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RESEARCH ARTICLE

Analysis of korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen) indigenous production practices and farm based biodiversity in southern Ethiopia

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Abstract Korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen) production is declining mainly due to destruction of the plant's natural habitat. A survey was conducted in the three major korarima growing administrative zones, Gamo Gofa, Debub Omo and Kaffa in southern Ethiopia to assess indigenous production practices, wealth status, farm based biodiversity and household characteristics using participatory rural appraisal (PRA) and semi-structured questionnaires. The wealth is unevenly distributed among households and not significantly different for korarima growers and non-korarima growers. Farmers acknowledged that shortage of shade trees; low yield and lack of improved varieties had contributed to decrease in production area (PA). A total of three distinct named korarima landraces were recorded, with a range from one to three on individual farms implying low farm based biodiversity. More households grew enset (*Ensete ventricosum* (Welw.) Cheesman) in Gamo Gofa and Kaffa while maize (*Zea mays* L.) was grown by nearly all households in Debub Omo. Only a few households grew korarima. Most of the household characteristics significantly affected the PA of korarima. The correlation coefficients indicated that the relationship of household characteristics were significant. Findings of this study suggest that the maintenance of shade trees on the main farm field is the main requirement for korarima production.

Keywords *Aframomum corrorima* · Farm based biodiversity · Household · Indigenous knowledge · Korarima · Shade tree

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Introduction

In developed countries well-documented information may be available on plant genetic resources even if the plant is less known and cultivated (Arora 1985). However, the role of wild germplasm in improvement of cultivated plants is still limited despite the availability of rich gene pools. The conservation and utilization of Ethiopian germplasm has not been fully exploited although Ethiopia is a major world center of origin and/or genetic diversity for many important domesticated crop plants (Vavilov and Chester 1951; Harlan 1969; Engels et al. 1991; Worede et al. 2000). The studies on agro-biodiversity have mainly focused on cereal crops. Research has comparatively been less in spices and medicinal plants including native plants of Ethiopia although these plants are widely used in traditional dishes, and

sold at higher prices in the local markets than cereal grains.

Korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen) belongs to the family Zingiberaceae and genus *Aframomum,* native to Ethiopia. It is a perennial tropical aromatic herb, often of large size, bearing flowers either terminally on aerial leaf shoots or from ground level. Korarima grows usually with strong fibrous subterranean scaly rhizomes and with leafy stems reaching 1–2 m high. It is usually self-pollinated. The position of stigma in the flower is below or against the base of the thecae of the anther. Most probably the flowers are open for 1 day only, but there is no experimental evidence. Occasionally cross-pollination by insects is possible due to the presence of large nectaries at the top of the ovaries. In Ethiopia, korarima grows naturally at 1,700–2,000 m asl (Jansen 2002).

Korarima, also called "false cardamom", has been part of daily Ethiopian dishes for preparation of curry powder used for culinary purposes. Earlier it was mainly harvested from wildly grown plants in the forests. The dried pods are sold in almost every Ethiopian market and are quite expensive compared to other spices. The seeds are used to flavour coffee, special kinds of bread, butter and all kinds of sauces. They are ground and often mixed with other spices. The seeds of korarima contain different types of essential oils having typical odour (Jansen 1981; Abegaz et al. 1994; Eyob et al. 2007) and are traditionally used as tonic, carminative and purgative drug. From a formal survey, korarima seeds, pods, leaves, rhizomes and flowers are used in southern Ethiopia as traditional medicine for human and animal ailments caused by unknown agents; and particularly used to treat any part of the animal body upon swelling (Eyob et al. 2008).

Korarima has been used as an export crop from southern Ethiopia. Ethiopia exported dried pods of korarima to Sudan, Egypt, Arabia, Iran, India and the Scandinavian markets (Jansen 1981; Lock 1997). On average 11,000 and 118,000 kg of dried pods were exported annually to Finland and Sweden, respectively, in the early 70s. However, the total annual export decreased to less than 60,000 kg from 1994 to 1998 fetching only some 2.1 million USD (Chanyalew 1999). In the early 1978 korarima was sold for 9 USD kg^{-1} in the export market, mainly as a substitute to cardamom (Purseglove et al. 1981). Due to shortage of supply in the year 2001, the export market price reached as high as 23.5 USD kg^{-1}.

The economic returns obtained from korarima (yields per ha) were much higher than food cereals grown in the major korarima growing administrative zones as reported by Ethiopian Agricultural Research Organization, EARO (2000). The great potential of this plant has, however, encountered different production problems. In the last few decades', yields, areas of production and biodiversity have declined both from farmers' field and natural forests of southern Ethiopia. Destruction of the plant's natural habitat for expansion of arable and grazing land, new settlement and forest fire have resulted in low supply and high demand of korarima in local and export markets.

