PATHWAYS FOR FITTING LEGUMES INTO THE FARMING SYSTEMS OF EAST AFRICAN HIGHLANDS: A DUAL APPROACH[1]

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ABSTRACT

Food legumes remained to be important components of various farming systems of Eastern Africa, while the attempt to integrate fodder legumes and legume cover crops (LCCs) became unsuccessful. Despite recognising their benefits as soil fertility restorers and high quality fodder, farmers remained reluctant to integrate legumes mainly due to community/farmer specific socio-economic determinants. This paper is based on the experiences of the African Highlands Initiative that has striven to integrate legumes in Ethiopian Highlands, Areka, and also understand the processes of integration of legumes of different use through participatory research. Areka had an altitude of 1990 masl, and rainfall amount of 1300mm, which is characterised by mixed subsistent farming systems, poor access to resources, intensive cropping, land shortage and soil degradation. Participatory evaluation was conducted on the agronomic performance and adaptability of eight legumes for three consecutive years during the main and small growing seasons, accompanied by extensive data collection on socio-economic determinants. PR experiences showed that the selection criterion of farmers was far beyond biomass production. The major biophysical traits are performance of the species under that specific agroecology, which was characterised by yield, disease and pest resistance, effect on soil fertility and the succeeding crop and its compatibility into the existing cropping system. Specifically, farmers identified firm root system, early soil cover, biomass yield, decomposition rate, soil moisture conservation, drought resistance and feed value as important criteria. The total sum of farmers' biophysical criteria showed that Mucuna followed by Crotalaria could be the most fitting species, but farmers finally decided for Vetch, the low yielder, due to its fast growth and high feed value. Farmers' priority was livestock feed over soil fertility. The final decision of farmers for integrating a food legume into their temporal & spatial niches of the system is dictated by the food habit while for non-food legume it depended on land productivity, farm size, land ownership, access to market and need for livestock feed. The potential adopters of LCCs and forage legumes were less than 7%, while 91% of the farmers integrated the new cultivars of food legumes. Strategic combination of biophysical and socio-economic determinants in the form of decision guides was suggested to facilitate the integration of legumes to help farming communities, development agencies and researchers to easily identify potential adopters, learn about the criteria of choice and suggest an improved system management. Moreover, it may also help them to identify niches and/ or create niches, modify the existing systems and promote the technology for wider use.

Key words/phrases: Legumes, subsistent farmers, selection criteria, integration, decision guides

INTRODUCTION

Legumes are known to play a pivotal role in nutrient cycling and nutrient enrichment in various subsistence farming systems of Africa. They are considered as engines of sustainable farming as they intensify the productivity and interaction of the soil, crop, livestock, people and other components. In most part of Africa, where livestock products are unaffordable, legumes, especially beans, cow peas, peas, chickpeas and faba beans are the major sources of protein. The maize-based, the banana-based and Enset-based systems are supported mainly by beans and cowpeas as major protein sources. Legume fodder, as crop residues or hey, is also a high value feed for milking cows, calves & draught oxen, especially when during the dry spell and in the time of high-energy demand. Legumes are also known to increase soil fertility through various mechanisms. High quality legume fodder produces also high quality manure that could improve soil fertility. Legumes can also boast the nitrogen stock of the soil through nitrogen fixation and nutrient release from their organic residues. Some legumes also release root exudates that may increase the availability of unavailable/fixed nutrients, e.g. phosphorus, through changing the rhizosphere pH and increased activity of the rhizosphere biota.

The increasing interest towards organic farming in the developed world and the challenge to decrease costs of inorganic inputs to maintain soil fertility in the developing world attracted the attention of researchers and policy makers towards legume technology. Organic inputs from legumes could increase crop yield through improved nutrient supply/availability and/or improved soil-water holding capacity. Moreover, legumes offer other benefits such as providing cover to reduce soil erosion, maintenance & improvement of soil physical properties, increasing soil organic matter, cation exchange capacity, microbial activity and reduction of soil temperature (Tarwali *et al*., 1987, Abayomi et al., 2001) and weed suppression (Versteeg et al., 1998). There are several studies in Africa that showed positive effects of Legume Cover Crops (LCCs) on subsequent crops (Abayomi *et al*., 2001, Fishler & Wortmann, 1999, Gachene *et al*., 1999, Wortmann *et al*., 1994). Studies in Uganda with Crotalaria (Wortmann, *et al*., 1994, Fishler and Wortmann, 1999), and in Benin with Mucuna (Versteeg *et al*., 1998) showed that maize grown following LCCs produced significantly higher yield than those without green manures mainly through high N& P benefits and partly through nutrient pumping from deeper horizons. LCCs could also decrease nutrient losses by trapping a huge amount of nitrate that could have been lost by leaching or denitrification if heavy pre-season rainstorms occur (Giller, 2001). However, the benefits vary with the legume species, their management, soil fertility status, the climate and the market value of the preceding crop. In some cases, integration of legumes for green manuring was not profitable when used for fertilisation of cereals. Participatory experiments on crotalaria in Uganda showed that green manuring was not compensating for the time it occupied the field although there was an increase in maize yield as an after effect (Fishler & Wortman, 1999). In general, the type of LCC species that is desirable for green manuring depends on the use to which it will be assigned. In the case of weed suppression or erosion control is desired, then a species with rapid development of a dense soil cover is required, but if the major aim is to intercrop with a cereal, species that grow slowly and erect are more suitable (Giller, 2001).

