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Introduction of deciduous fruit tree growing in the tropical highlands of Kabale, Uganda

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Abstract

Exploratory deciduous fruit trees trials in Kabale highlands started in 1999. Initial materials were acquired from Kenya. All initial plantings were grafted on Bittenfeldar rootstock seedlings raised from seed obtained from Germany. More species and cultivars were added in 2000 and by December 2003, over 30 cultivars of deciduous fruits namely; Apples, Peaches, Pears and Plums had been introduced for investigation. Initial trials of Apples anna and Golden dorsett were established at Bugongi, Buhara Kachwekano and Kalengyere. At Kalengyere Apple anna and Golden dorsett were top-worked in 2000 on rootstock trees that were established in 1995. Again in 2000, apples anna and Golden dorsett were supplied to 80 farmers at different altitudes for on-farm trials. Agronomical data, flowering and fruiting and yield data has been collected. Orchard management as well training trees to develop an open architecture have been practiced. The original aim of the deciduous fruit tree introductions was to confirm their potential to produce viable fruits in the highland systems of Uganda and therefore offer an alternative source of income and nutrition. In addition it was aimed at identifying relevant research studies that are needed to develop the deciduous fruit tree growing as a profitable enterprise. Twenty-four out of the 30 cultivars of apple, pear, peach, nectarine and plum, which have been introduced on station sites have flowered and produced fruits. Fruiting for apples anna and golden dorsett started after two years. At four years and under moderate tree management, apple Anna and Golden dorsett have produced an average of 5 kilograms per tree (a retail value of USh 20,000). No significant yield difference has been observed at different altitudes. Highest yields have however been registered on trees that were grafted in the field. In the Kigezi climatic conditions, two potential fruit harvesting seasons of May –June and November –December are possible for apples. Some cultivars of peaches have produced an average of 12 kg per tree per year. Also Pears have shown excellent performance while plums are trailing.

Key words: Cultivar, delayed foliation, dormancy, pruning and grafting, temperate climate

Introduction

Contribution of Africa to the world production of deciduous fruits (Apples, Pears, Peaches, Nectarines and plums) was a mere 1.84% in 1981 (Jackson, 1986). In 2002, the major producing countries of Africa namely, South Africa, Egypt, Tunisia, Morocco and Algeria contributed 2,151,877 metric tones, just 1.43% of the world production (CIAMD, 2002) a percentage which cannot meet the demands of African people. According to Subhadrabandhu (2001), there is increasing demand for deciduous fruits in the tropical countries. No East and central Africa country is known to produce any substantial amount of deciduous fruit, yet the people in the regions are increasingly consuming deciduous fruits. Deciduous fruits and products consumed in East and Central Africa, originate from South Africa or they are re-exports from other countries (Ssemwanga, 2003).

Though deciduous fruit are typical temperate climate trees, they also grow and produce fruit in the tropics where altitude ranging from 1500-2700 m.a.s.l. and temperatures average around 21-24^{0}C Bal (1997). The number of cold hours (chilling units) deciduous plants experience before buds break is critical to amount of fruiting for deciduous plants. Each deciduous species and cultivar have different chilling units that determine its productivity. According to Rice et al (1987), 7^{0}C is the highest temperature at which most deciduous plants enter into dormancy. The number of hours of temperatures below 7^{0}C that a given species or cultivar must undergo before bud dormancy is broken is the determining factor on the amount of bud breaking at a given time. Some cultivars of the same species require short hours while other need longer hours. Prior to this study, no studies have ever been conducted to investigate the potential of temperate tree fruits in the Kigezi highland systems despite the suitable climates. Kigezi highlands range between 1500-3000 m.a.s.l. and an initial systematic temperature recording shows a range between 2.2^{0}C and 29^{0}C with an average at 15^{0}C during the cold and dry seasons of May to July (Turyomurugyendo, Unpubl.). In India, areas with an

average maximum and minimum temperature of 20^0 and 10^0 C respectively have resulted into good apple fruit setting and excellent fruit yields (Bal, 1997).

Therefore, integration of deciduous fruit tree technologies in the agroforestry farming systems of South Western Uganda is a perfect option that conforms to the Uganda government's PMA strategy of transforming subsistence farming to commercial production without compromising the natural resource base. An on-farm assessment of the diversity of trees in the cool highlands of Kabale (Turyomurugyendo, in-prep; 2002) indicats a very low diversity of fruit trees in terms of abundance and species richness. Even for the fruit trees like avocadoes that exist in these highlands, no research has been conducted to identify the suitable varieties. Absence of appropriate fruit tree species and cultivars in the Kigezi highlands imply that people living in this mountainous area lack vital dietary supplements and have thus foregone an economic opportunity that would be accrued. The result is that there is low culture of fruit eating (fruits are for the children) and hence a small market for fruits.