According to the growers the actual average yield of dried pods recorded in farmers field in the 1980s ranged from 700 to 950 kg ha^{-1} when the korarima plants received filtered sunlight all day through permanent tree shades. A few h of direct sun light, 3–5 h seemed to damage the plants. Presently the yield was reduced to 250–400 kg ha^{-1}. At the same time, disappearance of unnamed korarima landraces from farm fields was reported by the elders of the community in the major korarima growing administrative zones of southern Ethiopia. To understand the reasons for changes in the production status of korarima in southern Ethiopia we conducted a household survey, to see what concerns farmers have in producing korarima and if any indigenous practices were related to the yield reduction. The local farmers are usually the first source of information in the studies of farm based biodiversity. They manage and conserve local varieties as they recognize unit of diversity (Hoogendijk and Williams 2002). In this study the objectives were to analyse the wealth status and the underlying indigenous knowledge systems of the households, to identify problems and opportunities associated with the korarima production, to evaluate farm based biodiversity and analyse the household characteristics.

Materials and methods

The study areas

Three major korarima growing administrative zones, Gamo Gofa, Debub Omo and Kaffa in southern Ethiopia were chosen for this study (Table 1; Fig. 1).

Table 1 The three administrative zones, Gamo Gofa, Debub Omo and Kaffa

Variables	Administrative zone		
	Gamo Gofa	Debub Omo	Kaffa
Altitude (m asl)	501–3,000	500–3,500	500–2,500
Temperature (°C)	12.6–27.5	10.1–27.5	15.1–27.5
Rainfall (mm)	1,401–1,600	601–1,600	1001–2,000
Latitude	6.12–6.67°	5.36–6.18°	6.24–7.28°
Longitude	36.68–37.20°	36.23–37.07°	35.92–36.40°
Area (km^2)	1807.8	4107.1	2929.8

Source: Bureau of Planning and Economic Development (BoPED 2006)

Different ethnic groups with different cultures, languages, resource levels, population density, farming systems and agro-ecology were living in these administrative zones. The study was carried out in 2005. From each administrative zone the major korarima growing woreda, an administrative division of administrative zone in Ethiopia, was chosen in consultation with agricultural officers of the administrative zone. Gofa Zuria woreda in Gamo Gofa administrative zone, Bakogazer woreda in Debub Omo administrative zone and Decha woreda in Kaffa administrative zone were chosen for this study. Each selected woreda represents the respective administrative zone as far as korarima production practices are concerned. Three peasant associations, the lowest administrative unit in rural Ethiopia, were selected from each woreda through discussion with woreda agricultural officers and key knowledgeable informants in the area. Each survey area was roughly stratified to include adequate representations of peasant associations in terms of elevation, geographic distance and cropping patterns. In each peasant association included in the study, home-gardens were cultivated permanently with enset (*Ensete ventricosum* (Welw.) Cheesman), coffee (*Coffea arabica* L.), tuber, root and vegetable crops. Surplus production from agriculture was sold at the road-sides and markets.

Survey on household wealth status

For household wealth ranking (Table 2), 105 households were selected from each administrative zone

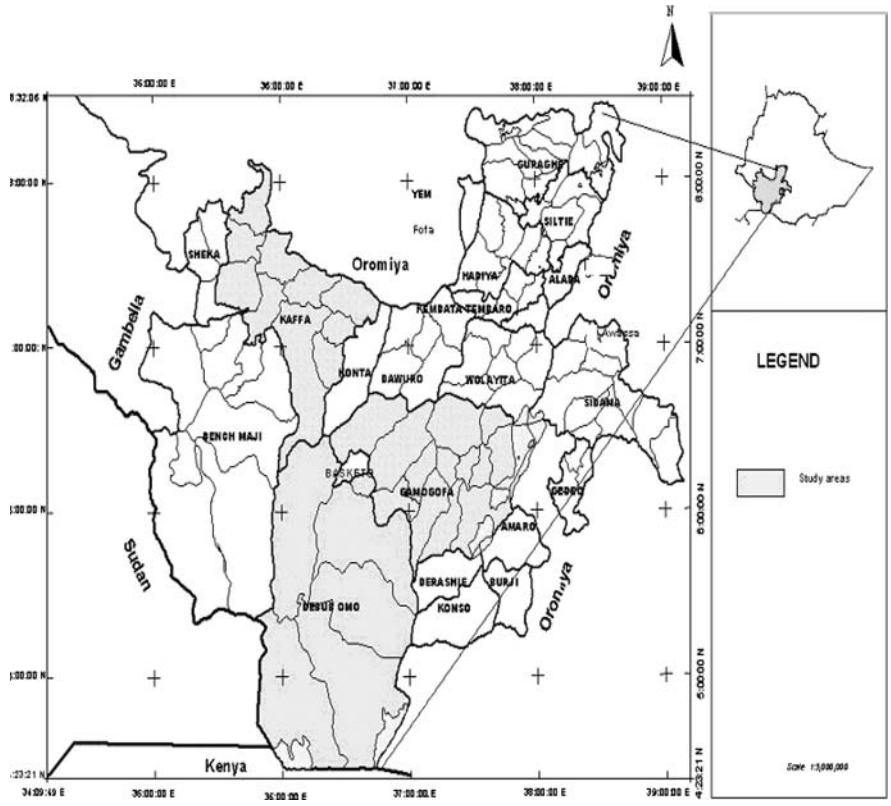

Fig. 1 The highlighted areas indicate the three administrative zones, Gamo Gofa, Debub Omo and Kaffa in southern Ethiopia, BoPED (2006)

