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Genetic erosion: assessment of neglected and underutilized crop genotypes in South Western Kenya

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Abstract

The loss of Neglected and Underutilized Species (NUS) of crop results in reduction of the genetic base of the remaining varieties that may have a consequence upon changing environmental and ecological conditions. There is therefore, an urgent need to collect, document, characterize, conserve and utilize the traditional crops and formulate policies that will protect them from further genetic erosion. There is lack of adequate knowledge and information on the status and risks posed to Plant genetic resources in south western Kenya especially with neglected and underutilized crop species. This study was carried out to assess genetic erosion of NUS so as to recommend effective strategies for conservation and sustainable utilization of these resources. The research was carried out in the three administrative areas of the Gusii region (Kisii, Gucha and Nyamira) of Kenya. These highlands are a source of much of the food that feeds the western part of Kenya as well as the home of unique, diverse plant genetic resources. However, these resources have been seriously threatened through genetic erosion due to high population pressure, more productive crop species and now climate variability and change. There is lack of adequate knowledge and information on the status and risks posed to Plant Genetic Resources, PGR, in Gusii highlands. Therefore, acquisition of this information through base line surveys is imperative in order to develop effective strategies for conservation and sustainable utilization of these resources for present and future generations. The study was carried out in from July 2011 to November 2011.In order to assess genetic erosion, survey research was undertaken. These were, formal and informal survey to explore the level of on-farm genetic erosion in depth by inter-viewing carefully selected group, homogenous in social composition with farmers; key informant interviews (interviews with special indigenous crop knowledgeable farmers in the communities) with selected farmers (farmers seconded by the farming community for their rich indigenous technical knowledge on native crop production i.e. key informants. Data were analyzed through descriptive statistics (frequencies, percentages, means, etc.) to generate summaries and tables at different levels. The study found millets, sorghums, wild fruits, bananas landraces, goose berry, passion fruit, loquat, guava, tree tomato, cassava, sweet potatoes, cocoa yams as the main_Underutilized and Neglected crops in the region. Important causes of this genetic erosion were high production cost and climate variability, cash crops population pressure and small farm size, outdated land use systems, poor cultivation methods, age and gender. There is an urgent need to establish or strengthen systems for monitoring genetic erosion, including easy-to-use indicators in the region. Support should be given to collecting farmers' varieties/landraces in particularly vulnerable or threatened areas, where these are not already held *ex situ*, so that these genetic resources can be multiplied for immediate use and conserved for future use.

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Introduction

Genetic erosion is a process whereby an already limited gene pool of an endangered species diminishes even more when individuals from the surviving population die off without getting a chance to meet and breed with others in their endangered low population. Genetic erosion occurs because each individual organism has many unique genes which get lost when it dies without getting a chance to breed. Low genetic diversity in a population of wild animals and plants leads to a further diminishing gene pool – inbreeding and a weakening immune system can then "fast track" that species towards eventual extinction. All the endangered species of the world are plagued to varying degrees by genetic erosion, and most need a human-assisted breeding program to keep their population viable, thereby avoiding extinction over long time frames. The smaller the population is on a relative scale, the more magnified the effect of genetic erosion becomes, as weakened individuals from the few surviving members of the species are lost without getting a chance to breed.

Genetic erosion in agricultural and is the loss of biological genetic diversity – including the loss of individual genes, and the loss of particular recombinants of genes (or gene complexes) – such as those manifested in locally adapted landraces of domesticated animals or plants that have become adapted to the natural environment in which they originated.Neglected and Underutilized Species (NUS) are "those species with under-exploited potential for contributing to food security, health (nutritional/medicinal), income generation, and environmental services."(Jaenicke and Hoeschle, 2006). Neglected and Underutilized plant species (NUS) include hundreds of locally domesticated and wild species, which are rich in nutrients and adapted to low-input agriculture. NUS and their traditional production systems can play a key role in supporting rural livelihoods. They are important in strategies to alleviate the effects of biotic and abiotic stresses – particularly those related to climate change. Their commercialization can provide income opportunities and many NUS species are important in traditional pharmacology. Due to the intensification of agriculture and the commoditization of food markets towards a narrow range of the most important food crops, diversity of NUS and associated local knowledge is rapidly being lost. Research, therefore, on NUS needs strengthening. The promotion of NUS contributes to achieving the Millennium Development Goals (MDGs), in particular with regard to eradicating extreme poverty and hunger (MDG1) and ensuring environmental sustainability (MDG7), as well as promoting gender equality and empowering women (MDG3), reducing child mortality (MDG4), improving maternal health (MDG5) and developing a global partnership for development (MDG8).