In an effort to comply with the Uganda's PMA policies, NARO together with ICRAF started an adaptive research and development programme of introducing deciduous fruit trees in Kigezi highlands in 1999. If successfully established, these trees will improve scenery of the already degraded landscape, improve nutrition, contribute to generation of household incomes, create additional jobs, reduce loss of foreign currency by substituting imports (Raussen, 2003) and may curtail emigration of Bakiga in search of productive resources. The initial objectives of the trial were to: confirm that the deciduous fruit trees produce fruit in the highlands systems; identify promising species and cultivars for further research and development; and recommend further research needs to enhance temperate fruit growing in Uganda. This paper presents findings of the trial that has been running for four years. It focuses on two cultivars of apples namely; anna and Golden dorsett. The information provided here is based on results of data collected between 2000 and 2003.

Materials and methods

Location and design of trials

Exploratory trials started in the Kabale highland systems in September 1999 with a very small number of grafted Apple cultivars namely; Anna, Golden dorsett, Winter banana and Rome beauty. All apples trees currently growing in Kabale were grafted on Bittenfeldar rootstock seedlings raised from seed obtained from Germany. Most fruit cultivars present in Kabale by 2004 were acquired from Kenya and Tanzania where they were introduced during the colonial times (Griebasch, 1992). The first plantings were at Bugongi (1830 m.a.s.l), Buhara (1930 m.a.s.l) and Kachwekano (2010 m.a.s.l). Being very few, no statistical design was considered during the initial planting. Later a complete randomised block design trial involving 11 apple cultivars was set up at Kachwekano and Bugongi in October 2000. At the same time, deciduous fruit tree species were expanded on to include pears, peaches and plums. Also in October 2000, 80 farmers hosted by AFRICARE were supplied with two trees of each of apples anna and golden dorsett and pears Naspal and Taiwan hybrid for on-farm trials. At Kalengyere (2499 m.a.s.l), there existed a seven year old bittenfeldar apple garden that had neither fruited nor flowered. In April 2000, the trees were cut back and selected re-sprouts grafted (top-working) with apples Golden dorsett and Anna. In addition, a few grafted seedlings of Golden dorsett and Anna were planted in the gaps.

Measurements and data collected

Tree growth, flowering and fruiting and yield data was collected as follows:

a) Tree growth

Parameters that were measured for tree growth were Root Collar Diameter, Height of the leading stem and the crown diameter. These measurements were done on trees that were between 1 year and 3 years old. In addition to tree growth variables that were measured, the vigorousness of the trees at each farm were subjectively recorded based on a scoring scale of 0 to 5. Scores were made based on the condition of the entire tree and the state of leafing at the time. Only one technician did the scoring of both on-station and on-farm trees. A score of 0 meant dead, 1 meant stunted, 2 meant poor growth, 3 meant moderate growth, 3 meant vigorous growth and 5 meant very vigorous.

b) Flowering and fruiting

Flowering and fruiting information provided in this paper mainly originate from on-station trees. Flowering and fruiting data was collected from previously tagged trees. These trees were randomly selected for monitoring in 2002. Data on flowering was collected once eery flowering season. This was done in the second and third week after the first flowering. Flowering was recorded on the number of floral clusters per tree. The total number of flowers per tree was estimated as the average number of flowers per cluster for five randomly selected clusters multiplied by the number of clusters on the tree. Only floral buds with clearly opened flower parts were counted. Similarly fruiting data was recorded once in the fruiting season. Amount of fruiting was taken as the total number of fruit found on the tree in the second month of the fruiting season.

c) Yield

Yield per tree was taken as the number of fruits present on the tree just three to four weeks before harvest time. After harvest, the harvests per tree were packaged in separate containers and weighed. All fruits in each lot were weighed as one unit and the average weight was taken as the weight of individual fruits for that tree. A random pick of one

fruit from the whole fruit lot per tree was made to determine the cross-sectional diameter and height of the individual fruits per tree.

d) On-farm data

After the June-July 2003 fruit harvest, an on-farm opportunistic survey was done to assess farmer harvests per tree per farm and also assess farmer practices. A total of 41 farmers were interviewed for on-farm fruit harvest and their 41 gardens visited to assess farmer management practices and challenges.

Also opportunistic monitoring of outbreak of diseases and pests has also regularly been done on both on-station and on-farm to identify critical diseases and pests affecting the trees in the new environment. A more detailed assessment of pests and diseases on deciduous fruit trees was done in April 2004 (Tumwine, 2004).

Data analyses

Being preliminary in nature, partial analysis has been done. The analysis has been done using GenStat statistical package (edition 6). The focus on the analysis was on the average performances (vigour, flowering and fruit yields) and comparisons made to show any differences at different altitudes. Significance levels were considered at 95% confidence limits.