Despite the positive benefits, the success rate in achieving effective adoption of soil-improving and forage legumes in Sub-saharan Africa has been low (Sumberg, 2002, Giller, 2001, Thomas and Sumberg, 1995) as farmers remained reluctant to adopt legumes cover crops and forages. It could be partly because of absence of methodologies and tools that extensionists and community mobilizers could use to facilitate the integration of legumes, as the information on legume technology is diverse and accumulated in patches. There is, therefore, a need to assemble and organise the available information not only to identify the gaps but also synthesize the data towards developing a decision support system that may facilitate the decision of farmers, researchers and policy makers to select options, niches and systems.

The objective of this paper is to explore experiences on integration of legumes in subsistent farming systems of East African Highlands, identify the biophysical and socio-economic determinants affecting their adoption and to suggest how those various determinants could be strategically combined, processed and utilised to develop decision guides.

LEGUMES IN VARIOUS FARMING SYSTEMS

Although legumes are important components of various farming systems, and farmers acknowledge the positive contributions of legumes, the amount of land allocated to grow legumes (food, fodder or cover crops) is relatively small. In the upper highlands of Eastern Africa above 2700 masl, e.g. Ethiopian highlands, only few legumes are integrated to the system. It is only lentils as a food legume and natural medics & trifolum as feed legumes, whereby the proportion of legumes in the system is < 2%. In the mid-highlands of East Africa 1000-2200 m asl (both in the cereal-based and perennial-based systems) the higher proportion of legumes is relatively higher, with about 20-25 %, growing both as intercrops, intermediate and break crops. If it was not for the contribution of legumes in restoring soil fertility and breaking the cycles of pest incidence for hundreds of years in these intensively cropped agro-ecology, the production systems may have collapsed long a go. The proportion of the legumes decreases in the low altitudes to less than 10%, as those regions are commonly drought-prone to grow most of the traditional legume species.

In the perennial-based farming systems of Eastern Africa, the only most dominant legume in the cropping is common beans, intercropped with maize or grown sole as a second crop. However, cultivation of beans may not contribute much to soil fertility improvement mainly because (Eyasu, 2002) 1) the crop is harvested by uprooting the whole plant as it needs to be stored by hanging bundles on a trellis and kept indoors to avoid sprouting; 2) no residue is returned to the soil as pods and tops are fed to livestock with the stalk is used as feed or cooking fuel and 3) beans has the least N-fixing potential particularly in low pH soil with low P availability.

WHY IS ADOPTION OF LEGUME TECHNOLOGY IS SLOW ?

Despite the positive contribution of legumes to the various systems, the proportion of legumes be it food, feed or cover crops is very low. There are multiple factors that affected the adoption and dissemination of legumes, which could be nested under and defined by three contextual factors (Sumberg, 2002) namely i) socio-cultural, economical and political ii) agroecological and iii) management at farm level.

From the food legumes perspective, there are three factors that dictate the decision of farmers to grow or not to grow legumes. i) In the subsistence farming of Africa the food habit dictates the amount of land to be allocated for various crops and the type and amount of input invested per crop. Since the food habit of most East African Highlands is cereal-dominated, the proportion of cereal to legume consumption in the households of East Africa is about 10 to 1. For a household with five members in Kenya, in average about 500 kg of maize and 100 kg of beans is required. Similarly, for the same household size in Ethiopian high lands 600 kg of barley and 70 kg of pea or faba bean is required. ii) The fertility status of the land and the incidence of pests and diseases dictate the frequency of legumes in the cropping systems. The proportion of legumes usually increases with decline in soil productivity and increased incidence of pests and diseases. iii) The market value of respected crops may dictate how much land is allocated for legumes. In few cases, as it is the case in the Rift-valley of Ethiopia with beans, farmers invest land and labour to grow legumes for market. They intend to grow legumes for the market and buy cereals for their home consumption, as the prize of legumes is relatively higher than that of the cereals.