The crops identified as 'neglected and underutilized species' in south western Kenya (Gusii region) include: millets, sorghums, wild fruits, bananas landraces, goose berry, passion fruit, loquat, guava, tree tomato, cassava, sweet potatoes and cocoa yams.

The Gusii highlands of South Western Kenya are a component of an intensively cultivated "eco-region" in Africa. These highlands are a source of much of the food that feeds the western part of Kenya as well as the home of unique, diverse plant genetic resources. These plant genetic resources are very rich and variable as well as a potential resource for agricultural development. However, these resources have been seriously threatened through neglect and underuse due to high population pressure estimated to be more than 400 persons per km2, intensive land cultivation, and land degradation (Africare, 2001; Mike, 2000; Jean-Mark, 1999). Also due to socio-economic pressure, landraces are being replaced with new crop varieties thereby leading to commercialization of farming, monoculture and consequently, genetic erosion. Genetic erosion has also been caused by other factors such as change in cultural norms, change of dietary habits, change of climate and

natural calamities as reported by Nnadozie *et al.* (2003). However, there is lack of adequate knowledge and information on the status and risks posed to PGR in Gusii highlands. Therefore, acquisition of this information through base line surveys is imperative in order to develop effective strategies for conservation and sustainable utilization of these resources for present and future generations.

Plant genetic resources, plant biodiversity are the foundation for sustainable agriculture and global food security, now and in future, whether they are used in traditional farming systems, conventional breeding or in new biotechnologies (FAO, 1998). Plant genetic resources are a reservoir of genetic adaptability, which acts as a buffer against harmful environmental changes and economic challenges (Hammer *et al.*, 1999; FAO, 1999). If not well managed, these plant genetic resources will be vulnerable to genetic erosion (FAO, 1998). The erosion of these resources results in a severe threat to the world's long-term food security (Hammer *et al.*, 1999). To ensure genetic resources are continually available for sustainable food security, the need for maintaining genetic diversity in agricultural systems is widely accepted (FAO, 1999).

The practice of modern intensive plant breeding leads inevitably to a reduction in the genetic diversity of crops (Clunies-Ross, 1995; Tripp, 1996). Such erosion would have serious consequences, both on the genetic vulnerability of crops to changes in the spectrum of pests and diseases, and on their plasticity to respond to future changes in climate or in agricultural practices (Tripp, 1996; Smale, 1996; FAO, 1995; Duvick, 1984). In some cases, the loss of particular crop varieties is not *complete,* but instead reduces surviving members of a landrace to a few isolated populations. In such cases, there is significant risk of the ultimate loss of diversity, because small populations will lead to increased inbreeding which reduces the fitness of individual plants and hence may lead to extinction (Van Treuren *et al.,* 1990).

Many national programmes have not regarded quantification of genetic erosion as a high priority, as apparent from the paucity of information in the State of the World Report (FAO,1997). The accurate documentation of the genetic diversity and genetic erosion of major agricultural crops is therefore important, both scientifically and socio-economically (Smale,1996; FAO, 1995; Swanson, 1996; Karp *et al.*, 1997). The documentation of present genetic diversity will also be used for measuring future genetic erosion and conserving the threatened crop plant species, for present and future generations. The objectives of the study were to document crop genetic diversity in the region, determine the extent and underlying causes of genetic erosion and to identify and document suitable conservation practices.

Material and methods

Study area

The study was conducted in the three former districts of Gusii region of south western Kenya, from October 2010 to September 2011 using qualitative research methods. These three regions have almost similar agro ecological conditions, but there were some differences in terms of agricultural systems and farming methods.

Assessment of threat of genetic erosion

In order to assess genetic erosion, survey research was undertaken. These were, formal and informal survey to explore the level of on-farm genetic erosion in depth by inter-viewing carefully selected group, homogenous in social composition with farmers; key informant interviews (interviews with special indigenous crop knowledgeable farmers in the communities) with selected farmers (farmers seconded by the farming community for their rich indigenous technical knowledge on native crop production i.e. key informants. The key informants were selected in order to conduct in-depth interview and discussion. They were selected from household heads of both sexes and different age groups based on their availability, willing-ness and practical knowledge on native crops genetic resources of the