Results

Fruiting species and Cultivars

Four major deciduous fruit tree species, namely; apples, pears, peaches and plums have been introduced in the agro farming systems of Kigezi highlands since 1999. Currently, 20 cultivars of apples, 7 pears, 6 peaches (including one nectarine and one Almond) and 8 plums have been introduced for investigation. A literature review indicates that out of the 20 cultivars of apples under trials in Kabale, seven of them namely; Golden delicious, Granny smith, Red Jonathan, Rome Beauty, Red Boskop, Gloster and James Grieve are among the top 40 major apple cultivar promoted in the world in 2002 (CIAMD, 2002). Plates 1 to 3 show selected fruiting apples and peaches both on-station and on-farm in the Kabale highlands. So far nine apples namely; Anna, Golden dorsett, Winter banana, Rome beauty, Swiss orange, Red Jonathan, Dulmener, James grieve and Gloster; and five peaches namely; Barbara, Florida gold, Sunlite, Exrangui, Ex-manalo have fruited. Four pear cultivars namely; Naspal, Spadona, Taiwan hybrid and Japanese yellow and five plums namely; Myrobolana, Ogden, Harry pickstone, Santarose and Eldorado have shown excellent growth characteristics. At four years the excellently growing pears and plums have started fruiting.

Agronomic performance of introduced apple cultivars

Table 1 shows the relative agronomic performance of 1½ year-old apple cultivars at altitudes of 1830 and 2500 m.a.s.l while tables 2 and 3 shows performance of one year old apple cultivars 1830 m.a.s.l. Irrespective of age, comparisons of apple cultivars with the Bittenfeldar rootstock shows that at 1½ year-old trees, Bittenfeldar has the least terminal growth. Based on observed vigour values shown in table 3, at one year cultivars anna and golden dorsett are the fastest and most vigorous of the apple cultivars present in Kabale. At two years, apple anna and Golden dorsett were the most vigorous in all the Kabale elevations. Measurements of height up to the terminal bud for the grafted show a lot of variation. This might be explained by the differences in the genetic make up of the rootstock seed.

Table 1. Agronomic performance on the 1½ year old apple cultivars at 1830 m.a.s.l

Variable	Anna	Bittenfelder	Golden dorset	Rome beauty	Winter banana
Average of Vigour score	4.44	4.41	4.20	3.80	3.60
StdDev of Vigour score	0.73	1.06	0.84	0.45	0.55
Average of Leaf score	4.22	4.71	4.00	3.40	3.60
StdDev of Leaf score	0.83	0.99	0.71	0.55	0.55
Average of RCD	1.80	1.49	1.99	1.46	1.94
StdDev of RCD	0.70	0.42	0.57	0.32	0.25
Average of Height	119.56	117.65	121.40	268.20	136.40
StdDev of Height	45.29	41.02	41.91	384.80	30.66

Table 2. Agronomic performance of 1 year old grafted apples at 2500 m.a.s.l

Variable	Anna	Golden dorset	Winter banana
Average of Vigour score	3.52	3.80	2.2
Average of Leaf score	3.48	3.90	2.4
StdDev of Leaf score	0.81	0.94	0.55
Average of RCD	1.89	2.51	0.74
StdDev of RCD	1.13	2.40	0.32
Average of Height	96.09	97.40	39.22
StdDev of Height	49.00	71.02	10.00

On-farm performance and management practices

Table 4 shows average agronomic performances of the two apple and pear cultivars introduced on-farm. Compared to on-station managed trees, the on-farm apple cultivar results show no significant difference. These results shows that there was reduced vigour in the second year of growth. This can be explained from the pruning effect that was done at the end of second year.

Table 3. Agronomic performance of 1 year old apple cultivars at Bugongi

Variable	Anna	Dulmen	FAW	Glock	Glost	G.dors	G.Smit	J.grieve	R.Bosk	R.beau	S.Orang	W.ban
Aver Vigour	4.00	1.90	2.33	2.40	2.80	3.50	2.20	2.20	2.10	2.40	2.50	2.60
StdDev Vigour	0.82	0.74	0.71	0.70	0.79	0.58	0.79	0.63	0.88	0.55	0.53	0.89
AverLeaf	4.25	1.90	2.22	2.20	2.50	3.50	2.10	2.00	1.80	2.20	2.60	2.20
StdDev Leaf	0.50	0.74	0.67	0.63	0.53	0.58	0.57	0.67	0.42	0.45	0.70	0.84
Aver RCD	2.73	1.28	1.56	1.72	1.96	2.23	1.46	1.49	1.57	1.28	1.71	1.75
StdDev RCD	0.95	0.36	0.50	0.50	0.73	0.31	0.26	0.43	0.48	0.18	0.52	0.88

Table 4. On-farm performance (averages) of apples and pears introduced in 2000

		Apple		Pear	
	Variables	Anna	Golden dorsett	Naspal	Taiwan Hybrid
2001	Vigour score	3.76	3.85	3.96	3.55
	Leaf score	3.79	3.72	4.27	3.89
	RCD (cm)	1.37	1.42	1.12	1.16
	Height (cm)	101.14	112.05	106.82	94.34
2002	Vigour score	3.43	3.47	3.59	3.57
	Leaf score	3.25	3.26	3.52	3.39
	RCD (cm)	2.46	2.25	2.31	3.30
	Height (cm)	129.17	135.42	156.68	170.89

