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Tree management for improved compatibility with other crops

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Abstract

Tree spacing, crown and root pruning were investigated on a variety of agro forestry tree species in the Lake Victoria shore region of Uganda with the objective of determining the best management options for improved compatibility with annual crops. Results showed that both *Grevillea robusta and casuarina* equisetifolia could be intercropped with annual crops at wider intra-row spacings of 3-5 metres without jeopardizing crop production while at the same time enabling the production of marketable poles. Both tree species spaced at 1 m intra-row suppressed grain yield of associated crops after first year. Positive crop responses to crown pruning increased linearly; pollarding encouraging the highest crop yields. In addition to providing household fuel wood; moderate pruning reduced competition for below-ground resources and this increased tree compatibility with annual crops especially during dry conditions. Overall, the management options investigated in this study showed that agro forestry provides significant opportunities in the Plan for Modernization of Agriculture (PMA) because it offers incentives to farmers to integrate trees into cropland thereby diversifying the product range and reducing the risk.

Introduction

Agroforestry, the practice of deliberately growing woody perennials with other crops is much more attractive economically than traditional agriculture of forestry because it produces a diversity of products (e.g. poles, fuel wood, fruits, fodder, timber) and provides services such as windbreaks, shade to crops, soil fertility improvement, etc. The diversity of products offered by agroforestry does not only reduce farmers' risks by widening the income base but also increases food security. The practice of agroforestry is therefore a key intervention in the modernization of agriculture in Uganda. However, as the trees increase in size, the crowns and roots compete with understorey crops for light and belowground resources (water and nutrients). The tree root systems deplete below ground resources, thus forcing the trees to rely on current rainfall, which in turn increases the risk of crop failure of associated understorey crops (Ong *et. al.*, 2000). Consequently, despite the benefits of trees, the majority of dry land farmers are still reluctant to plant trees because of increased risk of crop failure to competition from trees during drought (Ong *et. al.*, 2000)

Over the years of agroforestry research, it has become clear that when nutrients and water are confined to the topsoil, it is impossible to combine fast growth and low competition in tree species. The use of fast growing tree species in agroforestry results in the trees capturing most of the available resources (Ong and Leakey 1999). Root and crown functions are driving forces determining the severity of tree competition with other crops.

In agroforestry systems involving annual crops, these crops develop their root systems when those of trees are already established (Schroth, 1999). This interaction puts the trees at an advantage over crops in the competition for water and nutrients. Competition however, depends on the trees species used (Okorio et. al. 1994). Farmers can tolerate such competition only where the tree produces a product of commercial value (e.g. the Jack fruit in Uganda). In order to minimize competition, tree planting must be combined with appropriate management practices.

Crown pruning not only reduces transpiration and ultimately competition, but also leads to root die back (Jone *et.al.*, 1998; Schroth, 1999; Namirembe,1999). Crown pruning reduces demand for water by the trees and therefore the amount of water they extract from the soil. Namirembe's study (1999) at Machakos indicated that where soil N and moisture were low and timing of crown pruning was inappropriate (after rather than before anthesis), shoot pruning of Senna spectabilis did not benefit maize crops. On the other hand, with beans, where soil moisture was not limiting and N deficiency non-evident (because of N fixation), shoot pruning of spectabilis successful removed all of its negative effects on bean growth and yield. Namirembe's results show that with proper timing to march the crop's most vulnerable stages, shoot pruning has much potential for controlling competition for below – ground resources. Unfortunately, crown pruning may also lead to the development of more superficial root systems than normal (Hairiah *et. al.*, 1992).

Root excavations have revealed the overlapping distribution of tree and crop roots within the crop rooting zone and the apparent lack of significant spatial complementarily even for species which farmers regard as highly compatible for simultaneous agroforestry systems (Schoroth, 1999; Smith et. al., 1997; Odhiambo et.al., 1999). As there appears to be limited scope for spatial differentiation in rooting between trees and crops, it is more worthwhile to manage below ground competition by shoot and root pruning (Ong *et.al.* in press). Provided that there are adequate resources at depth, pruning lateral roots could re-direct root function; leading to spatial complementary in below ground resource use which in turn promotes closer integration of trees and crops.

Other tree root management options for reducing competition have been developed under different environments. For example, Singh et al. (1989) demonstrated that root barriers to 50 cm depth were effective in reducing competitions between four year old. *Leucaena leucocephala* hedgerows and associated crops in India. However, the beneficial effects lasted only one season, as the tree roots re-invaded the crop rooting zone from beneath the root barriers. In contrast, studies by Hocking (1998) and Hocking and Islam (1998) in Bangladesh revealed that pruning the lateral roots off the trees virtually eliminated below ground competition from a wide range of tree species. In Indiana,USA, Jose *et.al.* (2000) reported that root pruning is beneficial for maize growth in alleycropping with black walnut (*Juglans nigra L*) and red oak (*Quercus rubra L*).

Because of the advantages that agroforestry provides, it is important to find ways of mitigating its negative effects (Jones and Sinclair, 1996). Essentially, tree management strategies: should be aimed at reducing completion for resources. Three tree management strategies spacing, shoot and root pruning were investigated with a view to identifying management options that combine optimal crop and wood production. This paper reports on the preliminary results of these investigations.