Integration of feed legumes into the African farming systems also remained to be low despite the continuous research efforts since the 1930s. The major determinants that affected integration are (Sumberg, 2002), 1) there is limited tradition to grow feed legumes in the region, hence the genetic pool of legumes available for growers is very much limited to few, recently introduced germplasm. Moreover, there is limited knowledge not only on legume management but also processing and utilization of legumes towards market-oriented products. As most of those legumes were originated in the relatively favourable climates of the Andes, it became also challenging to identify high yielding, drought-resistant species to be integrated into the drought-prone environments of Africa. Most importantly, as the legume technology was considered as gender-neutral and wealth-neutral, the dynamism and complexity of socio-economic dimensions was not considered during the research-extension continuum.

In recent years, there has been increasing research interest across the region on the integration of legume cover crops into the farming systems with the objective of improving and sustaining soil fertility. Most of the legume cover crops are known to be ideal for improving soil fertility, as they are commonly fast growing, Nitrogen-fixing, efficient in capturing and recycling nutrients, and easily decomposable (Jama, et a., 1998). The problem of integration, however, is even worse for LCCs. Firstly, because the opportunity cost is much higher that the immediate benefits of LCCs. Secondly, most LCCs are sensitive to unfavourable environments (water stress & nutrient deficiency), and hence only very few them are growing well in degraded corners, where farmers want them to grow. And thirdly, farmers would like to integrate legumes that have multiple benefits, i.e. food, feed and soil fertility, while the LCCs commonly deliver only one purpose i.e. soil fertility maintenance/improvement through incorporation of the green manure to the soil.

Dual Strategies for Integration Of Legumes

There are two possibilities to facilitate the integration of legumes into the farming systems of East African Highlands. Designing a new production system, whereby the system demands a legume component is one possible option. This could be theoretically an ideal strategy to integrate legumes, as the production system will be geared towards the consumption of legumes as major production inputs. For example, a policy that prohibits free grazing and free herd movements in Ethiopian highlands, where free grazing is currently practised, and introduce fast growing feed legumes for cut and carry, would enhance the consumption of legume technology significantly. Promiscuous legumes, which are high yielding in both grain and straw, could be obvious choices if the system should provide high quality manure from few animals, and also increased household income and food. The second option is to understand the various farming systems, identify the existing temporal and spatial niches, creating new potential niches using the existing resources (land, water, nutrients, and solar radiation and human resources) and facilitating integration of legumes by delivering options and acknowledging diversities.

We are presenting a case study that justifies the second strategy; namely fitting the legume into existing systems by identifying the spatial and temporal niches of the existing system.

EXPERIENCES OF AHI IN INTEGRATION OF LEGUMES IN ETHIOPIAN HIGHLANDS

Characteristics of the site

The research was conducted at Areka, 430 km south-west of Addis Ababa, about 1950 masl, which could represent the mid highlands, with average land holding of less than 0.5 ha. The farming system is a perennial based (Enset-based system) highly intensive system with a possibility of up to three cropping per year. Due to very high population pressure (>450 people/km^2) there is small land holding and fewer livestock than in the upper highlands. The average livestock holding is less than 1.5. Only 15% of the farmers own oxen. Sharing or hiring of oxen for ploughing and other farm operations is a traditional practice. Unlike the upper highlands, where communal land natural pasture and free grazing area is available, only crop residues, weeds and aftermath grazing are the predominant feed sources in Areka. The cropping system is highly diversified and tree-based. Different forage crops are grown around the home garden in association with coffee, Enset (*Enset ventricosum*) and fruit trees. Crop-livestock integration is strong in such a way that farmers use crop residues as feed source, but also return the manure into the soil, applied mainly around the home garden. The farmers divided their land into several plots for various purposes. Trees are planted on valley bottoms, sloppy area, farm boundaries, in front of house and gully areas. Grazing land (tittering) are found in front of house. Some plots are left for cut and carry for livestock feeding. These plots have also differ in soil fertility status, that is soil fertility declines with distance from houses.

Determinants of integration of legumes into systems

1. Biophysical Factors Dictating Integration of Legumes

Farmers have multiple criteria to decide whether a technology in question would be appropriate for their circumstances, and whether they integrate those technologies into their farming practices. Although farmers were keen to learn about legume technologies in the farmers' field school and on-farm testing sites, they demanded time to test them not only under optimum research conditions, but also under their own real sub-optimal conditions. Experiences from this site showed that for a legume to be selected by end-users, it should fulfil the following biophysical traits (Amede & Kirkby, 2002);