area. The local administrators and agricultural extension workers helped in identifying the names of the focus groups.Data were collected during expeditions from the different sites and institutions through the application of Participatory Research Appraisal tools and techniques such as direct observation, individual interviews, and field visits using a questionnaire. Ten randomly selected individuals were interviewed per district. In the villages, interviews were conducted with the help of translators from each area and selected farmers were requested in advance to bring samples of the neglected and underutilized crops they produce or knew about. Through discussion, some key information was recorded on each of the species identified. These are local vernacular names, type of plant, part used, and period of availability of the part used. Each species was evaluated for nine parameters (extent of the production, extent of consumption, degree of consumption, perceived nutritional value, cultural importance, medicinal properties, market use, market value and contribution to household income) using three scores: 3 (low), 5 (average), and 7 (High). Field (home gardens, cultivated fields) visits were conducted to see some of the species under cultivation. Scientific names were determined and reported. Internet and library research (across national research and development institutions) were also conducted for better documentation of the NUC in the region. Data were analyzed through descriptive statistics (frequencies, percentages, means, etc.) to generate summaries and tables at different levels.

Results and discussion

Farmers' perceptions of genetic erosion

It was not easy to estimate precisely how many species had disappeared during the last decade but farmers could estimate percentages of cultivated areas that had been lost or had decreased. These estimates were made by asking the farmers directly about the history of crop cultivation in each village and to name species that had been grown during the last decade and that were no longer grown. In addition farmers were asked to identify the most important uses for specific vegetables such as for selling, domestic consumption, provision of seeds, medicinal and/or cultural or spiritual practices. This question was important because it was thought that if a crop had a wide range of uses then its cultivation may have been sustained for longer. From this point of view the threat of genetic erosion was a serious problem in study area.

It was determined that most vegetable species in region were cultivated for subsistence and that there was a negligible number of species cultivated for seed provision. In terms of medicinal use, there were no results for researched species. Thus, economic objectives were clearly identified as the main reason for cultivating specific NUC in the region. This highlights the threat of existence to some crops because it means that only those that could fetch high market prices were selected for cultivation whereas if there were other objectives for NUC cultivation, selections would have been more varied. In terms of changes in cultivated areas of NUC species, it was revealed that most villages had decreased during the last decade.

Reasons for genetic erosion

Farmers addressed issues of genetic erosion and identified several reasons that some NUC had reduced or ceased cultivation. Farmers named crops that had decreased cultivation areas or which entirely disappeared and were no longer cultivated by farmers in the researched villages. Some other species had undergone notable reductions during recent years.

These findings show that loss of diversity in agriculture in these villages could be attributed to several reasons. Imbalance between selling price and production costs, climate change especially that of drought and water shortage, more interest in cash crops, land degradation and small farm size, changes in land use systems, inappropriate cultivation patterns, and loss of soil fertility.

Loss of soil fertility

Due to frequent cultivation without furrowing, soil fertility had declined and the cultivation of some species had been dropped because of low yield. In addition, inappropriate application of pesticides and chemical fertilizers and overusing mechanization on farms in the area altered the physical and chemical properties of the soil in villages, which affected the soil fertility, further contributing to inhibit the natural processes that maintain diversity of crop species.

Age and Gender

In addition farmer's age and gender affected diversity of crop species grown in the studied area, as older farmers grew more crop types compared to younger farmers and female households grew more crop types compared to male households.

Production costs

Most farmers stated that price reductions had made them disappointed with the occupation of growing NUC. Indeed, the financial interest of farmers was the most important factor affecting determination of species' selection for cultivation and underpinned the tendency toward monoculture. Farmers were usually interested in growing the more expensive produce. The low selling price of produce appeared to have had a major influence a farming system

Climate variability

Another reason for the loss of NUC species in the three regions was climate variability contributed to low production. Access to water is always an important consideration and this affected most villages in the area.

Cash crops

Low prices for NUC had forced farmers to grow only those crops considered to be more profitable. Therefore, only a few species were cultivated in the area and numbers of available species had declined. Economic and financial considerations were the most important factors affecting farmers' enthusiasm for specific crops. Farmers chose to grow those crops that were the most profitable and that provided higher income in shorter times. Increased market prices of some special vegetable species during recent years had persuaded farmers to grow those particular vegetables as cash crops such as cabbage, kale, tomato and onions more than other species. This was the case in most of the areas with some differences.

Population pressure and small farm size

Due to population pressure in the region, there was a shortage of land and farmers had to utilize their meager acreage for more productive and high priced crop varieties. In due course, lower yielding varieties, which in most cases were the traditionally cultivated crops in the area were dropped. There was also a high rate of urban migration especially amongst the younger generation. This reduced the available labor force and resulted in abandonment of those more labor intensive crops.