Table 5. Management practices practiced farmers in 2003

Management practice	Number of farmers	Percentage%
Staking, defoliation, pruning, manure application	21	38.2
Defoliate, stake, manure app.	6	10.9
Prune, defoliate, stake	6	10.9
Defoliate, stake	3	5.5
Prune, stake, manure app	3	5.5
No management	3	5.5
Intercropping (sorghum, beans, Irish potatoes, Sweet potatoes, Cassava, bananas, Maize	36	65

Table 5 shows that of the 41 farmers assessed 38% were adopting all management practices trained in and 65% practice intercropping with a wide range of short and tall crops. This study also reveals that 82% of the fruit gardens are damaged by domestic animals particularly goats and sheep. Where fruiting is poor, on 82 % of the farms, the loss is attributed to flower abortion and another 34% farmers lose their fruit through bird damage. Only 17% of farmers have not succeeded in getting a fruit from their trees. Management failures are the main cause of the failure to produce fruit. Thus managing flower abortion and protection of trees against birds and domestic animals are some of the main challenges critical issues a successful fruit enterprise. According to farmers, most flower abortion occurs during the dry seasons. However table 6 shows that flower abortion also occurs during dry and rainfall seasons.

Pest and disease on deciduous fruit trees in Kabale

The main diseases so far observed on the introduced fruit trees are Scab, Powdery mildew, leaf spot diseases, Blights, and bacterial cankers plums and peaches. Pests observed are aphids, and an unidentified caterpillars. The diseases observed are some of the known diseases that affect the trees even in the temperate regions. Pest and disease incidence and severity have not been assessed. Scab has however been serious at Kalengyere where it is moist most of the year.

Flowering and fruiting of apples

The apple cultivars that have flowered and fruited in Kabale have displayed alternate bearing characteristics. In most places, apples start flowering in April and continue up to July and then start again in December up to February. Most flowering happens during the dry seasons, which have very cold nights and hot daytime. Table 8 shows the average number of flower clusters for selected apple cultivars per tree. The results are averages of data collected for two consecutive years. All the cultivars show an increased cluster production per year. However, the increase in cluster development varies per tree and per cultivar. This could be explained from the cause of variation in tree sizes despite the same age.

Table 6. Responses on incidence of flower abortion

Problem	Frequency	Percent (%)
Falling of flowers in dry season	22	40
Falling of flowers in wet season	5	9.1
Falling of flowers in any season	8	14.6

Flowering and fruiting of apples "Anna" and "Golden dorsett"

a) Landscape level

Table 10 shows an overall flowering and fruiting of apples "anna" and "Golden dorsett" in the four research orchards established in 2000 in the Kigezi highlands. It shows that apple Golden dorsett appear to produce more fruit and flower. The student t-test suggests a strong difference of the amount of flowering of apples "anna" and "Golden dorsett" in the entire landscape ($F=3.02$, $P<0.001$). Similarly, fruiting of the two cultivars is significantly different ($F=4.43$, $P<0.001$). Both flowering and fruiting results show golden dorsett producing more flower and fruit than apple anna. The negative skewed ness suggest that many trees are currently producing below the average trees. Figure 1 show the monthly flowering for the combined apples anna and Golden dorsett. These results suggest that apples anna and Golden dorsett are in flower and fruit almost all the year round. The current results show that the amount of monthly flowering varies greatly although April seem to be a peak flowering month for both Anna and golden dorsett. Figure 2 shows the trend of fruiting in the year 2003 for the grafted seedlings of apples anna and Golden dorsett. Figure 2 indicate that apples two fruiting seasons for apple anna and golden dorsett. The fruiting seasons identified are March-June and October-December. Both figures 1 and 2 show that apples anna and golden dorsett are in flower and fruit at the same time. The data suggests alternate productions for anna and Golden dorsett. The major fruiting season for apple anna seems to be March-June while it is October-December for Golden dorsett. Also, graph 2 seems to suggest that apple anna mature earlier than Golden dorsett in each fruiting season.

b) Flowering and fruiting at different altitudes

Table 11 shows flowering and fruiting of apple anna and Golden dorsett combined together at different altitudes. The analysis was done on the three year old trees. Both mean and maximum values shows highest flowering and fruiting at the highest elevations of Kalengyere. The ANOVA analysis shows higher flowering and fruiting ($P<0.001$) at Kalengyere compared to other sites. Kalengyere differs from other orchards because grafting was done on already well established rootstocks system. The in-field grafted trees are generally larger than grafted seedlings. The in-field grafted trees at Kalengyere are generally larger and more vigorous than all other trees in the whole landscape of Kabale.

Table 9 shows the average number of flowers per cluster for the apple cultivars in table 8. The results show that at two and three years, apples anna and Golden dorsett are producing more flowers than all other cultivars under trial in Kabale. However, the number of flowers on other cultivars shows great variation because the flowering and fruiting was still in its infancy.

