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HIV and orientation of subsistence and commercial home gardens in rural Ghana: Crop composition, crop diversity and food security

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An empirical study was conducted to explore differences and similarities in biodiversity in subsistence and commercial home gardens of HIV-positive and HIV-negative rural households in the Eastern Region of Ghana and their significance in household food security. Data were obtained through a household and home garden survey of a purposive sample of 32 HIV-positive and a random sample of 48 HIV-negative rural households and through in-depth interviews. A higher proportion of species common to all four home garden types consisted of food crops: vegetables, staples and fruits. In HIV-positive households, commercial home gardens were significantly larger, had significantly more species and individual plants, more perennial food crops and more species that were harvested all year round and evenness was lower, but there was no significant difference in species diversity compared with subsistence home gardens. Significantly, more HIV-positive and HIV-negative households with a commercial home garden consumed a staple crop cultivated in the home garden in the 24-h period prior to the survey than HIV-positive households with subsistence home gardens. Rural households with HIV that manage commercial home gardens cultivate a dual purpose home garden which supplies subsistence food and also provides cash income; such households may have better food security than households that cultivate subsistence home gardens.

Key words: Shannon-Wiener index, dual purpose, home garden biodiversity, evenness.

INTRODUCTION

Home gardens can serve as an important source of both food and cash income for vulnerable households. In recent years a great deal of emphasis has been placed on the potential value of the home garden in providing subsistence food and additional income for households affected by HIV (Irwin and Parker, 2004; Bukusuba et al., 2007; Murphy, 2008). There are, however, no empirical studies on the differences between the biodiversity in home gardens cultivated for subsistence only or for commercial purpose as well by rural households affected by HIV illness. It is this intersection that this paper addresses.

The primary function of most home gardens, that is, providing subsistence food, has overshadowed their role of contributing to the cash income of rural households. The primary objective of home garden production, for either cash income generation or for household

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consumption, influences home garden biodiversity (Trinh et al., 2003). Lack of access to good planting materials, land and labour opportunities affect species composition in home gardens (Wiersum, 2006). Research indicates that the mixture of home garden crops provides staples, fruits, vegetables, spices, and many non-food products for households (Gebauer, 2005; Peyre et al., 2006). Other studies point out that home garden production is mostly supplementary to staple food production and mainly focuses on vegetables, fruits and condiments (Kumar and Nair, 2004; Wiersum, 2006). Nevertheless the wide range of products from trees, shrubs and herbaceous plants cultivated in home gardens offers diversity to the diet for rural households and also serves as an important source of cash income through sale of surplus produce and cash crops (High and Shackleton, 2000; Murphy, 2008).

Differences in biological cycles of home garden crops and the kind of desired produce enhance the availability of home garden products for harvest (Okigbo, 1995). Conscious effort to improve yields for the market leads to intensification of home garden cultivation using external inputs such as chemical pesticides, fertilizers, labour from outside the home and purchased planting material (Yiridoe and Anchirinah, 2005; Ntow et al., 2006; Gebreselassie et al., 2008). Abdoellah et al. (2006) pointed out that the introduction of cash crops in home gardens is accompanied by reduced species diversity. On the contrary, Trinh et al. (2003) argued that commercialization of home gardens does not lead to reduced diversity, but to more diversity in terms of total number of species.

In Ghana there are two main home garden types cultivated in the semi-deciduous forest zone of the country: (i) the extensively cultivated home gardens where emphasis is on production of food crops for household consumption and (ii) the intensively managed commercial home gardens cultivated with cash crops (Asare et al., 1990). The choice of crops in these home gardens is influenced by the agroecological conditions, and by cultural and economic factors (Bennet-Lartey et al., 2002).

In rural households with HIV illness, household labour is constrained for field production due to frequent ill-health or the need to divert time to care for the individual who is ill. This labour constraint impacts availability and diversity of food consumed and threatens household food security (De Waal and Tumushabe, 2003). Home garden cultivation assumes an important role in contributing to the variety in a household's diet and also in providing cash income due to its diversity in crop species, proximity to the homestead, and flexible labour requirements (Garí, 2003; Akrofi et al., 2008). The cultivation of horticultural crops such as vegetables, medicinal plants, fruit crops and tuber crops in home gardens of HIV affected households to provide basic staple food, nutrition, medicine and cash income is encouraged by development agencies (Action Aid, 2005; Nordin, 2005). Research on biodiversity in home gardens of rural households affected with HIV is limited. The aim of this study is to explore the differences and similarities in the biodiversity of subsistence oriented (products solely for own consumption) and commerce oriented (products also for sale) home gardens managed by rural households affected with HIV in the Eastern region of Ghana and their significance in household food security. The study assessed the crop composition and diversity, availability of home gardens products and external inputs used in subsistence and commerce oriented home gardens of HIV-positive and HIV-negative rural households in the Eastern Region of Ghana and the consumption of a staple crop cultivated in these home gardens in the 24-h period prior to the survey. This study is relevant for the development of appropriate home garden management strategies that will enhance food security of rural households affected with HIV.

MATERIALS AND METHODS

Study area

The study was conducted in 17 rural communities in 12 out of the 21 districts of the Eastern region of Ghana. These communities were located in the semi-deciduous forest zone of the region. The Eastern region of Ghana has a population of about 2,000,000 and four main ethnic groups: Akan (52%), Ga-Adangbe (9%) Ewe (16%) and Guan (7%). The Ewe is the only non-indigenous ethnic group among these. Other minor non-indigenous ethnic groups in the region are the Gurma, Grusi, Mole-Dagbane and the Mande-Busanga (GSS, 2002). The semi-deciduous forest zone of Eastern region of Ghana is an important agricultural area of the country characterized by a semi-equatorial climate with average annual rainfall ranging between 1250 and 1800 mm. Temperatures are uniform throughout the year and the monthly mean is about 30 °C. The rainfall pattern is bi-modal; with a major rainy season from April to July, a short dry season in August and a minor rainy season from September to November. The main dry season is from December - March. The soils are predominantly forest ochrosols and oxisols which support the cultivation of food crops such as maize (*Zea mays*), plantain (*Musa sapientum* spp.), cassava (*Manihot esculenta*), pepper (*Capsicum annuum*), eggplant (*Solanum aethiopicum*) and okra (*Abelmoschus esculentus*) and high-value cash crops such as cocoa (*Theobroma cacao*), oil palm (*Elaeis guineensis*) and citrus (*Citrus* spp.) (Adu, 1992). In some rural communities of the region where these agricultural crops are cultivated in home gardens for both food supply and cash income, HIV prevalence has consistently been higher than the average prevalence in the country (GAC, 2004; Bennet-Lartey et al., 2002). Currently home gardens are evolving in ways associated with HIV positive status as their essential role in the nutrition of HIV