Outdated Land use systems

Change in land use was expressed by a large number of farmers, especially monoculture of cash crop production such as tea. Prices for tea had increased in recent decades so farmers had set up much of their farms for their production. The consequence of this was a reduction in land area of farms and less space for cultivation of other species especially NUC.

Poor cultivation methods

Better farming systems like crop rotation are important to maintain and regenerate crop diversity. It was observed this trend of cultivation determined by short term financial gain resulted in neglected diversity of the regions agricultural systems. Farmers should be informed of these consequences in order to facilitate more informed decision making in terms of choices of NUC for cultivation on their land.

Conclusion

Results of this study revealed that there was much genetic diversity on farms, however, so many species had been lost and replaced by cash crops. This trend had led to genetic erosion. Intensive monoculture,

encouraged by high short-term returns from cash crops, leads to dramatic long term yield loss due to decreased biodiversity. The study demonstrated that changing cropping patterns due to economic considerations was an important factor contributing to loss of agro biodiversity. The study shows that many of the traditional crops often provided low yields and extremely low income, forcing farmers to undertake other activities, for example, mono cropping and the cultivation of improved strains bringing about more uniformity in crop species and switching over from traditional crops to cash crops. Mono cropping and uniform cultivation results in increased vulnerability to pest epidemics and consequent loss of biodiversity. Besides, a significant proportion of traditional agricultural land has been brought under cash crops. This had adverse implications on traditional agro-ecosystems and traditional agro biodiversity of the region has shrunk over time.

Important causes of this genetic erosion were high production cost and climate variability, cash crops population pressure and small farm size, outdated land use systems, poor cultivation methods, age and gender.

The wide range of uses for NUC in the past, such as seed provision, religious ceremonies, medicine, traditional beliefs, and for condiments have been replaced by cultivation driven by financial gain and this has accelerated the rate of erosion in species with low selling prices. In other words, several applications for each species and increased demands can result in better sustainability.

From the results of this study, loss of profitability was determined as the major risk factor affecting genetic erosion in the region, so that farmers cannot face high production costs at the prices they were obtaining. So it is necessary to obtain a higher selling price for some underutilized species in comparison with cash crops. Social, political, technologic and economic factors were contributing to loss of species diversity in the region. The role of farmers in conserving diversity is crucial. Farmers, as primary producers, influence the status of diversity on farms through their decision-making processes, selection criteria, strategic management practices, local markets, cultural exchange mechanisms and diversity of processing and consumption choices at the household level. Furthermore, there is a need to sensitize farmers and policy makers about the importance of maintaining crop genetic diversity as a principal strategy for developing sustainable agriculture.

Recommendations

There is also an urgent need to develop improved indicators, including proxy indicators, of diversity, genetic erosion and vulnerability that can be used to establish national, regional and global baselines. These indicators should be objective and balanced, taking into account the systems in use at the national level. Local and indigenous knowledge should be recognized as an important component of surveys for assessing and inventorying genetic erosion and should be carefully considered and documented where appropriate.

Countries need to establish or strengthen systems for monitoring genetic erosion, including easy-to-use indicators. Support should be given to collecting farmers' varieties/landraces in particularly vulnerable or threatened areas, where these are not already held *ex situ*, so that these genetic resources can be multiplied for immediate use and conserved for future use. National gene bank collections should be duplicated outside the country (for example, in the genebanks of neighbouring countries and/or in regional or international gene banks). In some countries, the threat of invasive alien species should also be considered, as these may contribute to genetic erosion. Since the loss of plant genetic resources for food and agriculture (PGRFA) varies within countries and from country to country, support should be provided to establish monitoring mechanisms at all levels.

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APPENDIX A

QUESTIONNAIRE

1. District.....Village.....

2. Identification of person interviewed

Name.....

3. Sex Family size Length of residence

a) Male a) 1-5 a) 1-10

b) Female b) 6-10 b) 11-20

c) >10 c) 21-30

d)>30 years

4. Age Marital status Education level

a) 20-30 a) Married a) None

b) 31-40 b) Single b) Primary

c) 41-50 c) Widowed c) Secondary

d) 51-60 d) Separated d) Tertiary

e) >60 years

5. Which crops are more popular in your village?

6. Which crops have you stopped growing in the past few years and why?

7.What crops are you growing these days and why?