Materials and Methods

Spacing trials

Two experiments to study the effects of spacing of *Casuarina equisetifolia* and *Grevillea robusta* on the yield of beans, maize and soybeans were established at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), Wakiso District, Uganda. Kabanyolo is 1250m above sea level with mean annual rainfall of 1400mm and mean daily minimum and maximum temperatures of 15.7 C and 27. C respectively. Experimental plots measured 6 m in width and depending on the intra – row spacing lengths were 5 m, 15 m and 25 m for 1,3 and 5 m intra-row spacing. The treatments were arranged in a randomized completed block design replicated three times. Four crops each of beans and maize and two of soybean were sown.

On both sides of tree rows, food crops (beans, maize and soybean) were cultivated in rotation. Beans (*Phaseolus vulgaris L.*) Variety K20 were sown at a spacing of 60x10 cm, maize (*Zea mays)* variety Kawanda Composite A was sown at 75x50 cm and soybeans *(Glycine max*) variety Nam 1 at 50x5 cm . The control plot without trees was planted with annual crops.

At three-month intervals, growth of the upper-storey trees was assessed in terms of height, root collar diameter, crown diameter and diameter at breast height (dbh). The trees were side-pruned twice a year before sowing the food crop, leaving two thirds of the crown. Crops were harvested row by row on either side of the tree. Total grain yield per row was determined by direct weighing after shelling and drying to a moisture content of 15% and the yield data expressed in g m^{-1} row.

Crown pruning trials

The study was conducted at Kifu Forest Research Station in Mukono District; Uganda Kifu too is 1,250 a.s.l with 1240 mm of rainfall distributed binomially. Long rains start in March and end in June while the short rains start in August and end in November. Temperatures are equable thought out the year with mean minimum and maximum of 20.8 and 25.2°C. The vegetation around Kifu is characterized by elephant grassland and bushes, remnants of high tropical forest and some eucalyptus woodlots. The soils in the area have been classified as ferrisols and hydromorphic soils in the upland and valley bottoms respectively.

Experimental trial of a 3 x 4 factorial design involving three tree species, *Cordia africana, Grevillea robusta*, and *Senna spectabilis* and four crown pruning treatments: one-third, two-thirds, pollarding and no-prune were laid out on a farm land that was recently converted from tropical forest. The objectives of this study were three fold:

- To compare the effects of different pruning intensities on shoot mass production (branches, twigs, and leaves).
- To determine the effect of different crown pruning intensities on tree growth (dbh, height and crown diameter) and
- To determine the effect of different pruning intensities on yield of associated crops.

Single rows of nine test trees spaced 2m apart were established in the center of experimental plot measuring 8m wide and 16m long. After pruning the trees at the respective intensities, annual food crops were sown on either side of the plot in a one- year rotation. Two bean seasons followed by two seasons of maize. The beans variety K20 and maize variety Longe 1 were spaced at 60x10 cm and 75x50 cm respectively. The treatments were replicated 3 times in a randomized complete block design. Two types of control plot were used: control plots with sole crop without trees and plots with no-prune treatment. The pruning treatments were administered for each species when the crowns attained a crown spread of 2 m across the plot. Owing to differences in crown growth habits, the species were pruned at different times. At the time of pruning, growth parameters (height, root collar, diameter at breast height and crown diameter) were taken. Dbh was measured with a diameter tape and height with a long wooden graduated rod, while crown diameter was determined as the average of two diameter measurements in E-W and N-S directions. Five central trees were used for pruning treatment, leaving two trees on either end of the plot. Te total biomass was weighed and partitioned into stems and branches, twigs and leaves. Samples of 500 g wee taken for each of the components on oven dried at 70°C to constant weight. The biomass yield was then computed on dry weight basis per hectare. The leafy biomass from each tree plot was returned to the plot and evenly spread therein. At the time of harvest, the crops were harvested row-by-row from 10m, leaving 3m on either end of the row.

Root pruning trials

Another study was conducted at Kifu to assess the feasibility of root pruning as a tool to manage tree competition for belowground resources with annual crops. The study involved a simultaneous agroforestry system in which both indigenous tree species (*Maesopsis eminii* and *Markhamia lutea* and exotic *species Grevillea robusta, Alnus acuminat* and *Casurina equisetifolia* were inter cropped with maize and beans.

Single rows of 24 trees spaced at 2m planted in the middle of each experimental plot (25x30m each) were established in September 1995 and maintained as pole trees. After three years of growth, every other tree was thinned out to leave half of the original populations. Root pruning was started in February 1999 by digging a trench 30x30 cm on one side of the tree line. Trenches were dug 30 cm away from the tree line and ran half the length of the plot. The second pruning was done in April 2000.

Annual crops were inter-cropped in rotation of maize (Longe 1) in the first rains and beans (K132) in the short rains after a basal application of single super phosphate and NPK (25-5-5) at rates of 298 kg and 149 kg per hectare respectively. Maize and beans were spaced at 75x30 cm and 50x10 cm respectively. Before sowing of crops, the tree crowns were side-pruned by removing branches from one-third of the crown. Control plot (without trees) measuring 15x30m was sown to annual crops.

Tree growth was assessed at three monthly intervals for diameter at breast height (dbh), crown diameter and height. Crop growth was assessed by determining dry matter yield; phenology and grain yield from each side of the tree plot from a sample area of 10m in 1999 and 6m in 2000. Soil moisture was measured using a neutron probe (model Troxler 4301) through access tubes. The probe was inserted at different depths inside the access tube at 15cm intervals and readings taken from the logger. Soil moisture readings, however, depended on weather conditions: weekly or fortnightly for wet and dry weather respectively.

