the north Shewa and south Welo study area our analysis has demonstrated that as the number of farmers' selection criteria increases, sorghum landrace diversity in their fields increases (Fig. 3). This relationship was not a result of the correlations between selection criteria and environmental factors (Table 2), because the farmers' selection criteria variable was significant after statistically correcting for the effects of the other factors (Table 3 and Fig. 4).

From this relationship we infer a causal relationship between the number of selection criteria and landrace diversity; the more selection cri-

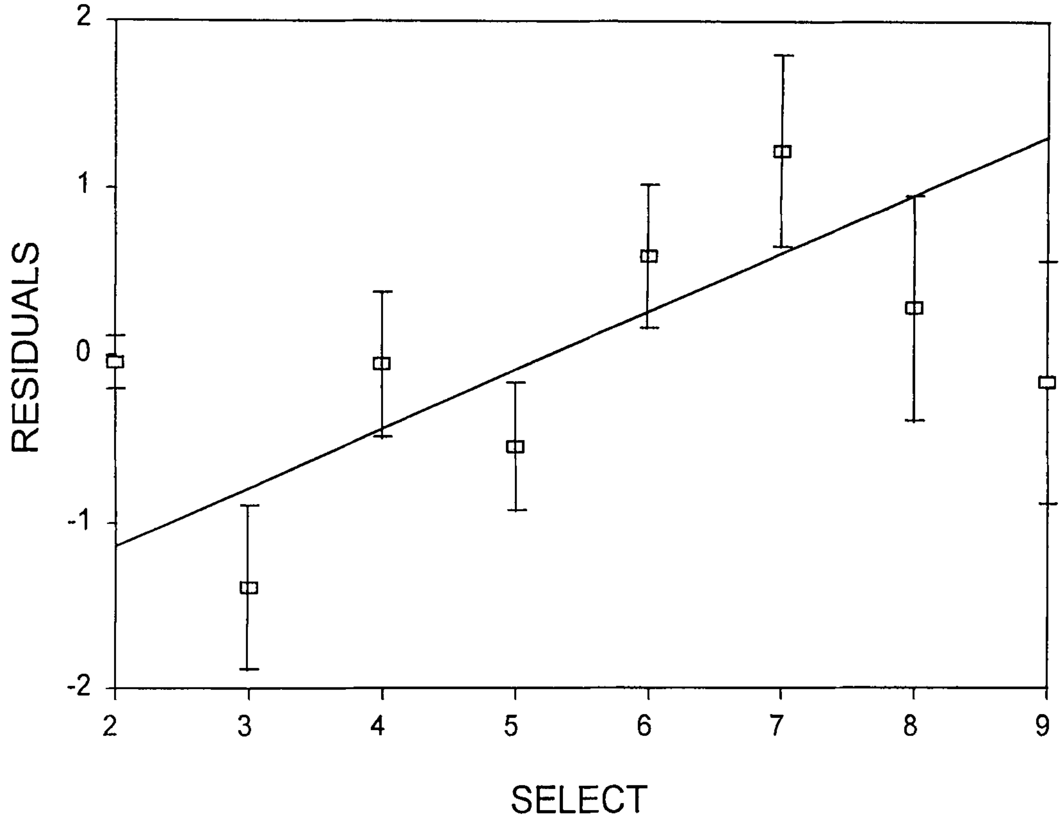

Fig. 4. Relationship between the number of farmers' selection criteria and the residual of the regression of sqrt (diversity) on Alt, Alt2, Alt3, pH, and Clay ($P < 0.0043$; N = 260; see Table 3). Standard error bars are shown.

teria a farmer employs, the more landraces he/she must necessarily plant to meet all his/her criteria. However, it is also possible that the causality could be reversed. In other words, we do not actually know whether farmers have more landraces because they use more selection criteria, or more selection criteria because they have more landraces. We infer the former from our observations of the farmers.