Table 2 Wealth status ranked by community leaders and key informants

Wealth indicator	Administrative zone								
	Gamo Gofa Wealth category			Debub Omo Wealth category			Kaffa Wealth category		
	Rich	Middle	Poor	Rich	Middle	Poor	Rich	Middle	Poor
	13.3%	41.9%	44.8%	10.4%	42.9%	46.7%	17.1%	42.9%	40.0%
Land size (ha)	>4	2–4	0–2	2–4	1–2	0–1	>7	4–7	0.25–4
No. of cattle	>17	8–16	0–7	>10	4–9	0–3	>10	3–9	0–2
No. of sheep	>7	4–6	0–4	−	−	−	>7	2–6	0–2
No of oxen pair	≥2	1	0–1/2	2	1	0–1/2	≥3	1–2	0–1/2
No. of horse	≥1	1	−	≥1	1	−	>1	1	−
No. of mule	≥2	1	−	≥1	1	−	>1	1	−
No. of beehives	>16	10–16	0–10	6–10	2–5	0–1	>12	5–12	0–4
Migration to town for work	−	−	+	−	−	+	−	−	+
Both wife and husband sell labour to rich	−	−	+	−	−	+	−	−	+
Hire daily labourers	+	+	−	+	+	−	+	+	−
Trees for shade	+	−	−	+	−	−	+	+	−
Contract others' land	+	−	−	+	−	−	+	+	−
Buy seeds for planting	−	+	+	−	+	+	−	−	+
Lending money for others	+	−	−	+	−	−	+	+	−
Renting house in town	−	−	−	−	−	−	+	−	−
Complete clothing	+	−	−	+	−	−	+	+	−
No. of coffee plants	>300	100–300	0–100	>500	150–500	0–150	>1000	800–1,000	0–800
Korarima production area (ha)	0.10–0.25	0.05–0.10	<0.05	0.15–0.25	0.10–0.15	<0.10	>0.25	0.15–0.25	<0.15
Iron corrugated house	+	+	−	+	+	−	+	+	−
House constructed from mud	−	−	+	−	−	+	−	−	+
Maize harvest per year (kg)	−	−	−	>80	40–80	<40	−	−	−
Enough food for family	+	+	−	+	+	−	+	+	−
Enset production area (ha)	>0.25	<0.25	<0.25	>0.25	<0.25	<0.25	>0.25	<0.25	<0.25
Cereal mill	−	−	−	−	−	−	+	−	−
Trader	−	−	−	−	−	−	+	−	−

+, yes; −, no

following a systematic sampling method. Three community leaders and 12 key informant farmers were involved in the wealth ranking practices. They were asked to list the household wealth indicators, and group them in relative wealth category in the community. The households were categorized into one of three-wealth categories: poor, middle and rich. The key informants sorted out a number of cards and placed them into three separate piles for rich, middle and poor households. On each card one household name was recorded. Following this ranking system, overall wealth distribution was established, and the proportion of each wealth group was calculated in each administrative zone. A total of 315 households were visited. The discussions were carried out with the households, and semi-structured interviews and participatory rural appraisal (PRA) procedures and techniques were used to gather data.

To analyse the impact of returns obtained from korarima on household wealth status, 105 households were sampled from each korarima growing and non-korarima growing farmer in each study administrative zone. A household was considered as an agricultural household when at least one member of the

Table 3 Comparison of wealth status of korarima growers and non-growers in Gamo Gofa, Debub Omo and Kaffa

Administrative zone	Korarima growers %			Non-korarima growers %		
	Poor	Middle	Rich	Poor	Middle	Rich
Gamo Gofa	44.8	46.7	8.6	44	41	15
Debub Omo	45	44	11	43.8	47.6	8.6
Kaffa	48.6	33	19	62.9	34.3	2.9
Mean	46.1	41.2	12.9	50.2	40.9	8.8

Table 4 Distribution of korarima landraces in the sampled household farms ($n = 105$)

	Administrative zone				
	Gamo Gofa				
Korarima landrace	Hato Sukese	Bulki Tere	Ankuzuzi	Number of households	Number of sites
Gelesh	1	3	0	4	2
Local	18	12	16	46	3
Mesketo	24	29	25	78	3
	Debub Omo				
	Meter	Shisher	Gumar	Number of households	Number of sites
Gaye	1	0	2	3	2
Gaco/Azakki	16	16	15	47	3
Jimma	28	25	20	73	3
	Kaffa				
	Kuti	Ogia	Ermo	Number of households	Number of sites
Shetto	6	4	3	13	3
"Male" (Mache)	15	15	18	48	3
"Female" (Anam)	28	29	24	81	3

household was engaged in growing crops and/or raising livestock in private and in combinations with other activities (CSA 2007). Descriptive statistics were used to analyse the data obtained (Table 3).