households are emphasised (Bukusuba et al., 2004; Parker, 2004; Murphy et al., 2006). Studies indicate that biodiversity in home gardens contribute significantly to dietary diversity in rural households with HIV (Akrofi et al., In press).

Methodology

From October 2005 to February 2006, a household and home garden survey was conducted in 17 rural communities located in 12 districts in the semi-deciduous forest zone of the Eastern Region of Ghana. Participants consisted of a purposive sample of 32 HIV-positive households of which 12 households had subsistence oriented and 20 had commerce oriented home gardens; and a random sample of 48 HIV-negative households of which 13 had subsistence oriented and 35 had commerce oriented home gardens, respectively. An HIV-positive household was categorized as one that had at least one household member between 15 and 49 years old diagnosed with HIV while an HIV-negative household had no member known to be HIV-positive in the household. As a result of the stigma attached to people known to be HIV-positive there was difficulty in locating households with people living with HIV in them; these households were identified through the Association of People Living with HIV/AIDS (PLWHA) at three district hospitals in the region. HIV-negative households were selected from the communities where HIV-positive households resided with the assistance of village elders. A home garden was described as "subsistence oriented" when crop produce was mainly for household consumption and as "commerce oriented" when one or more types of crop produce were cultivated also for cash income. A crop species classified as being cultivated for cash income had 50% or more of its produce sold. For convenience these home gardens were categorized as subsistence and commercial home gardens, respectively.

Data collection

A structured questionnaire was administered by the principal researcher to home garden owners during the survey. Household information gathered included ethnicity (native or non-indigenous tribe), number of years that the home garden had been cultivated by the current owner, benefits and constraints encountered in home garden cultivation, household farming characteristics (full time or part time), and household food consumption (24-h dietary recall). In the home garden survey, information on the local (vernacular) name of each cultivated species in the home garden, plant type (perennial or annual food crop or non-food crop species), major preferred human use (vegetable, staple, fruit, spice, medicinal or fodder plant), economic product (fruit, tuber, etc.) and the period of the year (rainy season, dry season or all year round) when each crop product was available for harvesting was obtained with the assistance of a botanist. The number of individual plants of each crop species was counted and the category of crop (subsistence or cash crop) noted. The cultivated area in each home garden was measured and the presence or absence of fences noted. The use or non-use of inputs from external sources (improved planting material, chemical pesticides and fertilizers and labour from outside the home) used in home garden cultivation was recorded. In-depth interviews were conducted with 20 home garden owners: five home garden owners purposively selected from each home garden type (representing 10 - 40% of each group) in their homes. Selection was based on the condition that the home garden owner had cultivated his/her home garden continuously for a period of at least five years. The assumption was that these home garden owners had adequate experience in managing their home gardens. The interviews explored in detail issues pertaining to the choice of home garden crops, use of extra-domestic labour, chemical pesticides and fertilizers used in home garden cultivation, main income earning activity of the household and household dietary preferences. Each interview lasting up to 60 min, was conducted in *Twi*, the most common local language in the study area, and audio-tape recorded.

Data analysis

The occurrence of each crop species was calculated as a proportion of each home garden type in which the species was recorded. This was used as a quantitative indicator of the presence of each crop species (Zaldivar et al., 2001). To quantify the diversity of home garden crops, ecological indices including species richness, species diversity, evenness and Sørenson's index of similarity were estimated (Magurran, 1988). Species richness was determined for each home garden surveyed using cultivated crop species count (Gautam et al., 2008). The overall crop species diversity (number and distribution of cultivated plant species) in each home garden was estimated using the Shannon-Wiener and Pielou's evenness indices with the cultivated area of each home garden representing a sampling plot. The Shannon-Wiener index takes a value of zero when there is only one species in the home garden, and a maximum value when all species are present in equal abundance (Mohan, 2004). Evenness represents a measure of relative diversity which presents the real distribution of species compared with the maximum distribution taking into account the number of species present in the home garden. Low evenness values indicate that one or a few species dominate in the home garden; values close to one reflect equitable species abundances (Schmitz, 2004). Similarity in crop species composition between subsistence and commercial home gardens was estimated using the Sørenson's index of similarity (Magurran 1988).

Each crop species was assigned to one of the four categories of harvesting periods: rainy season only, dry season only, both rainy and dry seasons, and all year round based on gardeners' and botanist's information and literature (Irvine, 1969; Burkill and Dalzie, 1985 – 1997).

Data were summarized as medians and ranges for non-normally distributed quantitative variables and as percentages for categorical variables. The Kruskal-Wallis and Dunn's multiple comparison tests were used to examine the differences across the four home gardens types with regards to non-normally distributed quantitative variables (Philip and Cook, 2000). Fisher's exact tests were used to test whether there was any relationship between the function of home garden (subsistence or commerce) and the ethnicity of the household (native or non-indigenous tribe), presence or absence of each individual species recorded in home gardens, and the use or non-use of external inputs (chemical pesticides and fertilizers and labour from outside the home). Chi-square tests were conducted to compare the proportions of HIV-positive and HIV-negative households with subsistence/commercial home gardens that engaged in full time farming; and consumed a staple crop cultivated in the home garden (based on 24 h dietary recall). Pair-wise comparison of proportions was performed using Fisher's exact tests when Chi-square tests showed statistical significance set at $p < 0.05$ for all data analyses.