Results

Spacing

The results showed the *Casuarina equisetifolia* trees spaced at 1 m suppressed grain yields of associated crops after the first year. This tree spacing not only suppressed associated crops, but also produced slender unmarketable poles at the age of five years (Fig. 1. On the other hand, however, trees spaced at 3 and 5 m did not significantly affect grain yield of maize and beans in the five years of the study (Fig. 2) and the *Casuarina* trees attained marketable pole size at the age of five years.

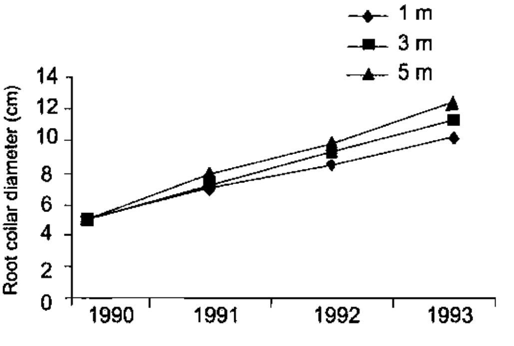


Fig. 1. Effect of tree spacing on stem diameter

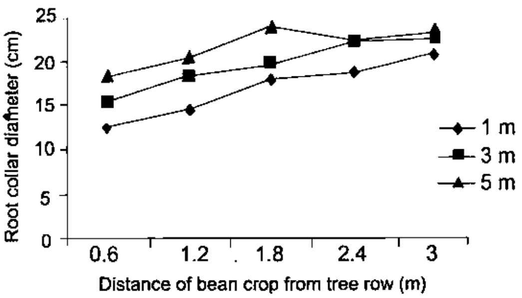


Fig. 2. Effect of Casuarina spacing and distance from the tree row on bean yields.

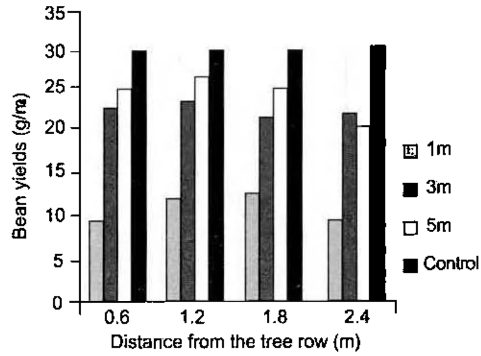


Fig. 4. How intra-row spacing of grevillea robusta affects bean yields

Grevillea trees did not affect grain yield of crops in the first nine months of growth. However, trees spaced at 1m suppressed grain yields of associated crops from the age of 1 year. At wider spacing (3m and 5m), Grevillea trees did not grain yield of maize and beans significantly (Fig. 4). The spacing of Grevillea did not affect the stem diameter or the trees significantly (Fig.3).

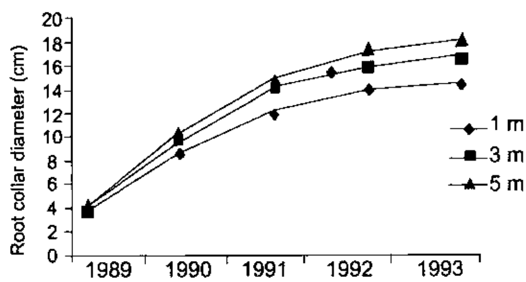


Fig. 3. Effect of intra-row spacing on root collar diameter of grevillea *robusta*

Crown pruning

Depending on the intensity, crown pruning significantly ($P<0.001$) reduced tree height (16%,29% and 56%), stem diameter (11%,24% and 32%) and crown diameter (23%,35% and 39%) for one third pruning, two-thirds pruning and pollarding respectively. The effect of pruning on the species growth was in the order Grevillea >Cordia>Senna.

In terms of total biomass production, the species differed significantly ($P<.001$) from one another. Cordia produced twice as much biomass as Greviallea and Senna. Similarly, cordia significantly ($P=0.002$) produced more stems, twigs and leaves than Grevillea and Senna (Table 1).

Table 1. Biomass production from prunings of tree species (tones ha $^{-1}$)

Species	Total biomass	Stem	Twigs & Branches	Leaves
Cordia abyssinica	***17.7***	***9.8***	***1.1***	***6.8***
Grevillea robusta	3.0	1.1	0.5	1.4
Senna spectabilis	9.3	7.8	0	1.5
SED	3..9	1.8	0.4	1.7

The no-prune treatment and one-third pruning intensity caused much shading to the crops and significantly suppressed grain yield of associated crops. Indeed, both the no-prune and one third pruning produced a net negative effect on the yields of beans and maize. Two-thirds pruning and pollarding of tree crowns gave crops distinct yield advantages with pollarding giving maximum advantage (Fig.5).