Survey on household indigenous knowledge systems

In each study administrative zone, 45 households were randomly selected from the three wealth categories to analyse the farmers' indigenous knowledge systems. After developing a questionnaire on various aspects of korarima production practices, semi-structured interviews were undertaken with the heads of each household. Data were collected on 23 selected variables. Males, females and different age groups were interviewed in each administrative zone. The households were asked about korarima production constraints and opportunities, cultivation methods, propagation methods, field management practices, uses of korarima seeds as spice for food flavouring, traditional medicinal uses, economic values, post-harvest handling techniques, marketing systems, domestication practices and others. Information on the farmers' selection preferences, and relative importance of korarima to other crop species were obtained. The questionnaire took approximately 20 min for one household to complete. All the households interviewed relied upon agriculture for their economic livelihood. Finally, the data were analysed using descriptive statistics.

Identification and recording of different korarima landraces and other crop species

The numbers of korarima landraces growing in the three administrative zones by the individual households were identified and recorded (Table 4). The

identification was carried out during the time of the year when the plants were growing in the field to make the identification processes of the various morphological features easier. The names of the korarima landraces grown in each farm were listed by asking the growers to name each landrace taking into consideration the main morphological and agronomic features of the specific landrace that they were cultivating, and the landrace grown in the neighbourhood. The households were questioned about the origin of the planting material of each landrace in the field. The distribution of the korarima landraces that the farmers grew in the different sites was identified. The total number of households and the total number of sites, where korarima were cultivated were recorded. All the crop species maintained in the home garden (around the houses) of the households were also recorded in each peasant association. Finally the proportion of the households growing individual major crops in the main farm field was obtained from crop production data profile of three peasant associations of each woreda to compare the production status of other major crops in relation to korarima.

Analysis of diversity index

Taking the proportional abundance into account as a measure of biodiversity of korarima landraces growing in the different sites of the three administrative zones, commonly used diversity measurement (richness and evenness), Shannon-Weaver and Simpson diversity indices were analysed according to the method given below.

$$\text{Shannon - Weaver diversity index } (\mathrm{H}') = -\sum_{i=1}^{n} pi \ln pi$$

where n is number of korarima landraces, pi proportion of korarima landrace i, and ln the natural logarithm.

$$\text{Simpson's diversity index} (1 - \mathrm{D}) = 1 - \sum_{i-1}^{n} (ni/N)^2$$

where ni is number of farms where korarima landrace, i was found, N is the total number of farms where individual korarima landraces were found.

The probabilities of two individuals randomly selected from a sample belong to the same category can be measured by Simpson (1949) diversity index.

Evenness (E) also called equitability index (J′) was calculated separately as a measure of the ratio of the observed diversity to the maximum diversity. It is defined by the function $E = \mathrm{H}'/\ln s$, where H′ is Shannon-Weaver index and s refers to the number of korarima landraces recorded in each site.

$$\text{Sørenson's similarity index} = \frac{2c}{a+b}$$

where, a is the number of korarima landraces at site A, b is the number of korarima landraces at site B, and c is the number of landraces common to both sites.

Sørenson's similarity index was applied to assess differentiation or beta (β) diversity as recommended by Magurran (1988), and it estimates how different or similar habitats are regarding diversity of the categories under consideration.

The study sites for diversity index analysis were sampled from Hato Sukese, Bulki Tere and Ankuzuzi; Meter, Shisher and Gumar; Kuti, Ogia and Ermo peasant association in Gamo Gofa, Debub Omo and Kaffa, respectively. According to Meng et al. (1998) the diversity at the level of household farms can be determined by any index, and the diversity concept the researcher seeks to present. In our study, index was expressed as the proportion of individual korarima landrace in relation to the total number of korarima landraces.

Analysis of household characteristics

The major important production characteristics of the households in relation to korarima were identified through group discussions. The major household characteristics were household size, household land size, age of household head, household livestock, oxen ownership, other crop species, korarima landraces, distance to the main road, korarima yield, availability of permanent shade trees in the farm, and proportional share of korarima production area (PA). To answer what factors accounted for korarima PA in southern Ethiopia, simple linear regression analysis was carried out using PA as dependent variable, and the other household characteristics as independent variables. The correlation coefficients were also

estimated by considering some of the major household characteristics. The data were analysed using Minitab software, version 15.