In-depth interviews were transcribed into English. Transcripts

were analyzed by arranging responses according to the key issues and themes indicated above. Explanations and range of opinions expressed by informants were grouped according to these themes.

RESULTS

Crop species composition in the home gardens

A total of 75 crop species belonging to 40 botanical families were recorded across the surveyed home gardens. Table 1 show the botanical, common and local names, type of plant, parts of the plant which are of economic use and the harvest seasons of the crop species. Fifty–five species (73%) were food crops (vegetables, staples, spices, fruits trees) and 20 (27%) were non-food crop species (medicinal plants and fodder plants). Among these about 39% were trees, 11% shrubs and 51% herbaceous plants. Home garden owners offered various explanations for the crop composition in their home gardens. Some indicated that staple and vegetable crops, medicinal and fodder plants cultivated in the homestead were convenient and enhanced access to food, availability of medicinal plants to treat common ailments and fodder plants to feed domestic livestock. Others pointed out that the availability of food crops from the home garden enabled households to save money for other food items not available in the home. Besides, labour required for home garden cultivation was reduced by maintaining shrubs and trees which grow continuously in the home gardens. Some informants from HIV-positive households with commercial home gardens emphasized that although they were not able to cultivate a lot of crops in distant fields due to frequent health problems or the need to offer care to the ill household member, their household members never went to bed hungry because their home garden produce served a dual purpose in providing food and cash income.

Occurrence of crop species in the home garden types

Cocoa (*T. cacao*) and oil palm trees (*E. guineensis*), the major cash crops in the study area, were found in a significantly higher proportion of commercial home gardens compared with subsistence home gardens (27 vs. 4%, and 60 vs. 12% respectively) ($p = 0.000$, Fisher's exact test). Most of these trees were not planted by the current home garden owner; they were components of the cocoa and oil palm plots which had previously occupied the home garden area. A commercial home garden owner pointed out that those cocoa and oil palm trees which had become unproductive were gradually being replaced with food crops that had better market prices. Another informant expressed that, although the oil palm trees in her home garden were tall and difficult to harvest, they were maintained as garden crops because the palm oil and palm kernel oil extracted from the fruits and the brooms and baskets made from the palm fronds provided a source of cash income. A subsistence home garden owner indicated that the single row of old cocoa on the boundary of her home garden had no economic value, but was useful in providing a wind break for young plants in her home garden and also provided fuel wood for her household.

Sixteen species out of the 17 crop species common to the four home garden types were food crops. These included major food crops such as plantain (*M. sapientum*), a staple crop locally known as *Brodie*, which was the most common species and present in 80% or more of all four home garden types. Others were yam (*Dioscorea* spp.), a staple crop locally known as *Bayerè*, and pineapple (*Ananas comosus*), a fruit known as *Abrobè*. These were present in at least 50% of all home garden types with the exception of subsistence home gardens of HIV-positive households. Informants reported that planting materials like yam setts, plantain and pineapple suckers were obtained locally from mature crops harvested in their own home gardens and farms, acquired from neighbours, relatives and friends, or purchased from other farmers. Other informants indicated that the choice of home garden crops was limited by unavailability of planting material, unfavourable weather conditions or unintended destruction of crops by strayed domestic livestock and poultry which often brought conflict between neighbours. HIV-positive households emphasized that lack of funds to purchase local materials or to pay for labour to construct a perimeter fence to protect garden crops from strayed domestic animals influenced the choice of garden crops.

Eighteen food and ten non-food crops species were found solely in only one home garden type. Among these, 11 species found only in commercial home gardens of HIV-positive households included the food crops: vegetables such as African eggplant (*Solanum macrocarpon*) locally called *Gboma*, Jack bean (*Canavalia ensiformis*), fruits such as Tropical almond (*Terminalia catappa*) known as *Abrofo nkate*, Jackfruit (*Artocarpus communis*), and non-food crops such as the medicinal plants blue gum (*Eucalyptus globulus*) and swizzle stick (*Rauvolfia vomitoria*) known as *Kakapenpen*, and the fodder plant common fig (*Ficus capensis*), locally known as *Onyankyere.* Some informants indicated that some of these species were not deliberately planted, but were retained during the initial clearing of the home garden area owing to their use as

Table 1. Inventory of crop species identified in home gardens, their botanical, common and local names, plant type, use, economic produce, and harvest season.

Botanical name	Family	Common name	Local name	Plant type/Economic produce	Harvest season
Annual food crops					
Vegetables					
Abelmoschus esculentus	Malvaceae	Okra	Nkruma	Herbaceous/fruit	Year round
Amaranthus spp.	Amaranthaceae	African spinach	Aleefu	Herbaceous /leaf	Year round
Arachis hypogaea	Papilionaceae	Groundnut	Nkate	Herbaceous/kernel	Rainy season
Capsicum annuum	Solanaceae	Chilli pepper	Meko	Herbaceous/fruit	Year round
Corchorus olitorius	Tiliaceae	Jew's mallow	Ayooyo	Herbaceous/leaf	Year round
Cucurbita spp.	Cucurbitaceae	Pumpkin		Herbaceous/fruit	Rainy season
Hibiscus cannabinus	Malvaceae	Kenaf		Herbaceous/leaf	Year round
Solanum lycopersicum	Solanaceae	Tomato	Ntoso	Herbaceous/fruit	Rainy season
Luffa acutangula	Cucurbitaceae	Ridged gourd		Herbaceous/fruit	Rainy season
Solanum aethiopicum	Solanaceae	Eggplant	Aworowo	Herbaceous/fruit	Rainy season
Talinum triangulare	Portulacaceae	Waterleaf	Boroboro	Herbaceous/ leaf	Year round
Trichosanthes cucumerina	Cucurbitaceae	Snake gourd	Krobonko	Herbaceous/fruit	Rainy season
Vigna unguiculata	Fabaceae	Cowpea	Adua	Herbaceous/grain	Rainy season
Staples					
Dioscorea spp.	Dioscoreaceae	Yam	Bayerè	Herbaceous vine/tuber	Rainy season
Manihot esculenta	Euphorbiaceae	Cassava	Bankye	Herbaceous/tuber	Year round
Zea mays	Poaceae	Maize	Abro	Herbaceous/fruit	Rainy season
Spice					
Ocimum basilicum	Lamiaceae	Basil sweet	Eme	Herbaceous/leaf	Year round
Fruit					
Ananas comosus	Bromeliaceae	Pineapple	Abrobè	Herbaceous/fruit	Year round
Perennial food crops					
Vegetables					
Bombax costatum	Bombacaceae	Red kapok tree	Akokonre	Tree/flower	Dry season
Cajanus cajan	Papilionaceae	Pigeonpea		Shrub/grain	Rainy season
Canavalia ensiformis	Fabaceae	Jack bean		Herbaceous vine/grain	Rainy season
Elaeis guineensis	Arecaceae	African oil palm	Abè	Palm tree/fruit	Year round
Phaseolus lunatus	Fabaceae	Lima bean	Adua	Herbaceous/grain	Rainy season
Solanum macrocarpon	Solanaceae	African eggplant	Gboma	Herbaceous/fruit	Year round

