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Enset and Root Crop Production in Relation to Food Supply Assessment, Food Security and Nutritional Status in Ethiopia

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Summary and Background

Enset ventricosum is the edible species of the separate genus of the banana family, thus named `false banana' but the Enset fruit is not edible. Variation within the species to altitude, soil and climate has allowed widespread cultivation in the mid-to-highlands of Western Arsi-Bale, the Southern Ethiopia Peoples Administrative Region, and Western Oromia including South and West Shewa, Jima, Ilubabor and Welega. Three Enset derived foods are popular but the most common is Kocho. The plant is cut before flowering, the pseudostem (see definition below) and leaf midribs are scraped, the pulp is fermented for at least 15 days and finally steam-baked flat-bread is prepared. As many as 7 million people consume the low-protein, Enset products as staple or co-staple foods, sometimes solely with Vitamin A foods but without the needed supplementation. Leaf, fibre and plant parts are used for food wrappers, cattle feed, ropes and house construction materials.

The December, 1993 FAO/WFP Crop and Food Supply Assessment gave figures and estimates of Enset and root crop production for the past 7 years amounting to about 10% of the net cereal and pulse production. Enset/root production was not included in the 1994 report, though `its contribution to nutrition is considerable.--a formula for its inclusion in the food balances needs to be determined--.' The Mission felt that some confusion exists over recent Enset yield reports of 4 metric tomnnes per hectare (Mt/Ha) in cereal equivalent (CE) compared to Ministry of Agriculture estimates of 5Mt/Ha-CE. Moreover in the Southern Peoples Administrative Region, 1994 estimates of 300,000 hectares of Enset is projected to yield 10Mt/Ha-CE. When Western Oromia is included, at least 7 million people (1/8th of Ethiopia`s population) are thought to derive a `substantial' portion of their dietary intake from Enset.

The present field trips and data compilations are in agreement that several Enset/root cropping systems form major food production/ consumption systems of the farm and urban population of these two regions. Four of the common Enset farming systems are described in relationship to their productivity, cash generation and food security. However, with the increasing population pressure on already limited cropland resources, a succession of increasing reliance primarily on Enset, but also on the highly productive root crops is proposed. This will predispose the population of these areas, especially weaned children, to the effects of critical deficiencies in protein intake. Also discussed are the effects of high dependency on these crops in relationship to fertilizer use and crop improvement, drought and rainfall deficiencies and crop diseases and pests.

It is hoped that this report will be helpful in stimulating FAO and the government to focus proper attention to these crops. Unlike the pulses (which also are about 10% of the grain production in Ethiopia, are the basis of non-meat national dishes, are a vital protein supplement to the cereal diet, but are very low in productivity), Enset and the root crops are simple basic starch crops, quite low in protein, not very adaptable to varying food dishes but very high in productivity. Therefore the implications of heavy dependence on these `poor nutrition' crops may have serious implications on the physical and mental health of the `Enset Culture'. The few reports and persons studying these factors are discussed.

The Importance of Assessing/Reporting Enset Production

An accurate account of vital food supply is important to the food security of any people but especially in areas which have experienced food shortages in the past. More than this, governments of the people need to take responsible actions to ensure food supplies. To do this, policies which encourage stability and growth of food production must be formulated to insure a reliable supply of inputs and protection against hazzards. This includes the focus of research and extension activities to address constraints limiting production and factors that could lead to increased output. These factors interact in determining the food security and nutritional status leading to health and welfare of the nation's people.

Definition of Terms

Pseudostem -the `tree trunk' formed by the bases of the leaves adhering to one another in concentric fashion

Corm -the enlarged structure at the base of the plant from which the leaves and roots emerge- such as Begonia sets

Kocho -the pulp of the Enset pseudostem derived by scraping the individual pieces and excluding the fiberous remains. After chopping, washing, squeezing and fermenting the raw mash is called Kocho and it is this product at 50% moisture that is being assessed. When steam baked, the flat-bread is also called Kocho.

Bulla -the small amount of water insoluable starchy product that separate from the Kocho during processing and is eaten as porige or added to the Kocho.

Amicho -the food resulting from chopping, pounding and cooking the corm again either eaten separately or added to the Kocho.

Assessment Production Data- Past and Present

Reliable Enset production assessment is difficult because plants are harvested a). after 4-7 years depending upon altitude- conditioned growth rate, b). depending upon the family's food needs, and c) vary greatly (agroecologically, varietally, and individually) in yield of Kocho which is itself `about' 50% water.
However this is not reason to abandon estimation of production of a crop that may be providing 10% of Ethiopia's food production. Certainly from the many reported surveys a reasonally accureate method of sampling could be used to assess production.