The farmers know the attributes of the various landraces and use the appropriate range of landraces to meet their varied needs. The farmers were aware that growing a range of sorghum landraces in a field increased the security of obtaining a satisfactory harvest. In agreement with the observations of Clawson (1985) and Altieri (1995), these traditional farmers were consciously applying a range of selection criteria and choosing a range of landraces that met these criteria. The employment of more selection criteria by a farmer increases the number of morphologically different sorghum landraces that are planted. The sorghum landrace diversity is, thus, created in response to use and preferences of the farmers in the study area (Teshome et al. in press).

In north Shewa and south Welo regions of Ethiopia, farmers use both time and space strategically to maintain the genetic integrity of the crop plants they grow. Farmers plant different sorghum landraces at different times and use separation of fields by distance or elevation to minimize the chances of undesired pollen exchange at the time of flowering. These practices enable the specific landraces to retain their integrity with regard to the intended selection criteria. At the same time, the farmers tolerate the presence of wild relatives of sorghum in or around their fields to allow some interpollination which could lead to beneficial characteristics being attained by the cultivated landraces. These farmers act according to the same principles that

Harlan (1975:163–164) and Altieri (1995:107–144) have observed for traditional farmers growing various cultivated crops, including sorghum, in other areas.

As opposed to the conventional breeding approach, farmers in north Shewa and south Welo regions are not interested in high yield and wide adaptability from a single crop variety. They are more concerned with stable yields on their fields and stable crop performances over seasons. The farmers do not look for the ideal landrace, rather they manage a range of landraces using a range of selection criteria, which in combination satisfy their food needs as determined by their social, cultural, economic, and ecological environments. The challenge of selecting the appropriate landraces to grow on their land could be a daunting task for individual farmers. The multiple selection criteria they employ are shaped by both the environment in which they live and centuries of accumulated knowledge passed from generation to generation.

IMPLICATION

This research has confirmed the essential role that traditional farmers play in the development and maintenance of landraces. It also confirms that this action is a consequence of their understanding of the environment in which they and their ancestors have farmed and their understanding of the inherited characteristics of crops (even though they do not necessarily understand genetics in the modern concept). It might be argued that the traditional farmers represent the first wave of biotechnologists, the modern plant breeders represent the second wave, and the genetic engineers are the third wave.

The major differences among the three approaches relate to the selection criteria of the traditional farmers which revolve around the fulfilling of certain needs within the context of a complex heterogeneous environment. The selection criteria include ability to survive under difficult and good conditions as determined by climatic factors, diseases, pests, and various soil limitations. At the same time, the combination of all landraces grown must produce adequate yield, and be suitable for the desired uses. The result over generations has been the development of a large number of landraces which are adapted to a range of environmental and cultural niches, and a farming tradition that provides for continued evolution of these landraces. The modern plant breeders and genetic engineers use selection criteria which revolve around yield, profit, uniformity to allow for mechanization, and introduction of specific characteristics to existing varieties to achieve a very specific trait within the recognition that their clients have the resources to "correct" many of the environmental limitations that might restrict success.

Undoubtedly the traditional farmers can benefit from some of the approaches of modern plant breeders and genetic engineers—most probably in the context of rapidly introducing specific characteristics into their germplasm base. However, it is not clear that changing or reducing the traditional farmers' selection criteria would be beneficial. In the Ethiopian Highlands, the heterogeneity of the landscape and the nature of other limitations (Dyer, Teshome, and Torrance 1992, 1993; Teshome 1990) make the approach of choosing the landrace adapted to the conditions superior to the approach of modifying the conditions to meet the varietal requirements over most of the area. For heterogeneous, marginal lands the traditional approach seems best; for moderately variable areas, a narrower range of variation within the crop may prove beneficial; and, for good, relatively uniform agricultural lands the modern approach with some incorporation of the traditional farmers' caution seems desirable.