a) The performance of a legume, in terms of biological productivity, under a given agroecology is the principal factor for a legume to be considered as potential candidate to be integrated into the existing system. The most favorite candidate is the one with relatively high yield, grain and biomass, under variable agro-ecological conditions, namely precipitation, temperature, soil fertility and variable management conditions. The other criterion was that when farmers tested legumes for restoration of soil fertility they assume that legumes should improve the fertility status of the degraded corners of their farm. Therefore, for a legume cover crop to be selected for a short term fallow at Areka conditions, the major biophysical criteria was whether a species is in a position to produce higher biomass under degraded corners of the farm. Farmers were not interested to grow the LCCs in the fertile corners, as they were allocated for food crops. The land they wanted to get improved are the border strips, the abandoned corners, steeply slopes and the barren land, where the land failed to produce any reasonable crop yield. But most of the LCCs, with strong history in improving soil fertility, demand relatively fertile soils to establish, produce large amount of biomass and to fix atmospheric nitrogen. That is the reason why farmers selected crotalaria for improving degraded farmlands over mucuna, canavalia, tephrosia and vetch (Amede & Kirkby, 2002). On individual farmer's field, Crotalaria was the best performing species regardless of soil fertility. Similar results were reported from Uganda (Wortmann *et al*., 1994). On the other hand, vetch and mucuna were performing best in fertile corners of the farms. This did not agree with the findings of Versteeg *et al*., (1998), which indicated that mucuna performed better than other green manures (including Crotalaria) to recover completely degraded soils. When those seven species, namely crotalaria, mucuna, canavalia, tephrosia, vetch, stylosanthus, and trifolium were planted in the driest part of the season, crotalaria followed by mucuna performed best and produced up to 2.9 t ha^{-1} dry matter with in three months of time.

b) Effect of incorporation of LCCs on the grain yield of the preceding crop is one other very important criterion. Application of high biomass of LCCs did not necessarily guarantee high yield of the preceding food crop, as the quality of the organic material dictates whether nutrients accumulated in the LCCs could be released at the required time and in required amount. Participatory experiment on after-effect of LCCs in Uganda recorded good increases in crop yields, although the green manure did not compensate for the time it occupied the land over a three crop cycle (Fishler and Wortman, 1999). Moreover, how large the benefit a green manure delivers for growth of the following crop depends on the initial fertility of the soil and the amount of nutrients that the LCC contributes (Giller, 2001). In Areka, tephrosia produced about double dry matter in comparison to vetch, but maize yield under vetch was significantly higher than under tephrosia (Amede & Kirkby, 2002), which could be explained by quality differences and synchrony of the demand and supply. The most important organic quality indicators are nutrient content, lignin content and polyphenol content of the respective organic resources (Palm et al., 1997).

c) Since the opportunity cost of growing LCC in a time when other food crops could be grown is very high, those fast growing, early maturing legumes, that could grow using residual moisture could be best fitting. In this case farmers were able to integrate them as intercrops, relay crops, and short term fallows once the major crops is harvested.

d) Those legumes, which did not strongly compete with the companion food crop for water, nutrients and light when growing in combination with food crops (e.g. maize), are best options. Because of land scarcity, farmers may not be willing to grow LCCs sole.

e) LCCs with firm root system to sustain the soil from erosion (based on the strength of the plant during uprooting) were favoured by farmers with steepy plots.

f) Rate of decomposition when incorporated to the soil (the strength of the stalk and/or the leaf to be broken by hand) was considered as an important indicator to predict whether the organic resource applied is in a position to release nutrients for the preceding crop in a short period of time or not.

g) The mulching capacity of a LCCs (based on the moisture content of the soil under the canopy of each species). There was a significant difference in soil water content under the canopy of the various LCCs. Higher soil water content under Mucuna, Stylosanthus and Vetch under Areka conditions implied that these species may improve soil water availability through reduction of evaporative loss if grown in combination with food crops. The ground cover (%) was the highest for Mucuna (100 %), and the lowest for vetch (60%). Similarly, the soil water content under mucuna was 22.5% while under tephrosia only 11%. This may have an implication on the water use efficiency of the respective legume, and its compatibility into multiple cropping systems.

h) Drought resistance of the legume when exposed to dry spells (wilting and abcission of the leaf during warm days and extended drought periods). As most of the land would be occupied by food crops for most of the growing season, farmers found it very expensive to find a spatial niche for LCCs during the cropping season. The most possible niche they identified to plant them was at the end of the growing season using residual moisture, which exposed LCCs to terminal drought. In this case there is little choice than growing legumes as a sole crop.