Table 1. Contd.

Solanum melongena	Solanaceae	Aubergine	Ntorobabayin	Herbaceous/fruit	Year round
Solanum torvum	Solanaceae	Prickly solanum	Saman-ntoroba	Herbaceous/fruit	Year round
Vernonia amygdalina	Asteraceae	Bitterleaf	Bonwen	Shrub/leaf	Year round
Staples					
Colocasia esculenta	Araceae	Taro	Kookoo	Herbaceous/corm	Rainy season
Ipomoea batatas	Convolvulaceae	Sweet potato	Ntrumõõ	Herbaceous/tuber	Rainy season
Musa sapientum	Musaceae	Plantain	Brodie	Herbaceous/fruit	Year round
Xanthosoma sagittifolium	Araceae	Cocoyam	Mankani	Herbaceous/corm	Year round
Spices					
Aframomum melegueta	Zingiberaceae	Grains of paradise	Famu-wisa	Herbaceous/fruit, seed	Rainy and dry seasons
Curcuma longa	Zingiberaceae	Tumeric	Akakadrum kökõõ	Herbaceous/rhizome	Year round
Monodora myristica	Annonaceae	Calabash nutmeg	Ayerew-amba	Tree/seed	Rainy season
Piper guineense	Piperaceae	Guinea blackpepper	Soro-wisa	Herbaceous vine/fruit	Dry season
Zingiber officinale	Zingiberaceae	Ginger	Akakaduro	Herbaceous/rhizome	Year round
Fruits					
Anarcadium occidentale	Anacardiaceae	Cashew	Atea	Tree/fruit	Dry seaton
Annona muricata	Annonaceae	Soursop	Adobo	Tree/fruit	Rainy season
Annona squamosa	Annonaceae	Sweetsop	Nŋawie	Tree/fruit	Rainy season
Artocarpus communis	Moraceae	Breadfruit	Dziiball	Tree/fruit	Dry season
Artocarpus heterophyllus	Moraceae	Jackfruit		Tree/fruit	Rainy and dry seasons
Carica papaya	Caricaceae	Pawpaw	Brõfrè	Tree/fruit	Year round
Chrysophyllum albidum	Sapotaceae	Star apple	Alatsa	Tree/fruit	Dry season
Citrus aurantifolia	Rutaceae	Lime	Ankaatwaree	Tree/fruit	Rainy and dry seasons
Citrus limon	Rutaceae	Lemon		Tree/fruit	Rainy and dry seasons
Citrus sinensis	Rutaceae	Sweet orange	Akutu	Tree/fruit	Rainy and dry seasons
Cocos nucifera	Palmae	Coconut	Kube	Tree/fruit	Year round
Mangifera indica	Anacardiaceae	Mango	Mango	Tree/fruit	Rainy and dry seasons
Musa x paradisiaca	Musaceae	Banana	Kwadu	Herbaceous/fruit	Year round
Pachira aquatica	Bombacaceae	Saba nut		Tree/fruit	Rainy season
Persea americana	Lauraceae	Avocado pear	Peya	Tree/fruit	Dry season
Psidium guajava	Myrtaceae	Guava	Oguava	Tree/fruit	Rainy and dry seasons
Saccharum officinarum	Poaceae	Sugar cane	Ahwidie	Grass/stem	Year round
Terminalia catappa	Combretaceae	Tropical almond	Abrofo nkate	Tree/fruit	Dry season

Table 1. Contd.

Theobroma cacao	Sterculiaceae	Cocoa	Chocolate tree	Tree/fruit	Rainy and dry seasons
Annual non-food crops					
Medicinal plants					
Catharanthus roseus	Apocynaceae	Madagascar periwinkle		Herbaceous/leaf, flowers, roots	Year round
Cassia occidentalis	Fabaceae	Negro coffee	Mofra brode	Herbaceous/leaf, seed	Year round
Nicotiana tabacum	Solanaceae	Tobacco	Tawa	Herbaceous/leaf	Rainy season
Perennial non-food crops					
Medicinal plants					
Alchonea cordifolia	Euphorbiaceae	Christmas bush	Gyamma	Shrub/leaf, stem, bark, root, fruits	Year round
Alstonia boonei	Apocynaceae	Alstonia	Sinduro	Tree/bark	Year round
Azadirachta indica	Meliaceae	Neem	Kintwo	Tree/leaf	Year round
Cola nitida	Sterculiaceae	Kola nut	Bese	Tree/fruit	Dry season
Cymbopogon citratos	Poaceae	Lemon grass	Sèrè	Grass/leaf	Year round
Eucalyptus globulus	Myrtaceae	Blue gum		Tree/leaf	Year round
Gossypium hirsutum	Malvaceae	Cotton	Asaawa	Shrub/boll	Rainy and dry seasons
Jatropha curcas	Euphorbiaceae	Physic nut	Nkrangyedua	Shrub/seed	Year round
Morinda lucida	Rubiaceae	Brimstone tree	Kankroma	Tree/bark, leaf	Year round
Newbouldia laevis	Bignoniaceae	Sweet Newbouldia	Sasanemasa	Tree/bark, leaf	Year round
Ocimum gratissimum	Lamiaceae	Fever plant	Nunum	Herbaceous /leaf	Year round
Paullinia piñata	Sapindaceae	Nistmal	Toa-ntini	Shrub/root	Year round
Rauvolfia vomitoria	Apocynaceae	Swizzle stick	Kakapenpen	Tree/root	Year round
Thevetia peruviana	Apocynaceae	Milkbush		Shrub/leaf	Year round
Voacanga Africana	Apocynaceae	Voacanga	Ofuruma	Shrub/bark, leaf	Rainy season
Fodder plants					
Ficus exasperata	Moraceae	Sandpaper tree	Onyankerere	Tree/leaf	Year round
Gliricidia sepium	Fabaceae	Mother of cocoa		Tree/leaf	Year round

Table 2. Differences and similarities in ecological indices and other characteristics of the different home garden types.