Results

The household wealth status

The households' wealth indicators (Table 2) were identified by the community leaders and key informants in the three different study administrative zones. In Kaffa 17.1% were rich, 42.9% middle and 40.0% poor. In Gamo Gofa and Debub Omo the corresponding figures were 13.3, 41.9 and 44.8%, and 10.4, 42.9 and 46.7%, respectively. The proportion of combined rich and middle household was 55.2, 53.3 and 60.0% in Gamo Gofa, Debub Omo and Kaffa, respectively. The lowest percentage of poor households was recorded in Kaffa. The enset land holdings of households as wealth indicator was >0.25 ha for rich households, and <0.25 ha for both middle and poor households in all study administrative zones.

There were no significant wealth differences between korarima growers and non-growers in the three administrative zones (Table 3). However, in Kaffa there tended to be richer korarima growers (19%) compared to rich non-korarima growers (2.9%). The combined mean proportions for all wealth categories of the three administrative zones showed that the percentage of rich korarima growing farmers (12.9%) increased by 4.1% over non-korarima growing farmers (8.8%), and was reduced by the same percentage for poor korarima growers from 50.2 to 46.1%. The proportions, however, were almost the same for middle wealth category growers (41.2%) and non-growers (40.9%).

Indigenous knowledge systems of households

As to farmers' knowledge systems about korarima production practices, the overall responses of sampled households were not significantly different within and over the study administrative zones (data not shown). The descriptive statistics on 23 variables revealed that 100% of the interviewed households within the study areas had responded similarly to seven variables (use of korarima as spice in food flavouring, traditional medicinal use, and importance of shade trees, co-importance of other cash crops, effects of harvesting time, cultural diversity and seed exchange practices of korarima). Of the interviewed households, 95% reported a decline in the korarima yield and PA. Correspondingly 70% households reported an increase in the PA for other crops over the same period. The growers had increased maize production in Debub Omo in the last two decades at the expense of korarima. In all three study administrative zones, as the area of production had been dramatically reduced and replaced by other annual crops, korarima supply declined by about 50%. Eighty-four percentages of the interviewed households recognized that korarima cultivation provides benefits to the overall farming operations, as it does not need intensive management after field establishment. For the other 16 variables the households responded differently but the differences were not significant except for 14% of the households which had propagated the plants by seeds in addition to vegetative propagation. Eighty-six percent of the farmers replied that they did not propagate korarima by seeds; and they had only practiced vegetative propagation using rhizome shoots.

Identification and recording of different korarima landraces and other crop species

The maximum number of korarima landraces identified in each study administrative zone was 3, and the landraces varied from 1 to 3 per farm (Table 4). All local names represent morphologically and agronomically different korarima landraces based on height, leaf number, leaf size, colour of leaf midrib, size and branching habit of rhizomes, flower colour, fruit size, fruit shape and maturity period. Among the sampled households a higher number of farmers were growing 'Mesketo' (78), 'Jimma' (73) and 'Female' (81) in Gamo Gofa, Debub Omo and Kaffa, respectively. Only a few farmers grew all three korarima landraces in their farms. According to the farmers in Kaffa the names 'Male' and 'Female' represented the productivity level of the landraces, 'Female' being more productive than 'Male'. Gelesh in Gamo Gofa, Gaye in Debub Omo and Shetto in Kaffa seemed to have similar morphological and agronomic features.

The total number of crop species maintained in the home-gardens was less in Kaffa as compared to the other two administrative zones (data not shown).

More tuber, root and vegetable crops were managed as supplementary food sources in most of the home-gardens. Among the major crops enset, sweet potato (*Ipomoea batatas* L.) and coffee were grown by a higher proportion of the households in Gamo Gofa (Table 5). In Debub Omo more farmers were growing maize, enset and coffee while there were more enset and coffee-growing households in Kaffa. Out of the households covered by the survey, more households were growing korarima in Kaffa (11.9%) compared to Gamo Gofa (6.3%) and Debub Omo (8.1%). Staple food crops such as tef (*Eragrostis tef* (Zucc.) Trotter), barley (*Hordeum vulgare* L.), wheat (*Triticum* spp.), sorghum (*Sorghum bicolor* L.) and maize were grown in the main farm fields.

Diversity indices of korarima landraces

The total number (richness) of the korarima landraces identified and recorded was low and ranged from 2 at Ankuzuzi and Shisher to 3 at the other sites (Table 6). Both Shannon-Weaver and Simpson diversity indices indicated that the biodiversity of korarima landraces in all study sites was very low. From the values of evenness korarima landraces were evenly distributed among the different sites of the three administrative zones also implying low farm based biodiversity. The differences in similarity indices among the sites were not significant. There were very high similarities between all possible pairs of sites with regard to korarima landraces measured by Sørenson's similarity index (data not shown). Sørenson's similarity index was uniform in Kaffa, indicating that the korarima landraces in the various household farms were homogenous. All households grew the same, few korarima landraces.