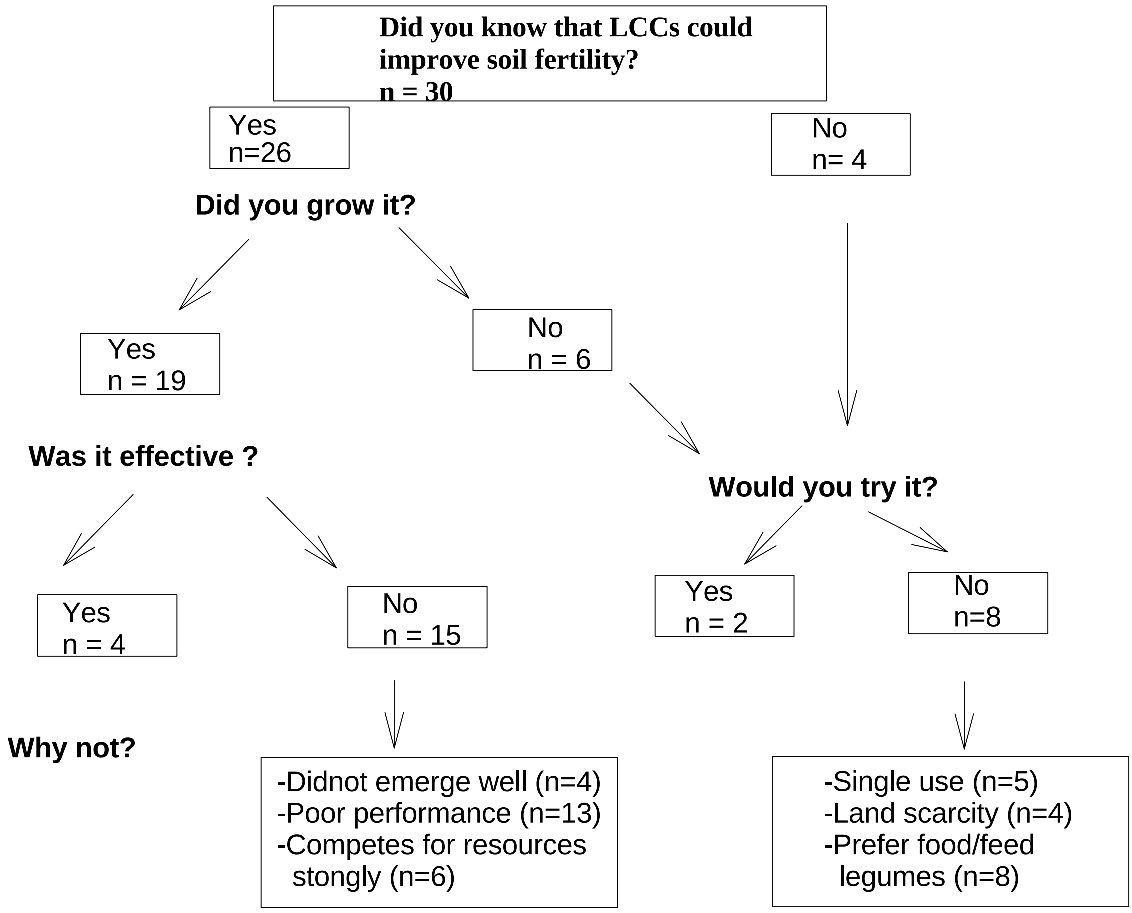
i) Feed value of the legume (livestock preference) and ability to produce high quality feed for the dry season. This was one of the most agreeable criteria across the community, especially because of high calve mortality during the dry seasons

j) Early soil cover. LCCs with fast mulching characteristics not only conserve water, mainly through reduction of evapotranspiration, but also keep the land easy to work with. It also reduced the kinetic effects of heavy rain on the soil and soil erosion.

However, the criteria of choice had different weights for farmers of different socio-economic category. For resource poor farmers (who commonly did not own animal or own few) legume cover crops were not first choices as they give priority to legume with short term benefits (food and feed legumes).

The major biophysical constraints that affect the integration of legume cover crops as perceived by farmers is presented in Fig 1. This approach would assist researchers to get a feed back information on the research questions that could be addressed to improve the drawback of the technologies and suggest other option that could fulfil the requirements of the end-users. It would help researchers not only to identify the major factors of non-adoption, but also to prioritise them in relation to socio-econnomic categories.

Fig 1. Schemes used for identification of factors of adoption or non-adoption of legume cover crops in multiple cropping systems of Areka.



Amede & Kirkby, 2002

2. Socio-economic Factors Dictating Integration of Legumes

After farmers went through participatory research processes for many seasons, and test those favourite legumes in their own fields, they were asked to suggest the most important socio-economic criteria that dictated the selection of one or other legume species to be integrated into their systems.

Results from informal monitoring farmers' activities accompanied by structured questioner showed that there are 21 different factors that affect the integration of legumes for different purposes. When farmers were asked to prioritise the most important factors that affect adoption and integration of legumes farmers mentioned a) farm size b) suitability of the species for intecropping with food legumes c) productivity of their land d) suitability for livestock feed e) marketability of the product f) toxicity of the pod to children and animals g) who manages the farm (self or share cropping) h) length of time needed to grow the species and I) risk associated with growing LCCs in terms of introduction of pests and diseases. None of the farmers mentioned labour demand as an important criterion. Earlier works also suggested that farm size and land ownership effect integration of LCCs into small holder farms (Wortmann & Kirungu, 1999). After comparing those factors in a pair wise analysis, five major indicators of different hierarchy were identified.