Flowering and fruiting of apples "Anna" and "Golden dorsett"

a) Landscape level

Table 10 shows an overall flowering and fruiting of apples "anna" and "Golden dorsett" in the four research orchards established in 2000 in the Kigezi highlands. It shows that apple Golden dorsett appear to produce more fruit and flower. The student t-test suggests a strong difference of the amount of flowering of apples "anna" and "Golden dorsett" in the entire landscape ($F=3.02$, $P<0.001$). Similarly, fruiting of the two cultivars is significantly

Table 8. Average floral clusters per tree for selected apple cultivars

Year	Data	Anna	Golden dorsett	Gloster	Red Jonathan	Swiss Orange	Winter banana
2002	No. observation	41.0	13.0	2.0	2.0	2.0	5.0
	Average floral clusters	5.2	3.2	1.0	1.5	1.0	1.4
	Max floral clusters	52.0	9.0	1.0	2.0	1.0	2.0
	Variance	80.7	6.3	0.0	0.5	0.0	0.3
2003	No. observation	93.0	53.0	10.0	9.0	13.0	27.0
	Average floral clusters	26.1	29.4	1.8	2.1	2.2	2.5
	Max floral clusters	193.0	263.0	6.0	5.0	6.0	11.0
	Variance	1497.9	3649.3	2.6	1.9	3.0	4.6

Table 9. Average flowers per flower clusters of selected apple cultivars

Year	Data	Anna	Golden dorsett	Gloster	Red Jonathan	Swiss Orange	Winter banana
2002	Average flowers	4.24	4.15	5.50	4.00	5.50	4.40
	Variance	1.29	1.97	24.50	18.00	0.50	2.80
2003	Average flowers	4.40	4.32	4.30	4.67	4.38	4.07
	Variance	1.31	1.99	4.23	1.75	1.76	1.69

Table 10. Amount of flowering and fruiting of apples "anna" and "Golden dorsett" for all orchards combined.

	Flowers		***Fruits***	
	Anna	Golden dorsett	Anna	Golden dorsett
n (trees)	134	66	134	66
Mean	92.2	117.9	15.34	24.5
Median	28.0	19.0	6.0	4.5
Max	965.0	1315.0	155.0	268.0
S.e	13.7	33.9	2.16	6.5
Cv	171.9	233.6	163.34	214.5

Table 11. Average flowering and fruiting at different altitudes of Kabale highlands

Development stage	Variants	Bugongi	Buhara	Kachwekano	Kalengyere
Flowering	N trees	38	29	39	81
	Mean	73.3	36.3	39.5	178.7
	Median	31.0	9.0	15.0	48.0
	Max	510.0	312.0	252.0	1315.0
	S.e.d	17.0	12.0	9.4	32.3
	Cv	143.2	178.2	149.3	162.9
Fruiting	N trees	38	29	39	81
	Mean	13.2	35.9	6.0	103.3
	Median	2.5	19.0	1.0	69.0
	Max	70.0	155.0	116.0	268.0
	S.e.d	3.3	7.5	3.0	5.1
	Cv	153.5	112.8	311.2	199.0

Discussion

In the temperate climatic zones, deciduous trees rest (start dormancy) in autumn, lose their leaves during the chilling winter time (natural defoliation) and start growing in spring (blossoming). This growth system is natural and characterizes the trees wherever they are. Kigezi highlands experience major winter-like and summer-like conditions in the June-July season and a slight one in December-January period. During these seasons, night temperatures fall to below 10^0C while day temperatures rise to 25^0C plus (Turyomurugyendo, in prep; 2004). In the tropics, large chilling units that are built during the low night temperatures are usually cancels during day time when temperature are very high (Smith Chris, pers. communication). This inevitably results into incomplete bud dormancy and breaking and delays foliation for the high chill cultivars. The implication is that the number of deciduous fruit cultivars that will give the maximum yields observed in temperate zones may not be found. Some cultivars like apple anna and golden dorsett will however perform better than others. The two observed fruiting seasons could actually be a result of incomplete bud dormancy and breaking in one season. In the temperate climates, flowering is a one time off event followed by fruiting. This happens once a year. The double flowering and fruiting observed in Kabale means that the cold nights and hot day times cause hormonal confusion for plants grown in the tropical highlands. Perhaps this explained the seemingly continuous flowering and fruiting observed in Kabale. It is therefore necessary that mechanisms to synchronize bud breaking are established in addition to determining the best fruiting season. Also, a large number of cultivars of each species need to be further investigated on to determine those that offer better market opportunities and have high yields. Judging from the number of cultivars already flowering and fruiting in the Kabale highlands, it is evident the number of deciduous fruit species and cultivars that will produce viable fruits will increase beyond the current ones. A large number of promising cultivars will in what Mudge (2002) stated as "offer opportunities and possibilities right on our doorsteps and there are already some good stories to tell". The wide