Evans[1] states that Enset crop production is a necessary parameter to measure since it is not only used for food security assessment of the Enset dependent areas but also for formulating government policy and research/extension resource allocation to the crop. In the words of one 1994 crop assessment team member

> `Everyone agrees that measurement of the Enset plantation area is straight forward and we have to rely on the farmer to truthfully report the number of plants he harvested. But there is where the consensus ends. What mathematical figure to use for the yield per plant, no one agrees.'

Enset production assessment for the years 1987 to 1990 were made by the Central Statistical Authority (Table 1) using enumerators trained in measuring yields from 2 x 2 meter samples of grain fields. For Enset production they had to rely on `farmers reported average yield per plant' and age of plants harvested to calculate per hectare per year harvest yields. It was to the farmers advantage during that time to report low yields to a government which was extracting a portion of their cereal production for storage and redistribution.

Beginning in 1991 the responsibility was shifted to the Ministry of Agriculture, first at the national level and recently to the wereda and zonal level. At first an `incremental growth level' was used but now from each wereda, local MoA staff estimate the proportion of the total cropland of each Peasant Association utilized for each crop and the yield levels for each agroecology.

In the 1993 MoA report compiled by CSA[2], the report of 2,831,000MT of Enset (1,655,000Mt of cereal equivalent) came from 137,000 hectares giving an average of 206 Qt/Ha (12.8Mt-CE). This is almost 3 times the amount reported by the 1993 WFP/FAO crop assessment for <u>Enset AND root crops</u>. At that time it was felt that the numbers must be exagerated so an incremental increase (4.7%) was used to estimate production. SEPAR, largely Gedio, Hadiya, N/Omo, Sidamo and Kembata, produced 2,417,000Mt on 102,000 hectares at 237 Qt/Ha while Region 4, largely

[1]Valerie Evans, 1993. Consultants Report for Enset Pilot Survey. FAO Project ETH/89/013.

[2] MOA/CSA Crop Assessment: 1993/94 Report on area, production and yield of crops - private holdings (Meher Season). September, 1994. Addis Ababa.

Borena, Jima and Bale produced 414,000Mt on 35,000 hectares at 117 Qt/Ha. Climatic, edaphic, cultural or varietal differences for the more than double yield levels between the two regions are not known but administrative emphasis on the crop may have entered into the assessment since Enset is reported to be the major crop (65% of the 37 million quintals of crop production) for SEPAR compared to Region 4 (9% of the 46 million quintals of production).

For the 1994 crop assessment, data provided by SEPAR MOA (Table 2 and 3) reported 5,008,000MT of Enset production (Using .6 as the moisture correction factor gives 3,104,900Mt-CE) on 300,000 hectares giving 166 Qt/Ha (10.3 Mt/Ha-CE). Sidamo moved from fourth to first in production changing from 227,000Mt on 23,000 hectares (82 Qt/Ha) to 1,026,000Mt on 43,000Ha (240 Qt/Ha). Gurage Zone moved from seventh to second changing from 53,000Mt on an unspecified area to 864,000Mt on 52,000Ha (166 Qt/Ha). Gedio zone moved from first to fouurth in production changing from 889,000Mt from 8,900Ha (1000 Qt/Ha) to 186,000Mt on 18,800Ha (100 Qt/Ha).

The SEPAR root crop production of 825,173Mt on 80,181Ha gives a cereal equivalent of 495,104Mt for a total Enset and root crop yield of 3,599,000Mt-CE from SEPAR alone compared to the estimate of 670,000Mt of the previous year. Production data from Region 4 has not yet been recieved (Table 4). It became evident that a realistic assessment of production needs to be made before entering into the picture for the national food availability report. Inclusion of these crop figures would significantly raise the caloric balance 30-50cal/day for all Ethiopia. It was concluded that misleading data may be worse than no data at all, so cereal and pulse production data alone were used in the 1994 assessment.

Some of the descrepancies can clearly be seen to be decimal/ typographic but others must be attributed to the zonal/wereda MoA staff. It was also reported that in the past villagization programs descouraged planting of the multi-year crop whereas now people are moving back to their holdings with expansion of their normal planting for food security. Nevertheless, the need for ascertaining the accuracy of these reports can be seen as we are dealing with a reported substantial volume of food from a potentially highly productive crop.

In published studies of enset production on sample areas, attempts to assess production are numerous. In a 1985 extension cirrular, Dereche proposed from his studies that a family of five using Enset as the major staple food would consume 60 plants (4 to 8 years old-the age depending on the altidude) per year. Further his estimates that 2000 plants per hectare would produce 500 quintals of product which amounts to 25 kg of product per plant. Using an average plant age of 6 years the yield would be 83 qt/ha and, at 1900 cal/kg of Kocho, this would amount to a somewhat high estimated consumption of 1560 cal/day of Enset for each family member.