1) Degree of land productivity: Farmers in Gununo associated land productivity mainly with the fertility status of the soil and distance of the plot from the homestead. The homestead field is commonly fertile due to continual supply of organic resources. Farmers did not apply inorganic fertiliser in this part of the farm. They remained reluctant to allocate a portion of this land to grow LCCs for biomass transfer or otherwise, but grow food legumes, mainly beans, as intercrops in the coffee and enset fields. The potential niche that farmers were willing to allocate for LCCs is the most out field.

2) Farm size: Despite very high interest of farmers to get alternative sources to inorganic fertilisers the probability that farmers may allocate land for growing LCCs depend on the size of their land holdings. For Areka conditions, a farm size of 0.75 ha is considered as large. Therefore, farmers with very small land holdings did not grow legumes as sole crops, but integrate as intercrops or relay crops. Therefore, the potential niches for LCCs are partly occupied unless their farm is highly depleted.

3) Ownership of the farm: Whether a legume (mainly LCCs) could be grown by farmers or not depended on the authority of the person to decide on the existing land resources, which is linked to land ownership. Those farmers who did not have enough farm inputs (seed, fertilizer, labour and/or oxen) are obliged to give their land for share cropping. In this type of arrangement, the probability of growing LCCs on that farm is minimal. Instead, farmers who contracted the land preferred to grow high yielding cereals (maize & wheat) or root crops (sweet potato). As share cropping is an exhaustive profit-making arrangement, the chance of growing LCCs in such type of contracts was almost nil. Without ownership or security of tenure, farmers are unlikely to invest in new soil fertility amendment technology (Thomas and Sumberg, 1995)

4) Livestock feed: In mixed farming systems of Ethiopia, livestock is a very important enterprise. Farmers select crop species/ varieties not only based on grain yield but also straw yield. Similarly legumes with multiple use were accepted by the community better than legumes solely for green manure purposes.

5) Market value: For a legume technology to be appraised by the end-users, mainly farmers, the legume should bring an immediate & visible benefit, either direct through generation of food or cash or indirect by making a significant and visible contribution to a secondary high value product.

The Decision Guides

We are presenting two guidelines for integration of legumes into the farming systems of multiple cropping, perennial-based systems. The decision trees were developed based on the following back ground information from the site.

1) Farmers prefer food legumes over non-food legumes regardless of soil fertility status of their farm
2) The above ground biomass of food legumes (grain & stover) is exported to the homestead for feed and food while the below ground biomass of food legumes is small to effect soil fertility. The probability of the manure to be returned to the same plot is less as farmers prefer to apply manure to the perennial crops (Enset & Coffee) growing in the home stead.
3) The tested legumes may fix nitrogen to fulfil their partial demand (we have observed nodules in all although we did not quantify N-fixation), but in conditions where the biomass is exported, like vetch for feed, most of the nutrient stock would be exported. Therefore, we did not expect significant effect on soil fertility.
4) LCCs produce much higher biomass when planted as relay crops in the middle of the growing season than when planted late as short-term fallows due to possible effects of end-of season drought on growth.
5) The homestead field is much more fertile than the outfield; hence those species sensitive to water and nutrients will do better in the homestead than in the outfield.

The first guide (Fig 2) is developed based on the data obtained from the farmers field and on-farm experiments, verified by on-station experiments. The overall idea is that not all LCCs are fitting every where, some are very sensitive to the availability of nutrients and water, at least at the establishment phase, and others do well across environments. When farmers got the options to select among seven commonly recommended LCCs species namely Vetch, Mucuna, Crotalaria, Canavalia, Tephrosia, Trifolium, Stylosanthus, to integrate into their systems, farmers of various socio-econmic category selected different species, planted them on different parts of their farm and managed them differently. Researchers have monitored how the farmers managed the LCCs, where did they plant them, when did they plant, how long they were left to grow, how much input they are investing, how was the biomass production, what benefits they are getting from them and what are their final decisions to integrate them into their systems. The guide, synthesised as the product of the participatory research, have two major frames, namely legumes suitable for maintaining the fertility status of a productive land and those suitable for improving the fertility status of a relatively less fertile crop land. Most farmers wanted the LCCs to improve the plots which are 'addicted' to mineral fertilizers, which refers commonly to less fertile corners of the farm, the out-fields. The guide showed that there are limited LCCs options that could be used to improve degraded croplands, as the legumes them selves, except crotalaria, were not able to grow under such harsh conditions. There are much more LCC options for maintaining the fertility status of the fertile corners of the farm, Vetch was suggested to be the best fitting legume for short term fallow. However, the guide left a space for other researchers to identify LCC option that may fit into their production systems.