Variable[1]	HIV-positive households		HIV-negative households		
	Commercial home gardens (n = 20)	Subsistence home gardens (n = 12)	Commercial home gardens (n = 35)	Subsistence home gardens (n = 13)	Kruskal-Wallis p-value*
Home garden size ($m^{2)}$	2140 (366-7176) **a**	1246 (220- 4428) **b**	1512 (380-4824) **b**	1230 (476-2688) **b**	**0.028**
Years home garden has been in cultivation	5.0 (2-30)	5.5 (2-15)	5.0 (2-40)	6.0 (2-40)	0.560
Field area cultivated (ha)	0.4 (0.2-1.9)	0.5 (0.4 -1.6)	0.8 (0.4 -1.6)	0.8 (0.2-2.0)	**0.050**
No. of individual plants	234 (73-1813) **a**	70 (31-197) **b**	138 (32-549) **b**	72 (40-324) **b**	**0.000**
No. of species	8.5 (4-17) **a**	5.0 (3-12) **b**	8.6 (1-18) **a**	6.0 (2-15) **ab**	**0.009**
No. of annual food crop species	2.0 (1-7)	2.0 (0-8)	2.0 (0-9)	2.0 (0-5)	0.839
No. of perennial food crop species	2.0 (1-5) **a**	1.0 (0-2) **b**	2.0 (1-7) **a**	2.0 (0-5) **ab**	**0.003**
No. of non-food crop species	1 (0-4)	0(0-2)	1(0-4)	0(0-2)	0.216
Shannon–Wiener index (H´)	1.15 (0.54-2.11)	1.17 (0.31-1.89)	1.46 (0- 2.28)	1.10 (1.07-1.84)	0.064
Evenness (E)	0.42 (0.23-0.69) **b**	0.57 (0.27-0.90) **a**	0.56 (0.27-1.00) **a**	0.51 (0.27-0.84) **ab**	**0.002**
Sørensen's index of similarity (%)	62.2		65. 9		
No. of species harvested year round	6.5 (2-9) **a**	3.0 (1-6) **b**	5.0 (1-10) **ab**	4.0 (1-8) **ab**	**0.019**
No. of species harvested in rainy season only	2 (0-4)	1 (0-4)	1 (0-8)	1 (0-4)	0.735
No. of species harvested in dry season only	0 (0-3)	0 (0-2)	0 (0-3)	0 (0-1)	0.244
No. of species harvested in both seasons	0 (0-3)	0 (0-1)	0 (0-3)	1 (0-2)	0.061

[1]Values are medians unless otherwise indicated; Figures in brackets are ranges.
*p-values in bold are significant at probability < 0.05; Medians in a row bearing different letters are significantly different at p < 0.05.

food, medicinal plant, fodder plant, shade trees or as fuel wood.

Crop diversity and other characteristics of home gardens

Table 2 shows the differences and similarities in the ecological indices and other characteristics of the subsistence and commercial home gardens managed by HIV-positive and HIV-negative households. In HIV-positive households commercial home gardens cultivated were significantly larger (2140 vs. 1246 m^2), had significantly more species (8.5 vs. 5.0), more individual plants (234 vs. 70), more perennial food crop species (2.0 vs. 1.0) and species that were harvested all year round (6.5 vs. 3.0) than subsistence home gardens. There was no significant difference in species diversity between subsistence and commercial home gardens but evenness was lower in commercial than in subsistence home gardens (0.42 vs. 0.57) (Table 2). On the contrary, there was no significant

difference between subsistence and commercial home gardens of HIV-negative households in any of the parameters studied. Within the category of commercial home gardens, HIV-positive households cultivated significantly more individual plants, but there was no significant effect of household HIV illness within the category of subsistence home gardens (Table 2). Informants from HIV-positive households with commercial home gardens pointed out that they were able to cultivate a larger home garden area and plant new crops because they had access to land and additional labour from other household members or from some extended family members who had come to assist in care giving. Moreover, by cultivating significantly more perennial crops which did not require re-planting each year, time was available for them to engage in cash crop production.

Comparison of the similarity in crop species composition between subsistence and commercial home gardens showed a moderately high Sørensen's index (HIV-positive households: 62.2% and HIV-negative households: 65.9%) (Table 2). Informants pointed out that both food and cash crop production in home gardens was rain fed. Short duration crops such as vegetables when cultivated for cash income were planted at the beginning of the major rains for early harvest and a better market price, while those for home consumption were planted at any time during the rainy season. Crops of relatively longer duration such as staples like plantain, yam and cocoyam were planted at the end of the dry season or just before the major rains to obtain enough moisture for growth. Seedlings of fruit trees like orange (*Citrus* spp.), mango (*Mangifera indica*) and avocado pear (*Persea americana*) were planted at the beginning of the major rains to obtain enough moisture for establishment.

There was no significant effect of household HIV illness on the home gardens with regard to the number of years the home garden had been cultivated by the current owner, the number of annual food crops and non-food crop species, species richness and the number of species harvested from the home garden in either the rainy or dry season only or in both seasons.