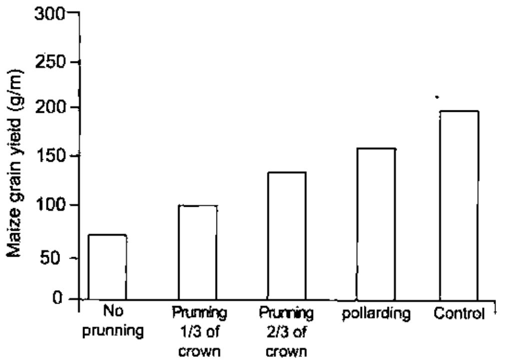


Figure 5. effect of pruning intensity on maize yield

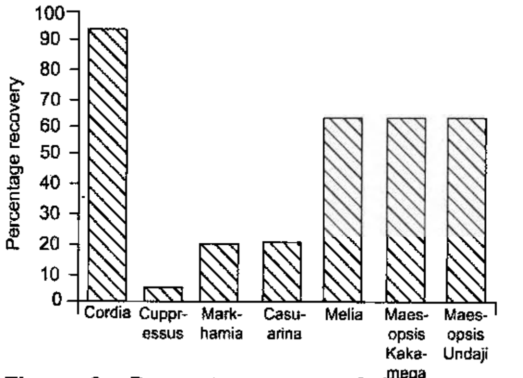


Figure 6. Percent recovery of different tree species after pollarding

But recovery of test trees from pollarded at the age of ten years showed mixed reactions (Fig.6). Cypress largely failed to recover while only 39% of Markhamia and Cauarine recovered from this extreme form of crown management.

Un-pruning tree roots suppressed crop yields while on the other hand, root pruning significantly increased crop yields as data on the beans show in Figs.7-9. Nor was tree growth affected by root pruning during the study period. It is nevertheless possible that the effects could manifest at later dates.

Figure 7. Bean grain yields at different distances from the three sides of the Grevillea p

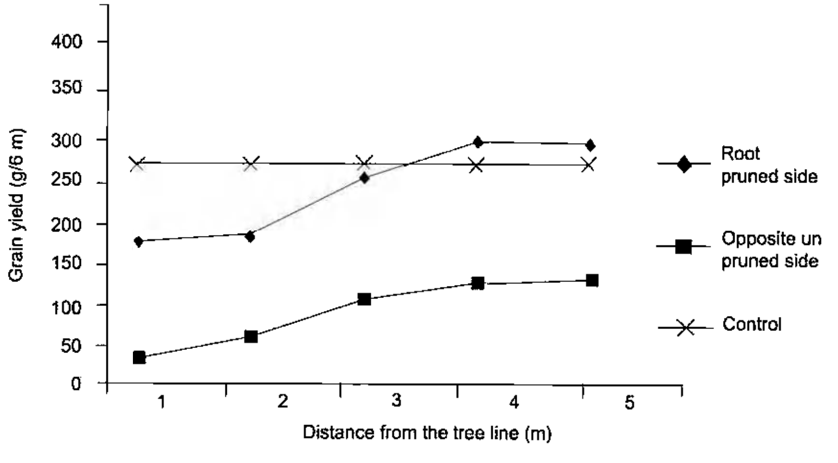


Figure 8. Bean yields at different distances from the three sides of the Maesopsis

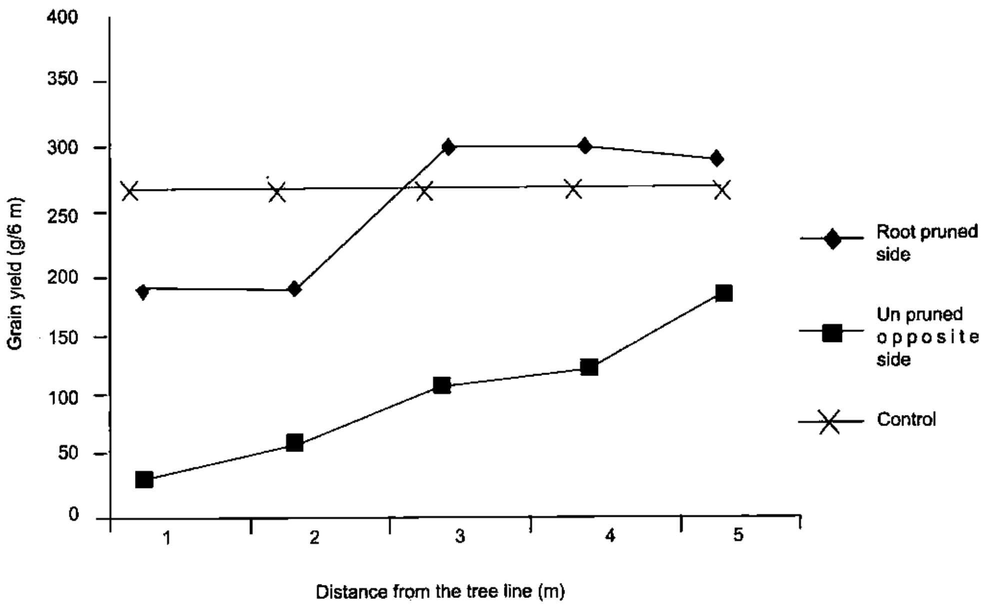
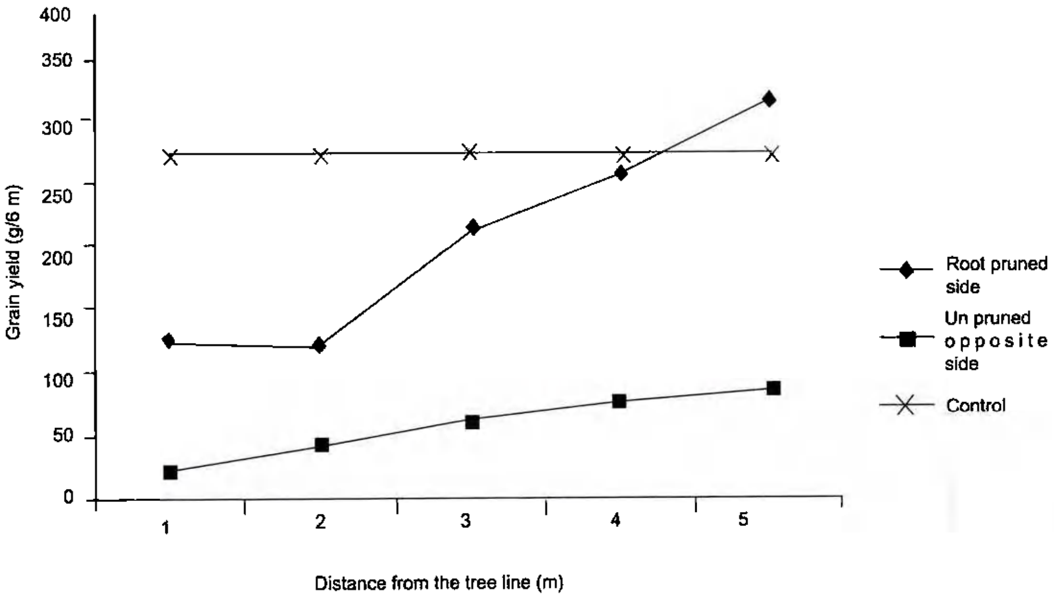