Household characteristics

Table 7 shows the simple linear regression coefficient (β-values) for all variables included in the regression functions. The age of the head of the household, the number of the household livestock and the number of shade trees in the farm significantly ($P < 0.01$) affected the korarima PA in the three administrative zones. However, the landrace of korarima grown and distance to the main road did not significantly affect the PA. The PA as response variable and shade tree number (STN) as independent variable over the administrative zones showed significant linear relationship when tested at $\alpha = 0.01$ (Fig. 2). With every increase in one unit shade tree, PA increased by 0.0133 units with regression equation of PA = 0.0481 + 0.0133*STN. Some of the farmers who had a relatively higher number of permanent shade trees did unusually increase the korarima PA giving rise to a few outliers.

The analysis of correlation coefficients implied that the relationship of household characteristics were

Table 5 Proportions of households ($n = 1{,}215$) growing major crop species and korarima in Gamo Gofa, Debub Omo and Kaffa in southern Ethiopia

Crop species	Gamo Gofa	Debub Omo	Kaffa
Korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen)	6.3	8.1	11.9
Coffee (*Coffea arabica* L.)	61.7	75.8	78.6
Enset (*Ensete ventricosum* (Welw.) Cheesman)	84.9	86.4	82.3
Maize (*Zea mays* L.)	53.5	99.1	20.2
Sorghum (*Sorghum bicolor* L.)	55.2	63.3	44.7
Haricot beans (*Phaseolus vulgaris* L.)	51.9	62.6	48.7
Horse beans (*Vicia faba* L.)	46.5	21.7	39.6
Peas (*Pisum sativum* L.)	15.1	12.4	14.6
Barley (*Hordeum vulgare* L.)	39.7	28.2	12.3
Wheat (*Triticum* spp.),	24.5	3.5	3.2
Tef (*Eragrostis tef* (Zucc.) Trotter)	45.8	12.5	23.5
Potato (*Solanum tuberosum* L.)	48.8	2.6	1.4
Sweet Potato (*Ipomoea batatas* L.)	81.7	6.3	2.1
Taro (*Colocasia* spp.)	62.7	40.4	4.4

Table 6 Korarima landraces diversity in the different sites of Gamo Gofa, Debub Omo and Kaffa administrative zones of southern Ethiopia expressed as richness, Simpson (1−D), Shannon-Weaver (H′) indices, and evenness

Administrative zone	Site	Richness	1–D	H′	Evenness
Gano Gofa	Hato Sukese	3	0.513	0.778	0.708
	Bulki Tere	3	0.487	0.812	0.739
	Ankuzuzi	2	0.476	0.669	0.965
Debub Omo	Meter	3	0.488	0.748	0.681
	Shisher	2	0.476	0.669	0.962
	Gumar	3	0.541	0.856	0.779
Kaffa	Kuti	3	0.565	0.939	0.855
	Ogia	3	0.530	0.875	0.797
	Ermo	3	0.551	0.882	0.803

significant in all the three administrative zones (Table 8). In all study administrative zones household land size and number of crop species grown were positively and significantly correlated when tested at 1% probability. The same trend was obtained for household land size and household size in the three administrative zones. The korarima landraces were significantly related to crop species, household size and household land size in Kaffa but not related to all the household characteristics in Gamo Gofa and Debub Omo. The household land size and household livestock were positively and strongly correlated ($r = 0.988$) in Gamo Gafa. The household size and crop species were positively and strongly related ($r = 0.952$) in Kaffa.

Discussion

Wealth status of households

The household wealth status was positively related to resources, and less affected by cultural background and agro-ecology in agreement with what Tsegaye and Struik (2002) reported on enset and Gedebo et al. (2007) on amochi (*Arisaema schimperianum* Schott). The wealth proportions of non-korarima growing rich farmers were higher in Gamo Gofa than in Debub Omo and Kaffa. A shortage of permanent shade trees encouraged non-korarima growing rich farmers in Gamo Gofa to produce horse beans (*Vicia faba* L.) at large for income generation at the expense of korarima (Birhanu, personal communication 2004). In Debub Omo and Kaffa the wealth status of korarima growing farmers was higher than non-korarima growers. Relatively higher proportions of farmlands were allotted for korarima cultivation in Kaffa due to high land holdings and availability of shade trees. The majority of non-korarima producing farmers were poor in the Kaffa areas indicating that korarima has been one of the main income generating crops. The status of natural forest where korarima grows wild was also better in Kaffa implying the possibilities for households to collect pods for sale from wild grown korarima.