For some time into the future it seems probable that the traditional farmers will have more to offer than to gain. Their landraces represent a dynamic pool of genetic resources and their knowledge system a reservoir of information which has substantial potential benefits for world agriculture. Their approach of choosing combinations of selection criteria to develop landraces compatible with environmental conditions and then matching landraces to these conditions has merit. Traditional farmers and conventional breeders should work together to modify the selection criteria so as to increase productivity while maintaining landrace diversity in the heterogeneous and marginal agricultural landscapes.

Explicit value must be placed on the maintenance and evaluation of the landraces and the knowledge base of the traditional farmers; they go together. Policies must be developed and applied to facilitate the retention of this valuable heritage in a dynamic, living fashion and a way must be found to recognize the collective rights and to reward the collective contributions of the traditional farmers whose deliberate actions have led to the development of the landraces.

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Book Review

Timber, Tourists, and Temples. Conservation and Development in the Maya Forest of Belize, Guatemala, and Mexico. Richard B. Primack, David Bray, Hugo A. Galleti, and Ismael Ponciano. 1998. Island Press, Washington D.C. vii + 426 pp. (paperback). $35. ISBN 1-55963-542-8 (paperback). $55. ISBN 1-55963-541-1 (cloth).

Timber, Tourists, and Temples is a comprehensive review of various issues concerning the protection and management of the Maya Forest in Belize, Guatemala, and Mexico. This volume stems from a 1995 conference held in Chetumal, Qintana Roo, México. In total, 50 contributors produced 25 chapters. These 25 chapters are divided into five sections. Part I includes two chapters, the first of which discusses data collection and background information on the conference and the second discusses a regional approach to conservation in the Chiquibul forest in Belize and Guatemala; Part II includes seven chapters that discuss community forestry, sustainable logging, national forestry policies, and the conservation implications of these topics in the Maya Forest region; Part III includes five chapters that discuss the role of non-timber forest products in conservation and development; Part IV includes three chapters about research projects providing base-line ecological data in the Maya Forest region; and Part V discusses community involvement in conservation and resource management projects. Part V includes eight chapters with topics such as ecotourism, organic farming, environmental perception of local people, and environmental education programs.

Timber, Tourists and Temples contains information regarding the cultural, political, and economic obstacles conservationists face in their efforts to protect the Maya Forest. For instance, several chapters in Part IV discuss the benefits and problems of using non-timber forest products as conservation and development tools. Authors point out that the extraction of non-timber forest products depends on low harvester population densities, stable species densities, and secure land tenure arrangements for the local population. These conditions are rarely met simultaneously in the Maya Forest region. As pointed out in Chapter 8, in the Guatemalan Peten, an influx of immigrants from the highlands has dramatically increased population densities leading to the unsustainable harvest of certain forest products such as xate palm. Another obstacle conservationists face, discussed in Part II, is the seemingly inherent conflict between logging and conservation. In areas where timber extraction is the primary land use strategy, how can this agenda be balanced with the goals of conservationists, particularly if commercial forests are developed? This volume discusses several specific examples where resource managers, conservationists, and local peoples are attempting to find a balance between income generation from logging, sustainable forestry, and the protection of biodiversity in the Maya Forest region.

Although *Timber, Tourists, and Temples* describes many obstacles conservationist face in this region, there are also success stories. Where the proper combination of education, training, financial support, and where land tenure issues are addressed, rural people have made positive strides towards reaching a balance between income generation and forest conservation. Chapters 20, 23, 24, and 25 highlight some of these success stories.

Overall, *Timber, Tourists, and Temples* makes a valuable contribution to the field of tropical conservation. Researchers from disciplines such as anthropology, botany, conservation biology, forestry, and geography will find *Timber, Tourists, and Temples* informative and useful in courses concerned with tropical conservation.

MICHAEL K. STEINBERG
DEPARTMENT OF GEOGRAPHY AND ANTHROPOLOGY
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LA 70803