The second guide (Fig 3) is intended to assist farmers and researchers in identification of potential legumes that could be compatible to the existing spatial and temporal niches. This guide was developed based on the fact that the homestead is much more fertile than the outfield, and that the outfield is larger in size the homestead field. The most important criteria at the lowest level is the presence or absence of livestock followed by who manages the farm, market access, the size of the land holding and the land quality. The factor that dictates the decision at the highest level is land productivity, which was governed mainly by soil fertility status. Growing food legumes was the priority of every farmer regardless of wealth (land size, land quality & number of livestock). Farmers with livestock integrated feed crops regardless of land size, land productivity and market access to products. However, the size and quality of land allocated for growing feed legumes depended on market access to livestock products (milk, butter and meat). Those farmers with good market access are expected to invest part of their income on external inputs, i.e. inorganic fertilisers. Hence farmers of this category did not allocate much land for growing LCCs, but applied inorganic fertilisers. In the homestead field, there was no land allocated for LCCs in the system, not only because farmers gave priority to food legumes, but also the homestead field, relatively fertile corner of the farm, became very expensive for farmers to allocate for growing LCCs. The most clear spatial niche for growing LCCs is the most out field, especially in poor farmers' field with exhausted land and limited market-driven farm products. Those categories of farmers experienced share cropping for some time, and as a result their farm was on the verge of being out of production due to the iniquitous nature of land management practices.

CONCLUSION

Integration of legumes to various production systems and clients is a complex agenda that may require a participatory approach to address both biophysical and socio-economic constraints/opportunities. The major biophysical traits need to be addressed are adaptability of the species into that specific agroecology, which may include yield, disease and pest resistance, effect on soil fertility and its compatibility to the existing cropping system. The most determinant socio-economic factors are land ownership, market value, farm size and trade-offs for various uses. Strategic combination of those biophysical and socio-economic determinants in the form of decision guides will help farmers, development agencies and researchers to identify potential adopters, learn about the criteria of choice, learn about the need for an improved system management. Moreover, it may help them to identify niches and/ or create niches, modify the existing systems and promote the technology for wider use.

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REFERENCES

Abayomi, Y.A., O. Fadayomi, J.O. Babatola, and G.Tian, 2001. Evaluation of selected legume cover crops for biomass production, dry season survival and soil fertility improvement in a moist savanna location in Nigeria. African Crop Science Journal 9,4: 615-627.

Amede, T. and R. Kirkby, 2002. Guidelines for Integration of Legumes into the Farming Systems of East African Highlands. Afnet proceeding . African Academy of Sciences. In press.

Eyasu, E., 2002. Farmers' perceptions of soil fertility change and management. SOS-SAHEL, Institute for sustainable development, Addis Ababa, 252 p.

Fishler, M. and Wortmann, C., 1999. Crotalaria (C. ochroleuca) as a green manure crop in maize-bean cropping systems in Uganda. Field Crops Research 61, 97-107.

Gachene, C.K., Palm, C, Mureithi, J., 1999. Legume Cover Crops for soil fertility improvement in the East African Region. Report of an AHI Workshop, TSBF, Nairobi, 18-19 February, 1999.

Giller K. , 2001. Nitrogen Fixation in tropical cropping systems. 2nd edition. CAB International, UK. 423 p

Jama, B., Buresh, R.J., and Place, F.M. (1998) Sesbania tree fallows on phosphorus - deficient sites: Maize yield and financial benefits. *Agronomy Journal* 90 (6), 717 – 726.

Palm, C., Myers, R.J. and Nandwa, S.M., 1997. Combined use of organic and inorganic sources for soil fertility maintenance and replenishment. SSSA Special publication No. 51, 193-218.

Sumberg, J., 2002. The logic of fodder legumes in Africa. Food Policy 27: 285-300.

Tarwali, S.A., M.Peters, and R. Schultze-Kraft, 1987. Forage lefumes for sustaiable agricultuire and livestock production in sub-humid West Africa. ILRI project report, Nairobi, Kenya. 132 p.

Thomas, D. and Sumberg, J., 1995. A review of the evaluation and use of tropical forage legumes in Sub-saharan Africa. Agriculture, Ecosystem & Environment 54, 151-163.

Wortmann, C. Isabirye, M., Musa, S., 1994. Crotalaria ochreleuca as a green manure crop in Uganda. Afri. Crop Sci. J. 2, 55-61.