Figure 9. Bean yiels at different distances from the three sides of the markhamia plot



Discussion

Tree completion is a major hindrance to tree planting and farmers can only tolerate it where the trees provide valuable products. The possibilities provided by the results presented in this paper offer valuable options for farmers to diversify their production and trees for poles and/or timber along boundaries without provoking disputes with neighbors, or scatter them in other crops. Although it was not addressed by the studies highlighted here, a combination of wide spacing with moderate crown pruning coupled with root pruning may make agroforestry a totally acceptable practice to farmers. Root pruning seems particularly relevant for fruit trees and overgrown timber trees whose crowns cannot be accessed. Crown pruning reduces shade and also provides valuable fuel wood and fodder for the household. In conclusion, farmers can diversify their production and income and spread the risk through integration of trees in cropland, provided they choose the right strategy for managing the trees to make them compatible with other crops.

References

Hairiah K, van Noordwijk m, Santoso B and Sykhfani MS (1992). Biomass production and root distribution of eight trees and their potential for hedgerow intercropping on an ultisol in Lampung. Agrivita 15:54-59

Hocking D (1998). Trees in wetland rice fields: a successful tree management technology developed through participatory action-research in Bangladesh. Agroforestry Today, 10:4-6

Hocking D and Islam K (1998). Trees on farms in Bangladesh: 5 Growth of top and root pruned trees in wetland rice fields and yields of understorey crops. Agroforestry Systems 39:101-115.

Jones M, Sinclair Fl, and Grime VL (1998). Differences in root system responses of two semi-arid tree species to crown pruning. Agroforestry Forum 7(2):24-27.

Jones M, and Sinclair FL, and Grime VL (1998). Effect of tree species and crown pruning on root length and soil water content in semi-arid agroforestry. Plant and soil 201:197-207.

Jose S. Gillespie AR,Seifert JR and Biehle D.J (2000). Defining competition vectors in a temperate alley cropping. 2. Competition for water. Agroforestry system 48 (11):41-59.

Namirembe S (1999). Tree shoot pruning to control competition for below ground resources in agroforestry. Un published PhD Dissertation, School of Agricultural and Forestry Sciences University of Wales, Bangor, UK

Odhiambo HO,Ong CK, Wilson J, Deans JD, Broad head J, and Black CR (1999). Tree-crop interactions for below-ground resources in drylands: root structure and functions. Annals of Arid Zone 38 (3): 221-238.

Okorio J.Byenkya S.Wajja N and Peden D (1994). Comparative performance of seven teen upperstorey treespecies associated with crops in the highlands of Uganda. Afroforestry Syetems 26: 1 –19.

Ong CK and Leakey RRB (1999). Why tree crop interactions in agroforestry appear to be at odds with grass
interactions in tropical savannahs. Agroforestry

Systems 45: 109-129.

Ong CK,Black CR Wallace JS, Khana AAH, Lott JE,Jackson NA, Howard SB and Smith DM (2000).Productivity, microclimate and water use in Grevillea robusta based agroforestry systems on hill slopes in semi-arid Kenya. Agriculture, Ecosystems and Environment 80: 121-141.

Ong CK, Wilson J, Deans JD, Mulatya J, Raussen T and Wajja- Musukwe (in press). Tree-Crop interactions: manipulation of water use and root function.

Schroth G (1999). A review of below ground interactions in agroforestry, focusing on mechanisms and management options. Agroforestry Systems 43: 5-34.

Singh RP, Ong CK and Saharan (1989). Above and below ground interaction in alley cropping in semi-arid India. Agroforestry Systems 9:259-274.

Smith DM, Jarvis PG and Odongo JCW (1997). Sources of water used by trees and millet in Sahelian windbreak systems. Journal of Hydrology 198: 140-153.

Table 1: Conservation practices, facilities and processes commonly utilised in PGR management and their relative efficiency rating in the three study districts.