Management aspects

Improved planting material was much more often used in commercial home gardens than in subsistence home gardens, both in HIV-positive households (100% vs. 0%, $p = 0.002$) and in HIV-negative households (90% vs. 10%, $p = 0.022$) (Fisher's extract tests). Chemical pesticides and labour from outside the home were used in a higher proportion of commercial home gardens in both HIV-positive and HIV-negative households but these were not significantly different compared with the proportion of subsistence home gardens (chemical pesticide use: 86 vs. 14%, $p = 0.212$ in HIV-positive and 84 vs. 17%, $p = 0.370$ in HIV-negative households; external labour use: 80 vs. 20%, $p = 1.000$ in HIV-positive and 93 vs. 7%, $p = 0.073$ in HIV-negative households; Fisher's exact tests). All commercial home gardens of both HIV-positive and HIV-negative households and none of their subsistence home gardens received chemical fertilizer application (HIV-positive households: 100 vs. 0%, $p = 0.029$; HIV-negative households: 100 vs. 0%, $p = 0.044$; Fisher's exact tests). In HIV-negative households a significantly higher proportion of commercial home gardens were fenced compared with subsistence home gardens (74% vs. 31%, $p = 0.01$; Fisher's exact test), but there was no significant difference between these home garden types with regard to fencing of home gardens of HIV-positive households, (70 and 67%, respectively). Commercial home garden owners stressed that although fencing, hired labour, improved planting materials, chemical pesticides and fertilizers purchased from agro-chemical shops increased cost of home garden production, they were sure of good harvests for the market. Adults were hired for land clearing, making of mounds, weeding, planting, chemical fertilizer and pesticide application, harvesting of produce and establishing home garden fences and payment was in the form of money. Subsistence home garden owners indicated that herbicides were the most common chemical pesticide used, because controlling weeds in home gardens with herbicides reduced the amount of time spent in manual weeding. A small proportion of these home gardens owners reported that children between 10 - 14 years from outside the home were engaged in situations of acute shortage of domestic labour for weeding and planting of garden crops. Remuneration for these children was in the form of some home garden produce or occasional gift.

Cash crops cultivation

Pepper (*C. annuum*), a vegetable crop, was cultivated as a cash crop in HIV-positive households only and in none of the HIV-negative households (100 vs. 0%, $p = 0.043$; Fisher's exact test). Informants pointed out that pepper (*C. annuum*) was the most preferred cash crop, because the stored harvest fetches a higher market price than the other food crops in the dry season. Moreover the relatively short maturity period (120 days) enables the

cultivation of more than one crop per year. Cash crops common to both groups included eggplant, cocoa, oil palm and oranges in 15, 10, 15 and 5% of HIV-positive households and in 9, 14, 22 and 6% of HIV-negative households, respectively. It was noted during field observations that not more than two crops were cultivated for cash income in any of the commercial home gardens.

Characteristics of the households

In both HIV-positive and HIV-negative households, the ethnicity of the household did not influence the type of home garden cultivated. In the group of HIV-positive households 67% natives and 33% from non-indigenous tribes cultivated a commercial home garden while 85% natives and 15% from non-indigenous tribes cultivated a subsistence home garden ($p = 0.38$; Fisher's exact test). 63% natives and 37% from non-indigenous tribes cultivated a commercial home garden in the group of HIV-negative households and 31% natives and 62% from non-indigenous tribes cultivated a subsistence home garden ($p = 0.19$; Fisher's exact test). HIV-positive and HIV-negative households differed in proportions that engaged in full time farming with regard to the type of home garden cultivated ($X^2 = 9.43$, d.f. = 3, $p = 0.024$). Pair-wise comparison revealed that both HIV-positive households with either commercial or subsistence home gardens were more likely to engage in full time farming compared with HIV-negative households with a subsistence home garden (83% vs. 17%, $p = 0.005$; 73% vs. 27%, $p = 0.047$ respectively; Fisher's exact test). However, there was no significant difference in the field area cultivated by the different households studied (Table 2). Informants from HIV-positive households indicated that farming was their main occupation due to lack of funds to take on non-farm income activities or time constraints owing to frequent bouts of illness or the need to take time off to care for the ill household member. Others expressed that major non-farm income generating activities such as cooked-food vendoring and processing of agricultural products had been given up due to the stigma attached to HIV illness and labour constraints, respectively.

There was significant difference in the proportion of both HIV-positive and HIV-negative households that consumed a staple crop in the home garden in the 24-h period prior to the survey with regard to the type of home garden cultivated ($X^2 = 9.15$, d.f. = 3, $p = 0.026$). Pair-wise comparison showed that a significantly higher proportion of both HIV-positive and HIV-negative households with a commercial home garden consumed a staple crop that was cultivated in the home garden in the 24-h period prior to the survey (88 and 91%, respectively) than in HIV-positive households with a subsistence home garden (12 and 9%, respectively). An HIV-positive household head with a commercial home garden emphasized that, although she did not grow a lot of field crops anymore because she could not work long hours in the field, her children never slept with hunger because she harvested plantain and cocoyam regularly from her garden for own consumption and the cash crops provided money for other food items not available in the home. Another indicated that it was very convenient to grow food and cash crops in his compound because it saved his household the problem of going to fetch food produce from the distant field on rainy days. HIV-negative counterparts on the other hand, indicated that by maintaining a variety of food crops regularly consumed in their home gardens besides cash crops, household food supply was sustained during the off-season when food crops are scarce and in situations when they do not have money to purchase this produce.

DISCUSSION

Crop species composition in the home gardens

This study explored the differences and similarities in crop species composition and diversity, availability of products and external inputs used in subsistence and commerce-oriented home gardens managed by HIV-positive and HIV-negative rural households and assessed the consumption of a staple food crop from the home gardens in the 24-h period prior to the survey.