In a study of 60 households in 6 villages nearby Attat Hospital in

Gurage zone[3], 46 plants/year were harvested per household of 6.1 persons averaging 34 kg of Kocho per plant. The household average of .16 hectare of Enset divided into the number and yield of plants was found to gave 95 qt/Ha/year assuming 6 year-old plants harvested. Average consumption of .55 kg/person/day amounts to 852 cal/day which was reported to be 78% of the carbohydrate intake. The high yield of Enset derived Kocho in this study was thought to be influenced by the presence of cattle and the use of manure. Although it was known that sale of enset occurrs, which would further reduce caloric consumption, no measurement of sales was attempted.

In extensive descriptive characterizations of Enset culture collected from various sources including their own, Kefale and Sandford[4] found North Omo Enset cultivation to average 78 square meters per household member or .69% of cultivated land. Quoting Teketel, 1975, yield of Kocho, Bulla and Amicho averaged from 27kg per plant in Sidamo to 34kg per plant in Kembata. From Wolayita Agricultural Development Unit data, 78 plants averaged 27kg per plant of Kocho only. Another WADU study of plant spacing with 18 plants per experimental treatment resulted in Kocho+Amicho yields of 18-42kg per plant which translates to 33-70Mt/Ha.

However Sandford (personal communication) who further divides Wolayita Enset plants into two sexes-at which point sex of plants verses varieties become confused (i.e. male plants/varieties being large, fiberous, late maturing and resistant to disease and pests while female ones are opposite), feels that drought, diseases, animal pests and harvest by choice or due to hunger are reducing the number of plants at each age, the number of plants reaching maturity prior to harvest and therefore the per plant as well as per plantation yield. All these factors if true on a widespread basis, would tend to upward bias Enset yield assessment if an average plant yield were used.

Anither factor that should be considered in Enset crop production assessment is inclusion of urban production. Although small garden production of other crops is assumed to be negligible, this is not the case for Enset with normal on-farm plantation size being the same as the size of a garden. Urban families with as little as 500-1000 square meters could grow half of their caloric intake in the Enset garden. For this reason and the increasing semi-urban population, it would be informative to include this Enset production when surveying the Enset areas.

Production assessment methods and survey techniques

In 1993 FAO project ETH/86/013[1] attempted to formulate a questionnaire to determine design and survey techniques for future measurement of

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[3] Pijls, Loek. et. al. 1994. Cultivation, Preparation and Consumption of Enset in Ethiopia. J Sci Food Agric. July 16, 1994.

[4] Kefale Alemu and Stephen Sandford. 1991. Enset in North Omo Region. Farm Africa FRP Tech Pamphlet 1. Addis Ababa.

Enset production, consumption, sales and contribution to diet. In the pilot survey, five households in each of 2 peasant associations in 4 awrajas in each of five zones (195 samples) were selected for data collection. Although field size of each crop was enumerated, results were not reported `because fallow and pasture land was not measures and would have biased size and proportion of landholding'. (NOTE: CSA has the raw data and promises to summarize before the mid-year assessment update.) In the Enset plantation 30% of the plants were new sets whereas only 15% (85 plants/landholder) were over 5 years old. Average number of plants/holder varied from 86 in Illubabor to 1190 in Sidamo.

When trying to measure production of Enset products, it was found that `local unit names for measuring the Kocho varied' as well as `the weight of the *bundle* for a particular unit varied from 1 to 15 kg within the same awraja'. Even after buying, harvesting, fermenting and weighing the products of 163 mature plants individually, yield of Kocho varied from 8.5kg/plant from 6 year old plants from Sidamo to 92.5kg for 5 year-old plants from Illubabor (Table 5). The standard deviation of yield from plants of the same age from the same zone averaged 9.3kg, nevertheless the average plant yield of the 163 plants was 30.8kg. Although other extensive data was taken such as storage and preservation, livestock and poultry ownership, and foods consumed, this data did not address the basic question of assessing Enset area and production.

The study concludes that in determining Enset production, instead of trying to determine the number of mature plants or asking producers the number of Kocho bundles produced, simply measure the plantation, ask the number of plants harvested this year and multiply by an average expected plant yield for the Region. The deficiency of this assessment method are 1) mainly the large individual variation in plant yield due to varietal, altitudinal, climatic, edaphic differences-even farmer husbandry and cultural differences such as times transplanting and manuring, 2) differences in age at harvest amoung farmers due to his current year food supply i.e. when food shortages occur, younger plants will be harvested, and 3) the accuracy with which the farmers can calculate the number of plants harvested i.e. farm men and women know the number of plants/batch fermented and for how long a batch will last the family. For instance they could readily answer 4 plants will supply our household for 20 days or 10 plants for one month but could not give plants consumed/year.