Conservation P ractice or FaciliT	Use intensity (% respondents) Mpigi	Masaka	Pallisa	Efficiency rating
Vegetative crops				
Planting in swamps	**5**	**5**	**10**	**Fair**
Continuous field cropping	**90**	**92**	**50**	**Good**
Planting under shade	**2**	**4**	**8**	**Fair**
Seeds or grains				
Metallic containers	**5**	**17**	**-**	**Fair**
Sacks (polythene)	**39**	**56**	**51**	**Fair**
Granaries	**-**	**4**	**26**	**Good**
Others (baskets, gourds, etc)	**33**	**13**	**23**	**Good**
Non-threshed grains				
Roof tops	**-**	**-**	**2**	**Fair**
Hang above chimney	**5**	**4**	**-**	**Good**
On fioors	**5**	**4**	**-**	**Poor**
Seed Pre-treatment				
Sun drying	**100**	**100**	**100**	**Very Good**
Banana juice	**5**	**-**	**-**	**Fair**
Chemicals (especially insecticides)	**-**	**4**	**-**	**Good**
Botanicals (Cypress spp, Tagetes minuta)	-	4	-	Fair
Non-cultivated plants				
Community responsibility	**-**	**-**	**4**	**Fair**
Land owner's responsibility	**-**	**17**	**4**	**Fair**
Individual's backyard garden	**1**	**2**	**4**	**Good**
Left to natural forces	**92**	**69**	**67**	**Good**
Elders	**8**	**12**	**-**	**Good**

Table 2: Selection criteria and its priority ranking in the three study districts (Note; 1- highest priority, 8-lowest priority)

Characteristic or selection criteria	Priority Ranking accorded Mpigi	Masaka	Pallisa
Yield	**1**	**1**	**1**
Disease and pest resistance	**2**	**2**	**5**
Early maturity	**4**	**3**	**2**
Drought resistance	**5**	**4**	**3**
Tolerance to low fertility	**3**	**8**	**4**
Seed setting/ grain filling	**6**	**6**	**7**
Palatability	**7**	**7**	**8**
Marketability	**8**	**5**	**6**

The respondents in all districts covered concurred that no selection is undertaken among the non-cultivated plants utilised. This implied that prevalent variations are attributed to natural selection. Apparently morphological variations are observed in several non-cultivated species, but are ignored in directional use oriented selections. Nonetheless, variants of such plants were given the same name and in addition differentiated

To gauge the local populace's perception in matters related to PGR; with specific reference to those already under utilization.

To identify neglected plant species in the three districts and the problems associated with the harvesting and conservation practices.

Methodology

Structured open-ended questionnaires were developed and used in a survey of 53 farm families from the districts of Mpigi, Masaka and Pallisa. . Randomly selected farmers of variable age groups and gender were interviewed at their farms and plant diversity on-farms verified.

The survey covered the sub-counties of Ssisa, Kasanje, Kilingente and Mituba II in Mpigi district, Lwengo, Bukulula, Kyazanga, , Lukaya TC and Kingo in Masaka district and Nabowa, Kadama, Bulangira, Pallisa TC (East ward), Kalaki, Kibuku, Kituti, Putiputi and Seeta in Pallisa district.

Data were collected on different parameters as provided for in the questionnaires (Appendix 1), which among other things included the common crops grown and source of seed, selection criteria, plants harvested from the wild, their attached value and uses, management of under-utilised and useful non-cultivated plants (mainly medicinal, fruits and crafts raw materials), partition of responsibility for PGR conservation within the communities, ethnic background, age and gender involvement in PGR issues and of indigenous knowledge. The data were compiled and responses in their respective categories and ranks were compared on percentage basis.

Results and Discussion

The survey results were basically descriptive. Each respondent used more than one conservation practice or facility and the response recorded (Table 1) was on basis of proportion of the total respondents utilising a particular practice. Management of PGR of vegetatively propagated crops was basically through continuous planting in the field, under shade or swamps, while for grain producing crops facilities utilised included granaries, metallic containers (tins, drums, pans or sufurias) baskets, clay pots, gourds but dominant was use of sacks/polythene (budeya) containers. Granaries, though rated very efficient in Pallisa were getting abandoned due to rampant thefts. Some storage methods were crop specific, for example hanging seed packages above chimney, spread of grain on store floor or house roof.

Seed treatment prior to storage by sun-drying was the commonest practice. During storage use of ash, concentrated banana juice and leaves of plant such as *Cypress* spp and *Tagetes minuta* and *Capsicum frutescens* were mentioned in Masaka and Pallisa. Farmers make little distinction between grain and seed under storage. The effects of the different storage methods on seed viability could not be quantitatively verified as respondents' experience and memory on storage periods and germination potential were vague and extremely varied. Farmers were aware that seed of small seeded crops (e.g. millet) had no storage pest problems as compared to larger grains (e.g. maize, beans). Ash treatment was given to all crop seeds intended for planting, while application of banana juice dressing was restricted for reasons not specified.

Though some plants are not yet domesticated, their persistent use and rising demand could in future lead to a need for their genetic enhancement and hence a search for variation amongst them. For non-cultivated plants (mainly medicinals, fruits and craft materials) a wide range of species were encountered, some of which were localised and rated rare (Appendix 2). Most responses implied little emphasis on direct management of this PGR with assumption that natural abundance will continue and remain communal. One of the factors hindering direct intervention in mass production of some useful non-cultivated plants is lack of knowledge of specific propagation methods. For example, *Vernonia amygdalina* commonly utilised for malaria treatment by all ethnic groups encountered, is not purposely planted in backyard gardens as is the case with other medicinals. The communities have no knowledge of its reproductive behaviour and propagation techniques and therefore rely on natural propagation. Luckily the natural dispersal mechanism of this plant ensures its wide distribution.