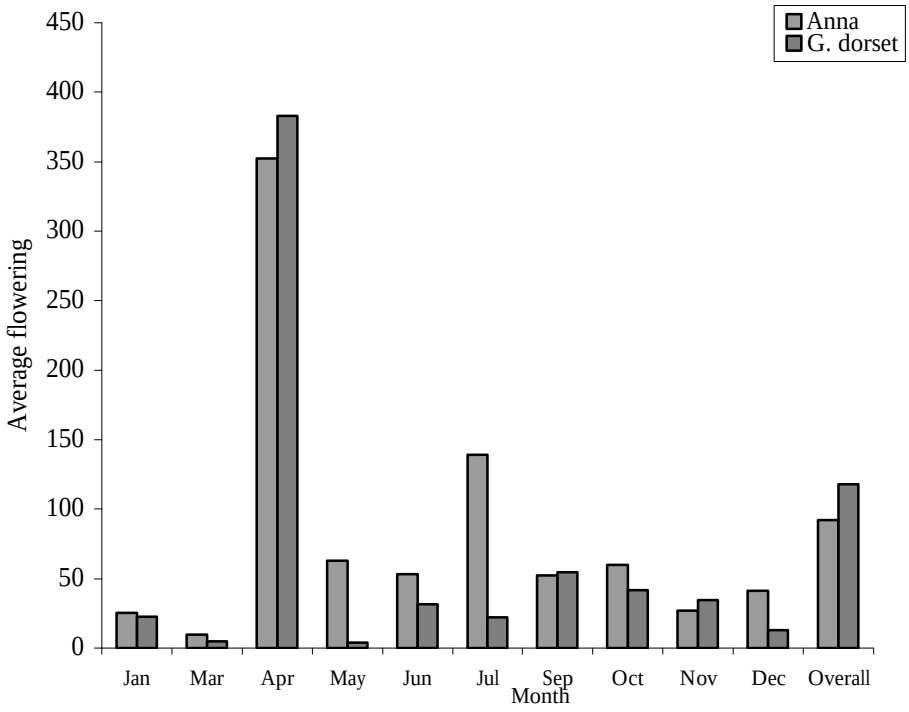

Fig.1 Flowering of apple anna and G.dorset

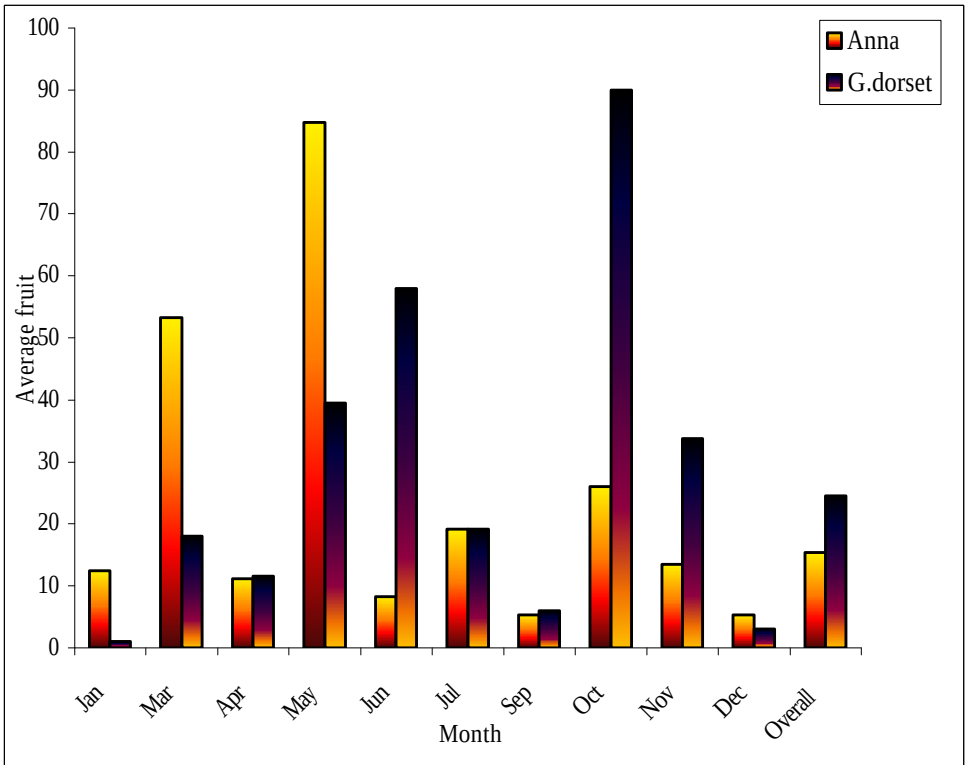

Fig 2. Average fruiting apples anna and Golden dorsett

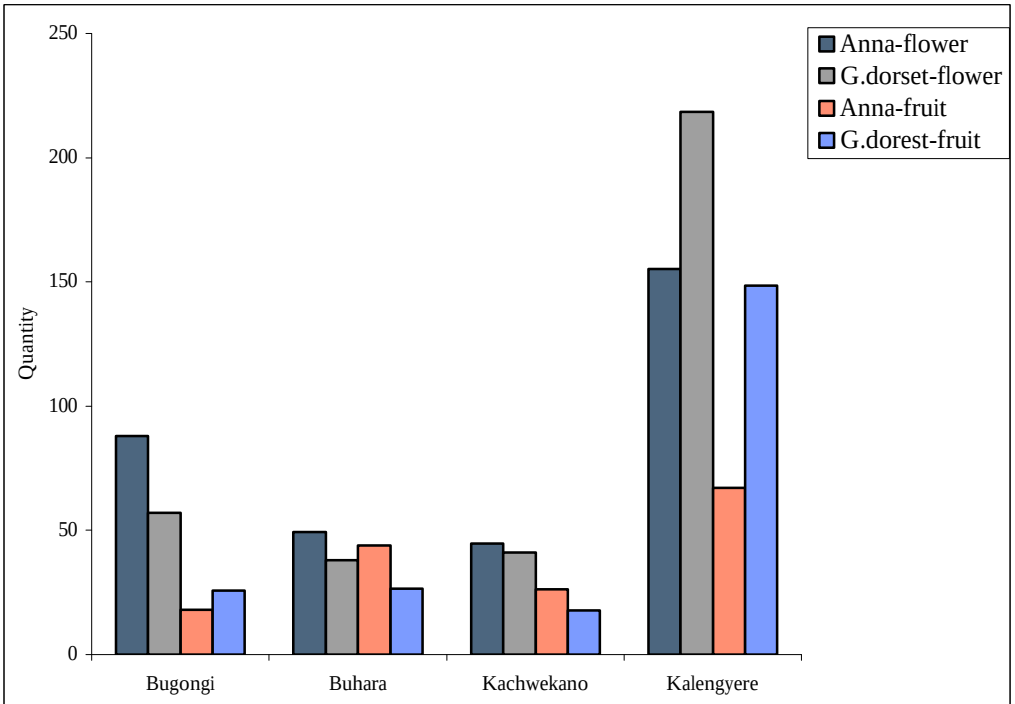

Figure 3. Average flowering and fruiting of apples anna and Golden dorsett at different elevations

range of fruiting cultivars have proved potential of deciduous fruit production provided the right crop husbandry practices are given. Some apple cultivars like Winter banana, Rome beauty and Granny Smith have shown problems of foliation. They are producing fruit at the tip of the stem and often at the end of two growing seasons. This has also been observed on some cultivars of peaches, which are generally known to be of low chilling requirements compared to Apples (Griesbach, 1992). In the tropics, deciduous fruit trees suffer from physiological disorders called delayed foliation as a result of inadequate low temperatures (Rice *et al*, 1987). Not only is more studies needed to establish the best performing cultivars but also it is important that practices to induce foliation in time are investigated. Based on the analysis done on apples anna and Golden dorsett, which have shown high productivity both on-station and on-farm, and the fact they are producing at every part of the stem (spurs, laterals and on the tips), they appear most promising and could as well be released for full scale development.

Information obtained from figures 1 and 2 suggests two possible harvesting seasons for apples but with different yields per season. Analysis of apples anna and Golden dorsett suggest alternate fruiting of apple cultivars where one cultivar could be on the market much earlier than the other. The wide range between