Table 7 Regression coefficients (β-values) for factors affecting the korarima PA in Gamo Gofa, Debub Omo and Kaffa

Independent variable	Area of production as dependant variable		
	Gamo Gofa	Debub Omo	Kaffa
Household size	0.0309*	0.0171	0.0340
Household land size	0.0339*	0.0239	0.0345*
Age of head of household	0.0038*	0.0032*	0.0075*
Household livestock	0.0103*	0.0143*	0.0265*
Oxen ownership	0.0804*	0.0587	0.1580*
Number of other crop species	0.0166	0.0212	0.0599
Korarima landraces	0.0642	0.0386	0.1070
Distance to main road (km)	0.0033	0.0019	0.0059
Estimated yield of korarima per hectare (kg)	0.0390*	0.0444*	0.0923
Number of shade trees in the farm	0.0096*	0.0082*	0.0195*

*Significantly different ($P < 0.01$)

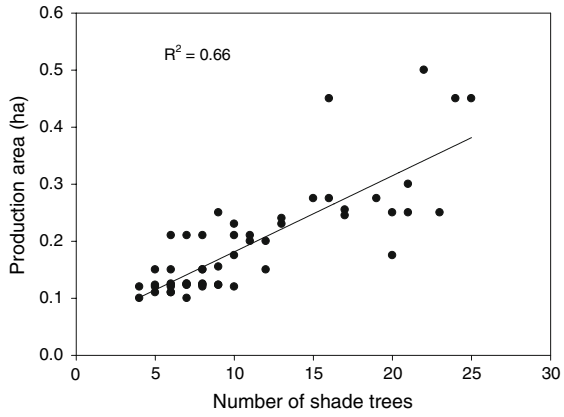

Fig. 2 Scattered plot with regression line indicating linear relationships between numbers of shade trees and production areas

Indigenous knowledge systems of households

The studies on the indigenous knowledge and production practices of korarima showed a general decline in the past few decades in southern Ethiopia. The most common reason given for the decrease in the production of korarima was shortage of permanent shade trees as a result of destruction of natural forests, low yield and lack of improved varieties. Farmers acknowledged that replacing korarima with other crops had contributed a lot to the increase in the areas of annual crops. The majority of the interviewed farmers explained that production costs of korarima were less compared to other major crops, as it did not need intensive management. However, both these and other problems have discouraged the framers. The majority of farmers planned to decrease korarima farms in the survey year. They had changed their production practices in an attempt to increase the yields and profits of other crops. Compared to the mid 1990s, most farmers in the study areas have abandoned the production of korarima. Teklu and Hammer (2006) reported similar findings on tetraploid wheats stating that displacement of landraces by other crops, and farmers' preference to yield potential reduced the chance of maintaining landraces. The overall responses of the sampled households indicated that farmers' knowledge and korarima production practices were similar in all administrative zones. The differences in social status, educational level, experience and exposure to information accesses probably contributed for some minor differences in household responses for the same variables interviewed.

Identification and recording of different korarima landraces and other crop species

One of the korarima landraces observed in all the three administrative zones seemed to be similar with respect

Table 8 Correlation coefficients (r) among major household characteristics

Administrative zone	Household characteristics	KLR	CS	HHL	HHS	HHLS
Gamo Gofa	Korarima landraces (KLR)	–				
	Crop species (CS)	0.412	–			
	Household livestock (HHL)	0.506	0.756*	–		
	Household size (HHS)	0.250	0.453	0.779*	–	
	Household land size (HHLS)	0.547	0.741*	0.988*	0.759*	–
Debub Omo	Korarima landraces (KLR)	–				
	Crop species (CS)	0.489	–			
	Household livestock (HHL)	0.440	0.833*	–		
	Household size (HHS)	0.224	0.602**	0.740*	–	
	Household land size (HHLS)	−0.016	0.607*	0.603*	0.677*	–
Kaffa	Korarima landraces (KLR)	–				
	Crop species (CS)	0.740*	–			
	Household livestock (HHL)	0.076	0.070	–		
	Household size (HHS)	0.738*	0.952*	−0.042	–	
	Household land size (HHLS)	0.707*	0.763*	−0.190	0.774*	–