For home saved seed, most farmers had two major selection criteria. Crop yield was ranked first followed by adaptation (Table 2). The adaptive traits considered by the farmers include; resistance to pests and diseases, early maturity, drought resistance, tolerance to low soil

fertility, ability to set seed or fill grain, resistance to pests and diseases. In addition, palatability and marketability were considered by farmers in their selection criteria. Many of the farmers practised no selection on newly acquired seed as they would take on any available seed in season; especially after a drought spell. Generally, every farmer tends to have some sort of different appreciation or preference for some crop characteristics, but for discarding the very bad or choosing the best group their opinions tend to coincide. In any case selection undertaken is dependent on the varieties available to them and would follow the priority ranking accorded which tended to shift from region to region (Table 2).

Table 1: Conservation practices, facilities and processes commonly utilised in PGR management and their relative efficiency rating in the three study districts.

Conservation P ractice or FaciliT	Use intensity (% respondents) Mpigi	Masaka	Pallisa	Efficiency rating
Vegetative crops				
Planting in swamps	5	5	10	Fair
Continuous field cropping	90	92	50	Good
Planting under shade	2	4	8	Fair
Seeds or grains				
Metallic containers	5	17	-	Fair
Sacks (polythene)	39	56	51	Fair
Granaries	-	4	26	Good
Others (baskets, gourds, etc)	33	13	23	Good
Non-threshed grains				
Roof tops	-	-	2	Fair
Hang above chimney	5	4	-	Good
On floors	5	4	-	Poor
Seed Pre-treatment				
Sun drying	100	100	100	Very Good
Banana juice	5	-	-	Fair
Chemicals (especially insecticides)	-	4	-	Good
Botanicals (Cypress spp, Tagetes minuta)	-	4	-	Fair
Non-cultivated plants				
Community responsibility	-	-	4	Fair
Land owner's responsibility	-	17	4	Fair
Individual's backyard garden	1	2	4	Good
Left to natural forces	92	69	67	Good
Elders	8	12	-	Good

Table 2: Selection criteria and its priority ranking in the three study districts (Note; 1- highest priority, 8- lowest priority)

Characteristic or selection criteria	Priority Ranking accorded Mpigi	Masaka	Pallisa
Yield	1	1	1
Disease and pest resistance	2	2	5
Early maturity	4	3	2
Drought resistance	5	4	3
Tolerance to low fertility	3	8	4
Seed setting/ grain filling	6	6	7
Palatability	7	7	8
Marketability	8	5	6

The respondents in all districts covered concurred that no selection is undertaken among the non-cultivated plants utilised. This implied that prevalent variations are attributed to natural selection. Apparently morphological variations are observed in several non-cultivated species, but are ignored in directional use oriented selections. Nonetheless, variants of such plants were given the same name and in addition differentiated by an additional suffix, (referring to size or colour) and yet in some cases the plants in question would be of different species though in the same genera (e.g *Afromomum spp).*

Cultural beliefs attached to some species, especially medicinal plants, limited propagation of some species while emigration had its effects on appreciation of wild fruits. Cultural values and indigenous knowledge associated with these plants were in some cases location or ethno-specific. Respondents in most cases hinted at the use of spectrum and ecological indicator aspects of these plants , thus implying the untapped potential of indigenous knowledge in locating specific genera in socio-ecological settings.

Perception of cultural values in monetary terms were difficult to internalise but would most likely play a significant role in communities' involvement in PGR conservation and management. Where possible the monetary value attached to the rare PGR was subjective, generally low or non-existent, and the respondents (80%) attributed this to reduced appreciation emanating from changed dietary behaviour and lifestyles. Among plants which are raw material in profitably traded domestic crafts, *Marantachloa spp* were in process of getting domesticated in Mpigi district, while Phoenix reclinata remained in the natural habitat. The differential approach for these two plant species was attributed to their growth pattern and adaptation. This implied community willingness to harness PGR which can be commercially beneficial.

As regards responsibility for maintenance of various non-cultivated plant species the respondents attributed this to users or nature. However, none of them, even after indicating active use of these wild plants would attribute their conservation to themselves individually. There was a tendency to expect continuous flow of seed variants of crop plants from outside the community. In case of vegetatively propagated plants various conservation methods of variants were indicated as mentioned earlier (Table 1). Though growing enough food for the family and search for variation in food crops on-farm was a role generally attributed to women in the three districts, men also participated in germplasm selection in course of their participation in the crop calendar activities.

Conclusion

Conservation of the plant species diversity needs to be done alongside documentation of uses and any subsequent bioprospecting, or novel products promotion has to include the community in benefit sharing as stipulated in the CBD. While expansion of farming land is a threat to some species survival, lack of monetary value attachment limits the populace's enthusiasm for protection of the rarely utilised species. Use of botanical herbs in treatment of complex diseases is on the increase amongst Ugandans and for species on demand with low multiplication rates in the wild, there is bound to be a shortage or genetic erosion. Consequently the population has to be sensitized on sustainable use of resources. The general impression was that the traditional herbalists should be more concerned about wild plants conservation as opposed to the local populace. However, the taboos associated with some plants, especially medicinal plants, most of which are non-cultivated, need to be demystified before deliberate propagation for conservation purposes can be undertaken with participation of the local populace. Since cultural ethics have to be respected there is need for participatory appraisal of PGR and intensified creation of awareness. If the marketing of novel PGR is sustained better income would be derived from them and the community's poverty levels alleviated.