Crop species recorded across the home gardens consisted of vegetables, staples, fruits, spices, medicinal and fodder plants. This confirms that the surveyed home gardens serve as source of food and non-food necessities to households (Gebauer, 2005; Peyre et al., 2006). Similar species were documented in previous studies by Asare et al. (1990) and Bennet-Lartey et al. (2002). Relatively fewer crop species (75 species) were recorded in the current study compared with the 104 species reported by Bennet-Lartey et al. (2002). The present study focused on home gardens in rural areas in the semi-deciduous agro-ecological zone whereas that of Bennet-Lartey et al. (2002) covered urban, peri-urban and rural home gardens in the same agroecological zone. In contrast, relatively more species were recorded in the current study compared with the 41 species reported by Asare et al. (1990) from urban and peri-urban home gardens. In urban and peri-urban home gardens, crop species are selected to meet a consumption pattern or a

market demand, whereas in the rural areas they provide a wide range of uses besides food, such as medicine, fodder, construction and craft materials (Drescher 1997).

Occurrence of crop species in the home garden types

The surveyed home gardens were highly variable with regards to the occurrence of individual crop species. This is attributed to the fact that home garden crops consisted of deliberately planted food crops species, such as plantain, cassava, pepper, eggplant, African spinach, pineapple and banana, food and medicinal plants species that grew volunteer plants such as pawpaw and the fever plant and species that had been maintained from the previous vegetation such as cocoa and oil palm.

Major food crops such as the staples, plantain and yam and the fruit pineapple were common to all four home gardens due to their importance in Ghanaian diet (Salm and Falola, 2002). It is evident that cocoa and oil palm trees found in commercial home gardens of either HIV-positive and HIV-negative households were planted or retained in these home gardens due to the high financial value of their main products. Castinẽiras et al. (2001) pointed out that agrarian policy could influence biodiversity in home gardens. Currently, cocoa is the main foreign exchange earner to the Ghanaian economy and contributes about 29% to the GPD and oil palm is a major source of edible oil and a key agro-industrial crop. These crops have a readily available market and a good market price is always assured (Amanor and Diderutuah, 2001; GIPC, 2002).

The high level of species similarity between commercial and subsistence home gardens indicated by the moderately high Sørenson's index could be attributed to similar climatic and environmental conditions across the districts where the surveyed home gardens were located (Bennet-Lartey et al., 2002). Major food crops like plantain, yam and pineapple propagated by vegetative means were widely cultivated in almost all the different home garden types due to availability of planting materials, ease of cultivation, minimum care in management and availability of products all year round (Gautam et al., 2008). Lack of access to good planting materials, or inability to cultivate these species possibly due to unintended destruction of these crops by domestic animals could be the reason why these species were not found in more than half of the subsistence home gardens of HIV-positive households. A higher proportion of the species common to the four home garden types included vegetables, staples and fruits. This could suggest similar food habits between the studied households which comprised 65% native and 35% non-indigenous ethnic groups. The influence of agroecological factors and households' dietary habits on home garden species composition has been emphasized by several authors (Shrestha et al., 2001; Wezel and Bender, 2003; Kehlenbeck and Mass, 2004; Kehlenbeck et al., 2007).

Crop species found solely in one home garden type had either been deliberately planted or had been retained in home gardens due to their food and non-food uses. This supports the report of Eyzaguirre and Linares (2004) that home gardens could serve as a conservation unit for agrobiodiversity.

Crop diversity and other characteristics

The proximity of the home garden to the homestead and its flexible labour requirement offered a suitable intervention for rural households with HIV illness which require more food security, better nutrition and lower labour-investment incentives (Garí, 2003; Loevinsohn and Gillespie, 2003). Consequently, available land and extra domestic labour enabled HIV-positive households to cultivate significantly larger commercial home gardens with a significantly higher species richness compared with subsistence home gardens. In maintaining significantly more perennial food crop species that did not require yearly re-planting in commercial home gardens, HIV-positive households with commercial home gardens were able to cultivate subsistence crops and also engage in cash crop production to enhance household income (Murphy, 2008). Cultivating together monocultures of cash crops with a variety of food crops for own consumption could account for the significantly greater number of individual plants present in commercial than in subsistence home gardens. Murphy (2008) asserts that as a result of information sharing, home garden owners who tapped into HIV/AIDS networks are more likely to have improved gardens: semi-permanent and irrigated by hand to overcome poor rain, with a greater diversity of plants and with newer varieties that are hard to procure. The surveyed home gardens could be regarded as semi-permanent production systems having been cultivated for a period of two to forty years (Table 2). In many rural areas of Ghana, use of domestic water supply for home garden crops is limited and most garden owners rely entirely on rainfall for crop cultivation (Obuobie et al., 2006). The bimodal rainfall distribution in the study area enabled home garden owners to cultivate both food crops and cash crops throughout the growing seasons.

In comparison with previous studies on home gardens in Ghana (Asare et al., 1990; Bennet-Lartey et al., 2002), the current study focused only on cultivated species and

so the availability of different varieties of the home garden crops was not considered.

HIV-positive households were identified through the association of PLWHA, where they had received nutrition education from health care officers. There was no significant difference in species diversity between subsistence and commercial home gardens of HIV-positive households, but there was a higher level of diversity with regard to the total number of species cultivated in the commercial home garden type. This is consistent with the statement of Trinh et al. (2003) that commercialization of home gardens reduces species diversity, but disagrees with that of Abdoellah et al. (2006) that commercialization causes no significant change in the number of species cultivated. This is supported by the fact that only cultivated crop species were considered in the present study; other types of plants such as useful weeds were not included. Unequal access to good planting material, land or labour could have contributed to the variation in number of species found in commercial and subsistence home gardens of HIV-positive households (Wiersum, 2006). Evenness was significantly lower in the commercial than in the subsistence home gardens. This could be attributed to the fact the few species cultivated as cash crops by HIV-positive commercial home garden owners were maintained in relatively higher numbers compared with other species present. Similar findings were reported by Bernholt et al. (2009) and Abdoellah et al. (2006). The findings of this study support that of Mendez et al. (2001), Abdoellah et al. (2006), and Perrault-Archambault and Coomes (2008) in their studies on the influence of a range of household socio-economic characteristics on home garden species composition and diversity.