*Significantly different ($P < 0.01$)

to morphological and agronomic parameters suggesting duplication in naming. Farmers used various morphological and agronomic characteristics to identify the landraces growing in the three administrative zones, which is in agreement with the findings of Taye et al. (2007) in *Plectranthus edulis* (Vatke) Agnew. The differences in the diverse ethnic languages of the three study administrative zones might have contributed for duplication in naming of this korarima landrace. To confirm this it should be investigated further by molecular methods. In each administrative zone the maximum number of distinct korarima landraces was three. This suggests that the farmers' named varieties of korarima were very low indicating low farm based biodiversity of korarima, a native plant to Ethiopia. The reason for the low number of distinct korarima landraces grown and the low farm based biodiversity might be both the lack of improvement program of korarima and the destruction of the natural habitat of the plant. On the contrary, Tsegaye and Struik (2002) reported diverse landraces of enset, native to Ethiopia grown in the Sidama (52), Wolaita (55) and Hadiya (59) administrative zones of southern Ethiopia. In the Sidama administrative zone of southern Ethiopia more diverse landraces (79) of enset were also recorded (Tesfaye and Ludders 2003); Tamiru et al. (2008) found a decreasing trend in the number of landraces in yams (*Dioscorea* spp.) maintained on individual farms in the southern Ethiopia. Traditional vegetative propagation by rhizomes and self-pollination in korarima might also have contributed to low farm based biodiversity. The higher number of the crop species maintained at the home-gardens of the households of Gamo Gofa and Debub Omo implies that the biodiversity of cultivated crop species at the home-gardens was higher in those administrative zones than in Kaffa where the households were specialized in a few cultivated crops to generate income. In each administrative zone enset was grown by a high proportion of households indicating that enset was used as one of the major leading food crops in southern Ethiopia. A higher proportion of households were growing korarima in Kaffa probably due to the availability of more arable land and shade trees.

Diversity index

When compared with other native plants of Ethiopia such as enset, tef and sorghum, the diversity indices for korarima were lower implying low farm based biodiversity. Tesfaye and Ludders (2003) found higher Shannon-Weaver diversity index values for native enset land races in different sites ranged from 8.2 to 23.8. Also for yam from different districts of southern Ethiopia, Shannon-Weaver diversity indices were recorded in the range from 1.36 to 2.14 (Tamiru et al. 2008). The low values H′ and less number of korarima landraces implies that the korarima landraces face considerable risks of loss mainly due to destruction of natural forests. Generally the low biodiversity indices that were observed in all study administrative zones may well indicate that the korarima landraces were highly affected among all by habitat destruction.

Household characteristics

Regression analysis revealed that PA as dependent variable was significantly and positively related to the availability of shade trees in the three administrative zones implying the more tree shades in the household farms, the more areas allotted for korarima cultivation. This finding suggests that the maintenance of shade trees on the main farm field is the main requirement for korarima production. The shade trees like *Croton macrostachyus* Hochst. ex Delile, *Cordia africana* Lam., *Dracaena* spp. and *Albizia schimperiana* Oliver were found to be suitable to grow korarima under the canopy of the trees (PFMP 2004). In Kaffa the korarima landraces had affected the PA of korarima in a significant and positive manner as household land holdings were higher than in the other two administrative zones. In Kaffa, the households increased the PA by clearing land under the canopy of trees in the natural forest close to their farm to maintain more korarima landraces. Most of the rich households in Kaffa were specialized in a few cash crop species. Specialization in the production of a few crops may offer the possibility to grow high-value crops at the risk of agro-biodiversity of native crops like korarima; and cropping activities become more market-oriented as reported by Clement et al. (2003). On the contrary Coomes and Ban (2004) reported that the proportion of native species was not affected by market orientation.

For a unit increase in shade tree number, there was a linear increase in PA. From $R^2 = 0.66$ value it is apparent that significant variability in PA over the

region could be explained by the number of shade trees in the household farm. Among household features, korarima landraces grown in the household farm generally appeared not to be related with most of the household characteristics in Gamo Gofa and Debub Omo. Generally in this study household characteristics did not influence farm based biodiversity of korarima, which is in contradiction with what Tsegaye and Struik (2002) found on enset, Gedebo et al. (2007) on amochi and Benin et al. (2006) on cereal crops where diversities were affected by the household features.

Conclusions

This is the first report on a substantial change of korarima production practices and farm level biodiversity in southern Ethiopia. In this study the korarima farm level biodiversity was not significantly influenced by wealth status and household characteristics. The farmlands allotted for korarima cultivation were small in all the three study administrative zones relative to other major crops indicating low farm based biodiversity of korarima. Generally, the returns obtained from korarima did not increase the economic well-being of the growers over non-growing households across the administrative zones. Farmers are generally dissatisfied with the korarima production and are abandoning planting to replace korarima with other crops to maintain food security at family level and generate income from the sales of other crops. Farmers explained that the yield of korarima has declined very sharply in the past few decades. The low yield, lack of improved varieties and shortage of permanent shade trees were major concerns. These bottlenecks have resulted in a small number of farmers growing korarima in a very small plot of farmlands in each study administrative zones.

Korarima faced considerable risk of loss mainly due to destruction of natural forests. Considering the importance of korarima in local agriculture and traditional uses, it is high time to address the problems currently faced by korarima growers. Findings of this study suggest that the biodiversity in korarima could be studied in detail using molecular techniques, and more research is required on management practices, conservation strategies, genetic diversity and crop improvement programs to develop new korarima varieties that grow under open conditions without shade trees.

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