There are several ways of verifying farmer reported data on Enset production. The number of plants reportedly harvested and yield/plant should be reasonable and consistent with 1) reported family consumption + sales, 2) the number of plants nearly mature in the plantation that would be available for the next year and 3) the number of holes or corms present in the plantation. Consumption of 1kg of Kocho/family member/day would provide 1900cal so #plants/year X yield/plant divided by 365 days and family members should not be more than 1kg/person/day. The second and third points can be verified by observation i.e. when a plant is harvested, usually the hole is not immediately filled with another plant or the corm remains to be used at a later time for other foods or seedlings. Counting the holes and corms can be used to verify the reported plants harvested. In the Gurage Zone the harvest area can easily be evaluated in the mature section of the plantation whereas elsewhere the evidence will be scattered throughout.

On a recent trip to famiarize the author with various aspects of Enset production and utilization, an extensive farmer interview was conducted in each area on consumption and constraints to production (Table 6). On the average from .17 ha or 15% of the land, 39 plants were harvested per year yielding 58 kg/plant. This would provide .62 kg of Kocho/family member/day or 1184 cal/person/day. However in most cases, MOA or NGO development agents directed the author to `better' or `progressive' farmers who were cooperating with them in development programs. When randomly chosen stops were made, three rather different cases were heard. In one case the father had died, the 14 year-old son was hired out for food, and the entire holdings were planted to Enset. In the second case a young man, married with two children-one with signs of Kwashiorkor-had recieved only 1/6ha from his father and couldn't find work even to buy food for the child. In the third case, after 4 children died of pneumonia, the family, which included newborn twins, had moved and with only 2-year-old Enset plants, the father was forced to resort to carrying firewood from the lowlands for 2 birr/day.

Some have suggested that an average minimum yield over each of 3 elevations be used, say below 2000masl the average yield per plant is X, from 2000 - 2500 the yield is Y and above 2500 the factor is Z. This method seems to be an attempt to be `fair' to the regions when in fact it is not. Some areas use high amounts of manure on their plants which is sure to increase growth although the relative effect has never been measured. Other areas group plants by age such that competition among plants for nutrients and sunlight would affect size of harvested plant. With this method of assessment, the actual yield would usually be underestimated because a base level yield would not take into account any factor of husbandry or meteorology that would influence yield. In addition the question of the accuracy of the three factors would continually be questioned and need costly re-evaluation.

Non-destructive measurement of plant characters contributing to yield would appear to be the most logical means of assessing Enset yield. Kefale and Sandford[5], while trying to use plant characteristics to distinguish varieties, report a reasonable 22 and 23% coefficient of variation for pseudostem girth and height respectively, with sample size of only 3 plants but yield was not determined. WADU[6] report plant Kocho yields of 48 plants after measurement of pseudostem girth and height. There seems to be good correlation and an attempt to obtain the individual plant data is being made.

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[5] Kefale Alemu and Stephen Sandford. 1994. First steps in distinguishing Enset landraces in North Omo. Farm Africa FRP Technical Pamphlet no 6. Addis Ababa.

[6] Wolayita Agriculture Development Unit. Crop and pasture agronomy report. 1979/80.

As far as estimating yield per plant, rather than extrapolating for an all-encompassing average yield factor, it is suggested that the farmer sampled be asked to show a couple of plants which he will next harvest (usually within 30 days)-indicating the harvest size and characteristic for that individual farmer being sampled. Measurement of the diameter and height of the pseudostem that he will harvest should enable calculation of the volume of the harvested plant material, which could be corrected for wastage (the fiberous upper and lower surface of the stem pieces) and moisture loss (expressed water) to give Kocho yield. It is not known whether 100kg of stem yields the same weight of pulp across varieties, agreoecologies and rainfall seasons. However since the harvested pseudostem is solid plant material except intercellular air spaces, there should be good correlation between volume of a standing plant and weight of pulp extracted.

This method is similar to yield assessment for high moisture vegetables and livestock forages. For instance all root crops yields are adjusted for 60% moisture even though the standard moisture content varies from 60% for cassava to 80% for white potato and the actual harvest moisture varies from 49-74% for cassava to 70-85% for white potato.

The most scientific and precise method would be to find which factors (preferably no more than 2-3) predict individual plant yield. Data from a sample of measurements would then be used to derive a multiple regression equation to predict yield of assessment surveys. The most direct measurements are usually the most closely correlated, for instance diameter of a plant should be more closely related to yield than the region in which the plant occurrs. Going backward from the final product -Kocho, pulp yield and Kocho yield should be closely related since the only difference is in expressed water (dependent on the moisture content of the plant or about 20% of the fresh pulp) and fermentation loss (which is small). Plant moisture content will vary with the season of the year but should be proportional if all the sample data is taken at the same time of the year, preferably the rainy season since no sample plants would be under moisture stress.