Management aspects

Improved seeds of vegetables such as pepper, eggplants and okra, and chemical fertilizers such as NPK, ammonium sulphate and urea were used much more in commercial home gardens than in subsistence home gardens in both HIV-positive and HIV-negative households to enhance yields for local markets. It is a common practice among garden owners in Ghana who cultivate non-tree crops for cash income to use improved seeds or chemical fertilizers and to establish fences around home gardens (Gerken et al., 2001; Yiridoe and Anchirinah, 2005; Ntow et al., 2006). The absence of significant difference between commercial and subsistence home gardens in chemical pesticides use in both HIV-positive and HIV-negative could be explained by the fact that some subsistence home garden owners, who use herbicides on distant fields, applied these herbicides in home gardens as well to control weeds. This is because farmers perceive that herbicide use is able to suppress weeds for a longer time than manual weeding with the hoe and cutlass even though this reduces the diversity in other plant forms present. It was noted that garden owners did not follow the recommendations for the safe use of chemical pesticides and this has both environmental and health implications which give cause for concern (Ntow et al., 2006; Asante and Ntow, 2009). It is apparent that lack of local fencing materials in both HIV-positive and HIV-negative households together with lack of funds to hire labour to construct these fences in HIV-positive households may have limited the establishment of a perimeter fence in some home gardens to protect home garden crops from destruction by domestic animals. Yiridoe and Anchirinah (2005) pointed out that live fences or hedges of species like milk bush (*Thevetia peruviana*) were the commonly used fencing material in the moist areas of the current study area due to all year round moisture conditions which is suitable for hedge growth. It was observed in this study that fences made from local materials like tree branches and bamboo stakes were commonly practiced in both commercial and subsistence home gardens. This could be due to the versatility of fences made from local materials compared with live fences. Studies report that domestic labour used in home garden cultivation occasionally includes children (Mendez et al., 2001); this study emphasizes the engagement of children from outside the home in garden work.

Cash crop cultivation

It is evident that a significantly higher proportion of HIV-positive households were motivated to cultivate pepper as a cash crop because of its financial value. Access to ready market is a major determining factor for cash crop production in home gardens (Michon and Mary, 1994). Routine markets organized on weekly basis in rural areas of the study area offered garden owners the opportunity to sell their produce (Owusu, 2004). Cocoa (*T. cacao*) was the only cash crop that was not utilized directly by households; the beans were sold to the state through local buying agents.

Characteristics of the households

In both HIV-positive and HIV-negative households, the proportions of natives and those from non-indigenous tribes that cultivated either subsistence or commercial

home gardens were comparable. Household's ethnic affiliation may not have influenced the type of home garden cultivated (Bennet-Latey et al., 2002; Bernholt et al., 2009; Kusumaningtyyas et al., 2006). The specific needs and preferences of the household and availability of market for garden produce could be the main factors that influenced the type of home garden cultivated (Abdoellah et al., 2006; Trinh et al., 2003).

The majority of HIV-positive households engaged in full time farming owing to constraints for non-farm income activities. Consequently, cash earnings from the sale of home garden produce may represent an important income for those with commercial home gardens given that crop farming is their main source of income. This supports the report that useful income-generating activities for rural households experiencing HIV illness are those based around local biodiversity and skills (World Bank, 2005). HIV-positive households with commercial home gardens had access to significantly more species and more perennial food crops with products in the form of leaves, corms, rhizomes, flowers and fruits all year round for household consumption.

A significantly larger proportion of HIV-positive households with commercial home gardens consumed a staple crop cultivated in the home garden in the 24-h period prior to the survey compared with their counterparts with subsistence home gardens. This evidence may suggest that HIV-positive households with commercial home gardens cultivate a dual-purpose home garden that supplies subsistence food and also provides cash income.

A household has food security when it has the ability to secure, either from its own production or through purchases, adequate food to meet the dietary needs of its members so that they can lead a healthy and active life (Egal and Valstar, 1999). HIV-positive households with a commercial home garden expressed the benefits of cultivating both food and cash crops in home gardens. The emphasis was that the home garden provided an important source of household food. Moreover food and cash crops cultivated in home gardens provided households' access to a diversity of foods from their own environment as well as cash income to purchase other food needs. This was on the advice of health care officers that intake of a variety of foods promotes good health. HIV-positive households with commercial home gardens have direct access to food from their home gardens and indirectly through purchases with cash earnings from their gardens. This may indicate a better food security for HIV-positive households with commercial home gardens compared with HIV-positive households with subsistence home gardens; this is in contrast to the general opinion that rural households with HIV illness are food insecure (De Waal and Whiteside, 2003; Loevinsohn and Gillespie, 2004). In the current study, besides available resources such as land and extra domestic labour, the nutrition education given to PLWHA may have been the additional factor that contributed to the cultivation of both subsistence and cash crops in commercial home gardens of HIV-positive households.

Conclusions

The findings presented in this study indicate that a higher proportion of the species common to the subsistence and commercial home gardens of HIV-positive and HIV-negative rural households consisted of vegetables, staples and fruits. HIV-positive households cultivated significantly larger commercial home gardens with significantly more species and individual plants, significantly more perennial food crops and significantly more species that were harvested all year round and evenness was lower, but there was no significant difference in species diversity compared with subsistence home gardens. Improved planting material was used more in commercial home gardens of both HIV-positive and HIV-negative households than in subsistence home gardens. Chemical fertilizer was only used in commercial home gardens of both HIV-positive and HIV-negative households and not in subsistence home gardens. HIV-positive households were more likely to engage in full time farming compared with HIV-negative households with subsistence home gardens. Significantly more HIV-positive and HIV-negative households with commercial home gardens consumed a staple crop cultivated in the home garden in the 24-h period prior to the survey compared with HIV-positive households with subsistence home gardens. These findings may imply that rural households experiencing HIV illness in cultivating commercial home gardens adapt the structure, species composition and management of home gardens to suit their needs. They cultivate a dual purpose home garden that provides cash income and also supplies subsistence food. HIV-positive households with commercial home gardens may have better food security than HIV-positive households with subsistence home gardens.

In the development of home garden management strategies to improve food security in rural households with HIV, more focus should be given to HIV-positive households that cultivate subsistence home gardens. Provision of extension support services to address production constraints such as access to good planting materials, efficient use of inputs and unintended destruction of home garden crops by domestic animals could improve home garden production and subsequently

enhance rural household food security.

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