Wortmann, C. , Kirungu, B., 1999. Adoption of soil improving and forage legumes by small holder farmers in Africa. Conference on: Working with farmers: The key to adoption of forage technologies. Cagayan de oro, Mindano, The Philipines. 12-15 Oct., 1999.

Versteeg, M.N., Amadji, F., Eteka, A., Gogan, A., and Koudokpon, V., 1998. Farmers adaptability of Mucuna fallowing and Agroforestry technologies in the coastal savanna of Benin. Agricultural Systems 56 (3), 269-287.

Fig. 2 Decision guide that suggest various legumes for improving degraded crop lands or maintaining the fertility status of a relatively fertile crop land through a short or medium term fallow.

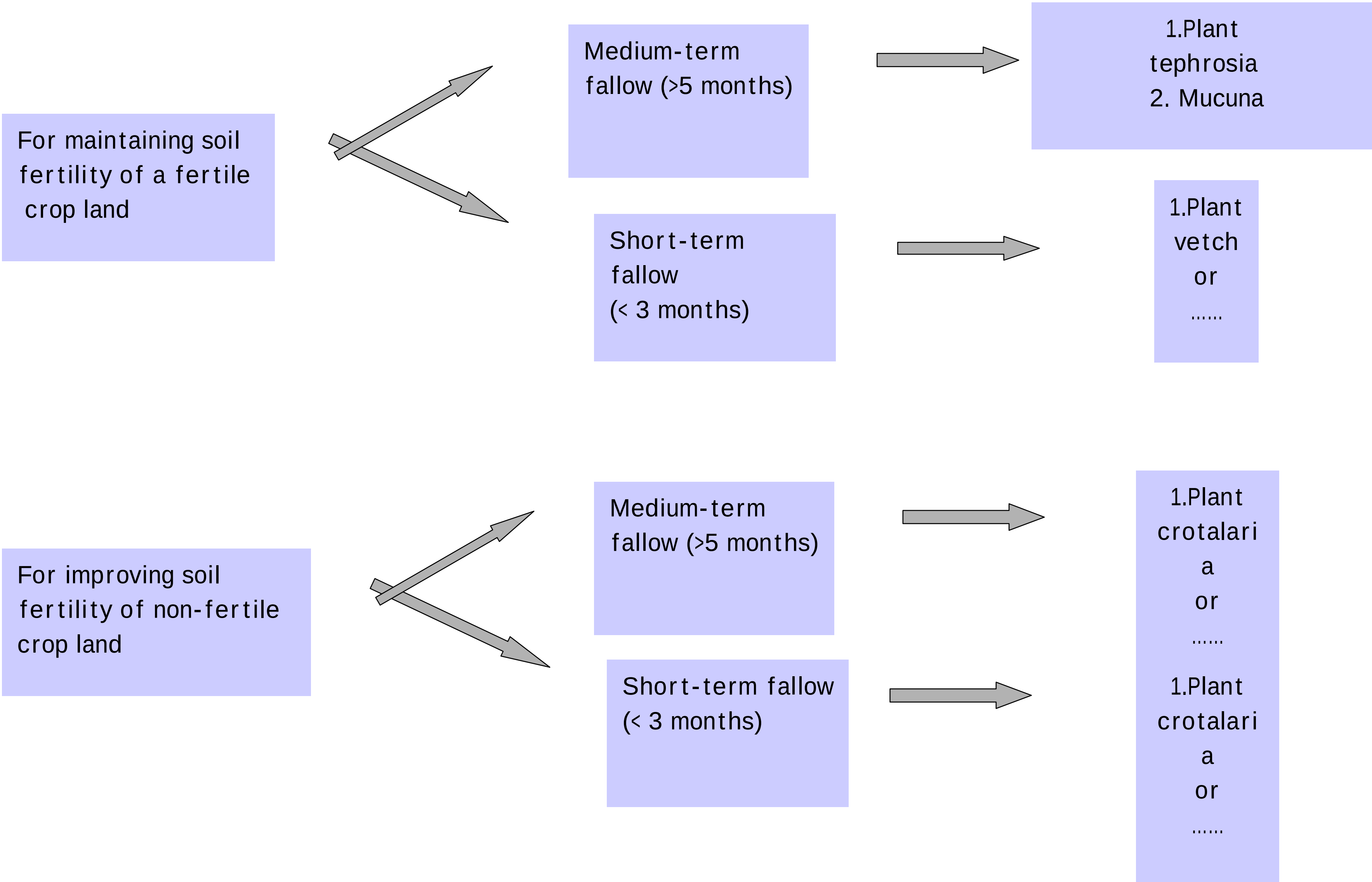

Fig. 3. Guidelines for integration of food, feed legumes and legume cover crops into small scale farms, with heterogeneous socio-economic conditions.