But pulp yield also would be difficult to survey. Therefore pulp yield must be further derived as a function of diameter and length of the stem less the fiber portion which is likely to be a fairly consistant proportion of a mature plant. Therefore a curvilinear regression equation of pseudostem diameter and length along with standard correction factors for moisture and fiber should predict yield (Figure 2). Computer calculation should be no problem but for field or non-technical use a response surface can be generated (Figure 3) and categories or classes delineated to generate a simple 2-way table (See example, Table 7). (Note that the categories may not be equal.)

The Role of Enset and Root Crops in Food Security

The Agro-ecological map (Figure 1) listing food crops by their tonnage of production shows the value of Enset and root crops as primary carbohydrate foods. Throughout the Enset growing areas, high population and small farm size necessitate high yielding crops like

Enset and root crops. It is more than coincidental that the two are most often found together. White potato is better adapted to loose soils and sweet potato to heavier clay soils but Enset thrives on both. The fact that cassava and yam are also grown to a lesser extent indicates the need for a variety of high yielding food crops.

Comparing Gedio and Sidamo with Bale and Jima Zones, although the populations are similar, the production of cereals is much less due to land availability. On the other hand the production of Enset and root crops in the two zones far exceeds that of the two surplus cereal producing zones. North Omo, in spite of its large cereal, Enset and root crop production, is clearly under producing for its population. The small zones of Hadiya and Kembata are high producers of all three but are also highly populated. Gurage production figures may be underestimated.

Enset is recognized and described by the farmer as a flex crop-i.e. in times when there is food shortage (drought, pests or seasonal gaps) additional plants of Enset can be harvested and processed. This was found to be true repeatedly in the Kindo Koshia area following the drought of 1993 and the failure of the sweet potato crop now in 1995. Although one cannot continue to harvest more and more immature plants without reducing future foodstocks, it was noted that as size of family increases or land holdings decrease, proportion of holdings planted to Enset or Enset/root crops increased.

Succession of cropping systems determined by land economy

In the Enset growing areas there are cropping systems adapted to the land availability and food production economy. In the far western part where forest and grassland is not so limiting, cattle herders grow Enset as food insurance. Plants as old as 17 years are reported and occasional plants maturing, dying and drying without being harvested occurs. Also there are areas where the forest soils support either naturally occuring or cultivated coffee trees. Coffee prices have gone up recently and the income per unit land is good. Both of these farming systems can purchase desired cereals from their cash sales. Once land is cleared and where topography allows cultivation, cereal and pulse cropping is popular- wheat, barley, and horse beans at the higher altitudes and maize, sorghum, and hariocot beans at the mid-to lower elevations. These crops also produce crop residues that support livestock in a supplementary role as draft power. However in land short areas, cultivation is by hand and cattle are slaughtered by age four for meat consumption or sale.

Nevertheless as size of holdings decrease, Farmers maintain cereal production but switch from low-yielding pulse cropping to high yielding root crop culture. Sweet potato and/or white are the main substitutes with taro, cassava, and yam being common on a smaller basis probably for variety and insurance since late blight of white potato is common and dry season drought commonly limits sweet potato. Finally vegetables and fruit, though still not large cash cropping systems for self-sustaining farmers, is beginning to occupy ever larger farming areas. Onions, cabbage, carrots and beet root patches are common and avocado, koke (peach), ghesho (hop) and zatu (guava) seedlings are in high demand so MoA tree nurseries have converted from fuelwood species.

High labor requiring, high value crops are the economic factors that would allow the densly populated areas to survive on small landholdings by generating cash for purchase of energy foods. However these crops too are dependent upon market development, climatic dangers, high seed costs and expensive chemicals to control diseases and pests. To give you an example, farmers from Wolayita were in Addis in early February looking for carrot seeds @28 birr/kg to plant at the first rain; the main carrot season is late June. One farmer had even planted carrots in October to hit the market the last week of Orthodox fasting when prices hit 5 carrots for 1 birr(in Shashememe). To do this he had mulched the field with criss-crossed maize stalks to keep out porcupine. This compares to 25birr/qt during the regular growing season. Such inovations and market niches are rewarding to the small landholder but lead him further into risk dependency.

The succession in the scale of decreasing land holdings and increasing dependence on cropping technology can be summarized as follows:

Livestock < Coffee < Pulses < Cereals < Enset < Root Crops < Vegetables < Fruit

It may appear fatalistic to forecast that as Ethiopia's population continues to grow with limited land available, the trend will be in the direction of more high yielding crops, poorer balance in terms of nutritional quality and quantity and higher risk of dependence on these few crops.

Agroecologies of the Enset dependent areas and current food security/nutritional situation in four Enset/cropping ecologies

When considering the problems and solutions to the problems of the Enset growing area, it is important to consider the agro-ecology of the entire crop/livestock system and its means of supporting the family food security. Numerous reports say 7-8 million people are dependent on Enset as a major food with another 2-3 million consuming it as a minor food. However soil, climate, elevation etc. enter into the productive potential and the solution of constraints in each area. The following is a preview of some agro-ecologies growing Enset and information sharing between them could be helpful in finding common solutions.