the average and the maximum flower and fruit suggest that there is big potential to produce more fruit per tree per age if uniform sized trees are attained. The two potential fruiting seasons observed for apple anna and golden dorsett may not result into the same yield every year. It is possible that one season will be heavier and another may crop poorly (Bal, 1997). Therefore, more study is needed to determine the best season for each apple cultivar. The year round flowering and fruiting of apples anna and golden dorsett is in sharp contrast with the production cycles in the temperate countries where they flower and produce fruit once a year. Although this may have its advantages, for example being able to supply markets throughout the year, it pauses difficulties of managing the trees for maximum production. Thus there is need to study the behaviour of the deciduous trees (bud development and differentiation) in the tropical highland systems to be able to determine appropriate tree management options. How to synchronize bud breaking for each period is a serious challenge that requires special attention.

This preliminary study has established varied tree sizes of the same age. It subsequently results into varied fruit yields per tree. The variability in tree sizes and fruit production could be explained by the variability of rootstocks raised from seed (Howard, 1989). Rootstock seedlings raised from seed usually result into varied plants because the seed is a result of cross pollination. Thus identification of suitable rootstock cultivars for each fruit

tree cultivar and environment (soil type, elevation and hill aspect) is critical for a thriving enterprise. Considerations for use of clonal rootstocks are therefore paramount.