References

Anon (1999). National Biodiversity Action Plan : Edited by Uganda National Environment Authority (NEMA).

Bukenya-Ziraba ,R (1997). The non-cultivated edible plants of Uganda. In Proceedings of the 15th AETFAT Congress, Harare, Zimbabwe

Bukenya-Ziraba, R (1998). Germplasm Collection and Conservation in Uganda; Conservation and Utilization of African Plants, Monographs in Systematic Botany from the Missouri Botanic Gardens, Vol.71 : 91 – 106.

Katende A.B, Birnie A and Tengnas B (1995). Useful Trees and Shrubs for Uganda; Publication of Regional Soil Conservation Unit, USCU/Sida Technical Handbook Series, 10, 710pp.

Katende A.B, Segawa P and Birnie A (1999). Wild Food Plants and Mushrooms of Uganda

RELMA Technical Handbook Series 19, 490pp.

Appendix 1

Key elements in the Questionnaire which was used in the survey

1. General Biodata : Name of farmer/informant, Ethnic group, Language, Age group (Young, middle age, old), sex.

2. Ecogeographic description : Location district, Sub-county, village, Altitude, Climatic condition/ rainfall pattern, major vegetation type.

3. Crops grown : (List and ranked in order of importance)

4. Source of Variation : Seed source, selection criteria (ranked in order of importance) and process; criteria for discarding or retaining a variety, harvest process, quantity of harvest that constitute next season's crop, Non-seed producing crops and how availability of their germplasm is maintained.

5. Plants harvested from the wild (non-cultivated), their use, value and relative importance ranked, user spectrum.

6. Community responsibility for wild useful plants (rules, regulations, norms), who is responsible, any selections done.

7. Seed storage : Type of facility, pre-storage treatment, storage period, efficiency of method or facility (very good, good, fair), which crops were stored longest, their viability thereafter and any differences noted, what factors determine storage method/ facility used.

8. Crop plants grown and minor plants in backyard gardens, effects of seasons on plant variation on-farm, how germplasm is maintained in non-favourable seasons, gender roles in cropping calendar and germplasm management.

9. Ethnobotany : Plants maintained for cultural or medicinal purposes and source of their knowledge, reasons why they are not mass produced, suggested methods for their conservation, which plants are for human, animal or crop treatment, any other uses.

10. Plant Protection : How disease/ pests affect or influence farmers' conservation efforts and how selections are handled under disease/ pest infestations, names of pests/diseases known in the area, their frequency and control measures used.

Appendix 2: Plants harvested from the wild in Masaka, Mpigi and Pallisa Districts.

Appendix 2: Plants harvested from the wild in Masaka, Mpigi and Pallisa Districts

Plant species	Local Names	Major uses
Pseudospondias microcarpa	Nziru, Nzigu, Mitooga, Mikyoga	Fruit
Cyphostemma adenocaule	Akabombo	Medicinal
Erythrina abyssinica	Girikiti	Medicinal
Tagetes minuta	Kawunyira	Insecticide, Medicinal
Capsicum frutescens	Kamulali	Medicinal,
Chenopodium opulifolium	Omwetango	Medicine
Carisa edulis	Nyonza	Fruit
Momordica foetida	Bombo	Medicine, ceremonial
Aspilia africana	Makayi	Medicinal
Cleome gynandra	Joobyo	Vegetable
Punica granatum	Nkomamawanga	Fruit
Amaranthus spp	Dodo	Vegetable
Garcinia buchandrii	Nsaali	Fruit, Medicinal
Mangifera indica	Miyembe	Fruit
Lantana camara	Kayukiyuki, Kapanga	Fruit
Lantana trifolia	Kayukiyuki	Fruit, Tooth brush
Psidium guajava	Mapera (guava)	Fruit
Vangueria apiculata	Matugunda	Fruit
Vigna ungiculata	Goobe	Vegetable
Morus alba	Nkenene	Fruit
Afromomum alboviolaceum	Matungulu	Fruit
Afromomum miidbraeddii	Matungulu amatoono	Fruit
Rhus vulgaris	Bukwasokwanso	Fruit
Physalis peruviana	Ntuntunu	Fruit, Medicinal
Physalis minima	Ntuntunu	Fruit, Medicinal
Carica papaya	Papali, (pawpaw)	Fruit
Vernonia amygdalina	Mululuza, Lubirizi	Medicinal
Marantachloa spp	Enjulu	Crafts
Acacia hockki	Obusaana	Medicinal
Albizia coriaria	Mugavu	Medicinal, Timber
Grewia mollis	Enkoma	Bridge support, Charcoal
Termitomyces aurantiacus	Obutiko (8 types)	Food
Rubus pinnatus	Enkenene	Fruit, silkworm feed
Dioscorea adoratissima	Kaama	Food, medicinal
Saba comorensis	Amavungo, Mabungo	Fruit
Corchorus olitorius	Kamutyerere (wild okra)	Vegetable
Ficus natalensis	Tera, Nkoni	Bird traps
Strychnos innocua	Ekwalakwala	Vegetable
Tamarindus indica	Nkooge	Fruit
Canarium schweinfurthii	Mpafu	Fruit
Phoenix reclinata	*Ensansa, Lukindu*	Crafts