1. The Enset/coffee/maize culture of Sidamo-Dilla

This area is an intensive coffee growing area with years of development work by the Ministry of Tea and Coffee. Fertilizer and pesticides have been made available for coffee growing especially in the case of the latter for control of the Coffee Berry Disease to the extent that there are no honeybees in the area. With the current price of coffee being good, farmers can buy cereals and pulses as needed and there is no signs of malnutrition in the majority of the population. However from past fluctuations in coffee prices and production, farmers have become accustomed to growing their own Enset as insurance of food supply.

2. The Enset/maize culture of Jima-Mizan Teferi

Because of the high rainfall and length of the Krempt season this area has been renown for high maize yields and surplus production. However to cultivate the maize fields, farmers oxen have consistently been plagued with Trypanosomiasis. Also because of the high rainfall, plant diseases prevalence and severity are high restricting crops adapted to these conditions. Enset however gives the high energy foods needed by the farmer without the risk of disease. Because of the inherent low vitamin A content of Enset, yellow maize high in carotene, the precursor of Vitamin A, is preferred in these areas.

3. The Enset/root crop/maize culture of Wolayita-Sodo

Due to land pressures, livestock production has decreased and area devoted to low yielding pulse production is diminishing. Not only is the population dependent on these high yielding crops but they are grown and eaten successively within the same year. Maize can be planted in February and in July for two harvests in July (June for fresh maize) and November whereas sweet potato can be planted in October and February for harvest in January and May. Therefore oftimes from late February until the end of May, Enset (Kocho) is the only available energy food usually eaten with a little `Ubasha cabbage' as a source Vitamin A. White potato is planted at the higher altitudes in April to be eaten after June because late blight disease becomes severe with the heavy rains. Taro is harvested in November and Cassava is ready in September.

4. The Enset/Livestock culture of Dawro-Waka

The Omo valley is dry and stony with pockets of maize/sorghum and cotton until returning to the Enset highlands, about 30km before Waka, the wereda center. These highland hills are steeply sloping though soils are deep and rainfall percolation is rapid so erosion is not yet evident. The growing season is short supporting only early barley varieties and cabbage. For the three months of July-September it is reported to be only a little lighter in the daytime fog than at night. Pastures are green throughout the year though growth is not luxurious. Meat and milk products supplement the heavy consumption of Enset with no cereals or pulses except those purchased for holidays or by the wealthy. Although pneumonia and TB are present here, many of these people choose to live here and take their cattle to work in the surrounding lowland only in the Meher rainy seasonbecause of the presence of malaria and trypanosomiasis.

Food Nutritional Comparisons for the Enset/Root Crop systems and the interacting factors of nutritional status

During the food shortage of early 1994, it was reported that starving children from the lowland maize/sorghum cropping areas would recover much faster than those from Enset dependent areas. This is thought to be related to the higher incidence of Kwashiorkor related malnutrition cases. Unlike marasmus, energy intake deficiency which is corrected by willing intake of caloric foods, Kwashiorkor is first symptomized by loss of appetite and apathetic unresponsiveness. Accompanying these symptoms, loss of immune response is followed by death from illness, usually diarrhea or malaria, unless protein intake is forceably administered.

Table 8 lists the caloric and protein content of foods eaten in the Enset growing areas. The cause for protein deficiency during the food shortage-high Enset consumption period of February to May can be seen from the very low protein content of Enset and the root crops. The greatest risk is to children under the age of five who are weaned from their mothers milk. This is why vigilant and targeted supplementary food programs are needed for poor and/or food insecure families in the Enset growing areas. Areas with cereal base consumption will last or recover with cereal relief supplies, but Enset/root crop dependent populations will show high child mortality unless supplementary food programs are carefully administered.

In an US/AID Kenya study[7] of the effects of food intake on toddlers and schoolers, limited quantity and quality of diet was found to cause growth retardation, reduced illness resistance and impared cognitive function. In rural areas where large amounts of energy requiring work exist, no resting energy adaptations were found and stunting without recovery was prevalent. While mild illness was found to be related to household sanitation, parental literacy and illness exposure; low levels of food intake, particularly protein and fat, predicted serious illness. After duration of schooling, diet quality (protein composition) was the second most important determinative of cognative performance in school. Students with good diet quality were also found to show more spontaneous social and leadership behaviors than their peers.