On-farm survey results on management practices suggest that continuous training and monitoring of farmers is critical. Perhaps, most farmers still regard fruit trees as any other tree planting/growing practices where trees are left to grow and produce with little input on management. These attitudes need to change through constant practical training and follow-ups. It is also important that research helps to determine which annual crop could integrate well with the introduced deciduous tree crops. More information is needed on the ways to control flower abortion as well as control of bird and domestic animal damage. Diseases and pests so far identified on the introduced deciduous fruit trees are those common on other crops. Most diseases observed are the well-known fungal problems that all fruit producing countries experience. Their control measures are known and therefore cannot become a limiting factor in Kabale. However, more studies are needed to identify particular causes of the disease identified, the seasons of high incidence and severity and also determine the appropriate management options.

According to Griesbach (1992), one of the major factors that will limit deciduous fruit production in East Africa and Uganda in particular is the lack of sufficiently cold temperatures to break the bud dormancy. There are however, a large number of cultivars that require low chilling hours (ARC- INFRUTEC, 1997), which Uganda could benefit from and perhaps consider as priority in the enhancement programs.

Conclusions

This study confirms that deciduous fruit trees from temperate regions are adapted to the highland conditions of Uganda. They therefore offer excellent opportunities for widening the limited range of available nutritive foods and income generating opportunities for the people living in Uganda's highlands. Since local demand for temperate fruits is increasing and is currently only met by imports, the unexploited potential for local production can now be addressed. Even before sufficient biophysical and market evidence has been gathered, the encouraging initial results have generated huge demand for planting materials. Substantial financial support from local government to promote temperate fruit farming is forthcoming. Efficient and effective scaling up of temperate fruit production in Uganda's highlands has to address the need for decentralized multiplication of high quality planting material, local capacity strengthening for provision of advisory services in tree propagation, management and pest and disease control, market and producer organization development, as well as continued adaptive research to establish best suiting cultivars and management practices. The encouraging agronomic and yield performance of apples anna and golden dorsett offer reasonable promise for scaling up. However, Jackson (1986) mentioned that temperature, humidity, light, soil, wind, topography, and pests and diseases are important factors that determine the distribution of deciduous fruits and their cultivars. Thus to ensure a strong foundation for a successful enterprise, the focus of research should be expanded on to include among other things the following:

a) Development of appropriate management systems for different cultivar/rootstock combinations
b) Determination of chilling units for the highland systems to be able to introduce cultivar of high probabilities
c) Investigation of performance of cultivar/rootstock combinations in different soils, elevations, hill slope aspect
d) Continuous surveillance to identify and design measures to control diseases and pests
e) Monitoring of bud development/breaking and evaluate different ways to synchronise flowering and fruiting
f) Investigation of ways to increase fruit set and size and development of full colours
g) Understanding the effect cultural and traditional factors (agricultural practices, fruit eating habits) may have on fruit growing on both small and large scale producers.

The idea of promoting deciduous fruit in Uganda is good for purposes of local markets and improving nutrition. However, more effort is needed to identify low chill cultivars. Extension for large-scale production should be cautious, as it may be difficult to compete with imports. Costs of production and storage may be the same as those in temperate zones and yet the mountainous people of Uganda may not have adequate resources to produce quality and quantity. In other words, it is essential that cheaper ways of production and storage be integrated in the whole research paradigm.

References

ARC-INFRUTEC., 1997. South African deciduous fruit cultivars list. ARC-INFRUTEC Public relations office, Stellenbosch, South Africa.

Bal J.S., 1997. Fruit growing. Kalyani publishers.New Delhi, India

CIAMD (Centre for International Agricultural Marketing and development)., 2002. Key deciduous fruit statistics. Deciduous fruit producers trust. Paarl. South Africa.

Griesbach J.., 1992. A guide to propagation and cultivation of fruit trees in Kenya. Deutsche Gesellschaft (GTZ), Germany.

Jackson, D., 1986. The distribution of fruits. In Temperate and sub-tropical fruit production. Butterworths of New Zealand (Ltd). New Zealand.

Mudge Nigel. 2002. South African Apples and Pears. *Deciduous fruit producers Trust annual review report.*

Howard B.H., 1989. Rootstock propagation in *Rootstocks for fruit crops*.(pp 29-72). Edited by Rom.R.C. and Carlson R.F. 1989. Publ. John Wiley and sons. New York,

USA.

Raussen T., 2003. Proposal for Uganda national strategy for temperate fruit development. Based on Planning workshop held February 16-20 2003. World Agroforestry Centre (ICRAF) Office, Kampala Uganda.

Rice C., Rice L.W. and Tindale, H.D., 1987. Fruit and Vegetable production in Warm climates(pp 147-177). Published by Macmillan. Smith Chris, an expert at ARC-INFRUTEC in South Africa

Ssemwanga.,E., 2003. Assessment of market potential for selected tree fruits in Uganda. FORRI-ICRAF report, ICRAF-Kampala Uganda.

Subhadrabandhu, S., 2001. Deciduous fruit in Thailand. *Acta hroticulturae*