Enset production reliability and improvements needed

Effects of drought and rainfall on productivity of the system

Enset grows best at altitudes above 1600masl not because it cannot withstand the heat but because it needs adequate soil moisture. Irrigation studies in hot climates show that it stores large amounts of water but wilts severely during long periods without rain. The fact that transplanting is done in the dry season, usually just before the start of the Belg rain, and that growth resumes, though at a reduced rate, through the dry season has earned the crop the reputation for being drought tolerant. The fact is that in the higher elevations, soil moisture reserves are being depleted by this deep rooted plant, while at the lower elevations severe leaf pruning is practiced to conserve plant water use. The practice of manuring, natural mulching by leaf and stem residues, and the interception of rainfall by plant

[7] Charlotte Neumann et al. 1993. Diet quantity and quality: Functional effects on rural Kenyan Families. Human Nutrition CRSP US/AID.

leaves all contribute to rainfall capture, soil moisture conservation and reducing run-off as compared to bare-earth farming. Therefore Enset is a reliable crop during seasonal rainfall shortages but it would succomb to prolonged droughts.

The effect of the dry period on carbohydrate reserves and caloric content of the Kocho has not been studied. Especially in the lower altitude and dryer climates, it would be expected that plant reserves would be depleted when growth rates decline. Under these circumstances advantage may be taken by harvesting and storing the Kocho supply for the dry period rather than harvesting month-by-month.

Soil fertility and Enset crop improvement prospects

The MOA Enset group has decided to undertake fertilizer and variety yield trials. These will be quite difficult to interpret considering the 5-7 year length of the cropping season and the variance in plant yield even before treatments are imposed. Plot size of 4 plants with 3 replications could have above 20% inherent variation. Based on the limited data of the Institute of Agriculture Research, 6 Enset nursery sites have been selected for increasing certain `selected improved clones' for distribution to farmers. These clones are reputed to be less susceptable to bacterial wilt and better adapted.

Other agronomic practices should be critically examined for contributions to yield. For instance transplanting is practices to conserve land area but is known to delay growth to maturity by 1-2 years. It is not known the size of the trade-off between time and space in the two cropping systems. Some transplanting death occurs (individual farmers transplant 2-3 plants per space) and some selection is probably practiced for better appearing plants. Grouping of transplants is probably practiced to fully utilize the limited supply of manure and well established plants shade out intercropped species. However intercropping with competitive species such as maize, sorghum and climbing beans or already established coffee, hops or tree fruits might allow more efficient Enset production.

Constraints to production from diseases and pests

Bacterial wilt (*Xanthomonas musacearum*) appears to be the only major disease of Enset. While the disease is present and `of concern' in most Enset growing areas, farmers are not alarmed and appear to be living with the disease though asking for `medicine'. Extensive experiments were conducted by Dereje[8] to explore the mode of transmission. One hundred percent infection occurred from cutting leaves with contaminated knives or injecting the bacteria onto the cut surface. Thirty to 60% infection was achived by dipping transplants or watering the soil surface with bacterial solutions. But no infection occurred when transplants replaced dead infected plants (time between replacement not specified). Bacteria were found to survive on the surface of contaminated knives for up to 3 days under humid conditions

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[8] Dereje Ashagari. 1984. Studies of the bacterial wilt of Enset and prospects for its control. Ethiopian Ag Res Conf. Addis Ababa.

and up to 4 days under dry conditions. MOA pathologists and extentionists are instructing farmers in removal and burying diseased plants and sterilization of knives with fire but many farmers believe other means of spread occur and do not cooperate. Presently it appears that most simply grow additional plants and do not bother with diseased plants.

Certainly other means of disease spread are possible and the real means of spread should be elucidated. It is known that bacterial infection of plants occurs by contamination through wounds, breaks in the epidermis or through the stomates (natural ventilation pores). So being able to manually transmit the disease does not mean the same as how the disease is transmitted under farmers conditions. The unanswered questions about Bacterial Wilt of Enset are

1. In areas where transplanting and knife prunning are not practiced, what is the means of infection of Enset plants? (Up to 10% infection was observed in these cases). Possible sources of Xanthomonas spread to new plants are
   a. Splashing rain
   b. Birds, bees/wasps, flies(fruit)
   c. Wind blown leaves of infected plants
   d. Lizards, snakes, etc
   e. soil inhabiting organisms (mole rats, insects, nematodes)
   f. rainfall runoff to newly planted corms or plants

2. Is the farmers' practice of tying down the leaves, allowing the diseased plant to dry, then burning a sanitary control practice? It does prevent contanimation of adjacent plants that could occur during the recommended practice of removal of diseased plants.

3. Wilt occurs most commonly in 3-4 year old plants so is wounding necessary for natural infection and how long does it take for symptoms to show in the central shoot of intermediate age plants?

4. What is the threshold titer of bacteria necessary to incite the disease i.e. could small amounts of inoculum from the above listed natural sources be sufficient to cause disease?

Another threatening pest which can be more devastating to an individual household is mole rats. These animals the size of large rats tunnel from plant to plant eating the roots and corm, inciting variable damage including immediate decline and death of the plant. Cases were observed where serious infestation had caused 10-20 plants/week to be salvaged for what little pulp was possible to extract. Control consists of flooding the tunnel and killing the emerging animals. A large fish-hook type snare trap with a string trigger through the tunnel is being introduced by the MOA.

Table 1. Annual national food production in Ethiopia for the crop year 1987/88 to 1993/94. (1993 FAO/WFP Crop and Food Supply Assessment. Dec, 1993)

Production 000 MT	87/88	88/89	89/90	90/91	91/92	92/93 est.	93/94 fcast
Cereals/Pulses less feed, seed export and postharvest loss	5,703	5,763	5,693	6,231	6,000	6,755	6,322
Enset and Root Crops	570	570	570	600	620	640	670
Milk and Milk Products	249	261	273	285	300	300	330
Meat and Eggs	185	190	195	200	200	200	210
Total Production	6,707	6,784	6,731	7,316	7,120	7,895	7,532

Table 5. Kocho yield statistics for individually measured plants by age and region.[1]

Region	Plants Sample	Plant Age	Kocho yield	Standard deviation (kg)	Coefficient of variation(%)
West Shoa	1	6	23	-	-
	8	7	24	9.45	39
	5	8	23	8.32	35
	3	9	34	2.39	9
	2	10	17	.99	5
	3	12	34	6.56	19
	1	13	20	-	-
	3	14	18	2.05	11
	3	15	33	6.95	21
	2	16	35	7.07	20
	1	17	35	-	-
South Shoa					
	5	4	46	14.08	30
	10	5	56	15.81	28
	12	6	36	24.88	69
	5	7	31	6.02	19
	5	8	37	11.99	32
	1	10	12	-	-
Illubabor					
	2	2	31	3.54	11
	10	3	47	23.66	50
	6	4	47	10.39	22
	2	5	93	10.61	11
	5	6	29	14.17	49
North Omo					
	4	3	11	5.64	52
	13	4	26	11.28	43
	12	5	29	11.21	38
	4	6	31	11.34	36
	2	7	34	.64	1
Sidamo					
	16	4	11	5.26	49
	5	5	22	11.02	49
	6	6	9	1.82	21
	6	7	33	14.89	54
Total	163	Average	30.8	9.33	30.48

Table 6. Enset cropping data from sample farms of the Southern Ethiopia Peoples Administrative Region in March,1995.

Town Zone	Farm size Ha	Enset area Ha	Plants/yr consumed	Plant Yield	Family size	Plant spacing	Plant Dai cm	other foods		Income generation
								grow	buy	
Dilla Gedio	1.5	.5	25	10-15	4	2.0	190	maize fruit	s.pot	Coffee Kocho
Bule Gedio		.08	14	40-60	12	1.25	250	cereals lentil meat		Cereals livestock
H.Selam Sidamo	1.5	.07	100	6-10	8	1.0	50	wheat onion milk		wheat onion
Geneto D Sidamo	.5	.04	12	50	7	.75	175	maize fruit S. cane	pulses onion	tobacco coffee Euca trees chat
Durame Kembata	1.0	.16	100	70	12	2.0	160	maize s.pot w.pot	maize wheat	coffee chat euca trees
Boditi	1.25	.04	24	75	9	.8-1.0	145	maize s.pot h.bean		teff s.cane
Wajakero Wolayita	.75	.12	20-25	100	24	1-4	100	maize s.pot w.pot	wheat barley pulse	coffee teff maize
D.Wogane Wolayita	1.0	.05	40-50	65	12	1.5	125	wheat s.pot w.pot milk	maize s.pot taro	wheat horsebean
Waka	1.25	.38	18	100	7	1.0	225	meat	maize F.bean	
Angacha Kembata	1.25	.35	24	35	8	1.5	180	wheat F.bean		wheat F.bean

Average	1.10	.17	39.2	58	10.3	1.6	160		

Table 8. Nutrient value of some common foods eaten in the Enset growing areas.

Food Source	% Water	Value of 100gm edible portion	
		Calories	% Protein
Cereals			
Maize	12	363	10.0
Wheat	13	344	11.5
Teff	11	345	8.5
Legumes			
Haricot bean	10	339	24.0
Horse bean	9	342	25.0
Fleshy plants			
Enset	50	190	1.5
White potato	80	75	2.0
Sweet potato	70	114	1.5
Yam	73	41	1.0
Cassava	60	153	0.7
Taro	70	113	2.0
Oil Crops			
Niger	6	513	17.0
Vegetables			
Beetroot	87	45	1.8
Carrot	90	33	1.0
Leaf cabbage	90	28	2.0
Fruits			
Avocado	75	165	1.5
Banana	70	116	1.0
Papaya	89	39	0.6
Meat			
Beef	66	202	19.0
Fish	78	95	18.0
Eggs			
Milk			
Cow, Whole	88	64	3.3