Journal of Agriculture
and Rural Development in
the Tropics and Subtropics

Volume 106, No. 2, 2005

Journal of Agriculture and Rural Development in the Tropics and Subtropics
formerly:
Der Tropenlandwirt. Beiträge zur tropischen Landwirtschaft und Veterinärmedizin,
Journal of Agriculture in the Tropics and Subtropics

ISSN 1612-9830

Publisher
German Institute f. Tropical and Subtropical Agriculture (DITSL GmbH), Witzenhausen
Association for Sustainable Development (GNE mbH), Witzenhausen
Institute for tropical Agriculture e.V., Leipzig
University of Kassel, Faculty of Organic Agricultural Sciences, Witzenhausen
Association of Agronomists in the Tropics and Subtropics Witzenhausen, e.V. (VTW)

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Subscription
The *Journal of Agriculture and Rural Development in the Tropics and Subtropics* is published twice a year (April and October). It may be subscribed by a price of € 30,– + shipping. The subscription is for at least one year and is automatically extended unless otherwise stated by the subscriber till the end of the year. Single copies may be purchased for € 20,– + shipping.
Orders may be placed at Kassel University Press, Diagonale 10, D-34127 Kassel (www.upress.uni-kassel.de), Fon ++49 (0)561 804 2159, Fax ++49 (0)561 804 3429 or at any bookstore.

Publishing House
kassel university press GmbH
www.upress.uni-kassel.de

Composition and Layout
Bierwirth & Gabele Softwaredesign GbR, Steinstr. 19, Postfach 1128,
D - 37201 Witzenhausen, http://www.bg-softwaredesign.de

Cover layout: Jochen Roth, Melchior v. Wallenberg, Kassel

Printed by: Uniprinter University of Kassel

Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 97–103

Plant Species Diversity of Home Gardens in El Obeid, Central Sudan

J. Gebauer [1]

Abstract

Home gardens are very common in El Obeid, but information about plant species diversity and its significance for household food supply is not available. To analyse this, cultivated plants of 81 home gardens were surveyed. The plants studied in the home gardens included those for human consumption such as fruit trees, wild fruit trees and vegetables. In total, 32 plant species were found in the study gardens. The range of species was found, because irrigation is used under semiarid conditions. However, the lack of continuous sufficient irrigation water is the main factor which prevents an increase in species number and species diversity. In general, home garden products are mainly used as supplemental food in households and not sold on local markets.

Keywords: fruit trees, household gardens, Kordofan, multipurpose trees, semiarid, vegetables

لتنوع النباتي للحدائق المنزليه في مدينه الابيض بوسط السودان

الخلاصة:

تعتبر الحدائق المنزلية أمراً عادياً في مدينه الابيض ، ولكن المعلومات عن التنوع النباتي ومغزاها لدعم غذاء الأسرة غير متاح. ولكي نتعرف علي هذا، فإنه قد تمت دراسه مسحيه للنباتات المزروعة في ٨١ حديقة منزليه. تلك النباتات التي تمت دراستها في الحدائق النزليه تتضمن النباتات المستهلكة من قبل الإنسان مثل أشجار الفاكهة ، أشجار الفاكهة البرية والخضروات. إجمالاً، فقد وجد أن هناك ٣٢ نوعاً من الاصناف النباتية في تلك الحدائق التي خضعت للدراسة. مدى التنوع النباتي الذي وجدّ، اعتمد اساساً علي نظام الري المستخدم تحت الظروف الشبه صحراويه، وعليه فإن نقص الري المائي المستديم هو العامل الأساسي الذي يمنع زياده عدد الاصناف والتنوع فيها. عموما فأن منتجات الحدائق المنزلية تستخدم كعامل إضافي لتغذية الأسرة ولا تباع في السوق المحلي.

مفاتيح:

أشجار فاكهة ، حدائق منزلية ، كردفان ، أشجار متعددة الأغراض ، شبه صحراوي ، خضروات.

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1 Introduction

In many parts of the world home garden systems provide supplementary food, fuel, fodder (Brownrigg, 1985) and serve as a recovery area for the people. Home gardens in the tropics vary greatly in species, species richness, structural complexity and size (Gillespie *et al.*, 1993). Most of them display different vegetation layers making them typical agroforestry systems. Home gardens in the humid tropics have been studied by many authors (e.g. Alvarez-Buylla Roces *et al.* (1989); Jensen (1993); Esquivel and Hammer (1992); Lamont *et al.* (1999); Teklehaimanot *et al.* (2001)), but little information is available about home gardens in semiarid areas such as Central Sudan.

El Obeid is the biggest town in Central Sudan. Houses with a surrounding garden are a very common feature. However, no information is available about plant species diversity and its significance for household food supply. To gather information a survey was conducted on species diversity and uses of plants in home gardens of El Obeid.

2 Materials and Methods

The study was conducted in March and April 2004 in El Obeid. The town is the capital of the North Kordofan State and located in Central Sudan (latitude 13° 20' N, longitude 30° 15' E, 570 m above sea level). El Obeid has approximately 300,000 to 500,000 inhabitants. The semiarid area of North Kordofan receives an annual precipitation of about 280 – 450 mm in the months from July to September. Temperature is generally high averaging 37°C in the summer and 18°C in the winter. The most important soil types according to the FAO-classification are Cambisols and Regosols. In Kordofan rainfed agriculture is the traditional farming system (Bashir, 2001). The natural vegetation cover of the surrounding area of El Obeid is scarce (Fadl and Gebauer, 2004) and consists mostly of shrubs (e.g. *Boscia senegalensis*, *Calotropis procera*, *Ziziphus spina-christi*) and a few scattered trees (e.g. *Acacia albida*, *Adansonia digitata*, *Balanites aegyptiaca*).

For the study 81 home gardens were visited in El Obeid and plant species growing in the households noted. The survey was mainly carried out in a district called El Ghalaa in the north of El Obeid. The El Ghalaa area is characterised by houses with a surrounding garden.

In addition to the plant survey, occurrence of domestic animals kept in the home gardens was also documented. Information about size of home gardens and households, profession of the owners, plant origin and cultural practices was also collected.

3 Results

Home gardens in El Obeid are traditionally surrounded by a approximately 2 m high wall. The size of the home gardens varied between 40 m^2 to 150 m^2. The average household consists of seven household members. Most of the male home garden owners (68%) are labourers working as drivers, road or railway constructors or in the field of agriculture. 15% are teachers in school, 10% are working as research assistants in the close by Agricultural Research Corporation and the remaining 7% are merchants. Women mainly stay at home with the family.

In total 32 different plant species and eight animal species were identified, which are grouped in Table 1. Each home garden contained an average of 3 plants for human consumption. However, in five out of the studied home gardens no plant species were found.

Fruit trees were the predominant horticultural crop in the home gardens. In 76 out of 81 home gardens fruit trees were cultivated. The five most common fruit trees were lime (*Citrus aurantifolia*), guava (*Psidium guajava*), mango (*Mangifera indica*), date palm (*Phoenix dactylifera*) and grapefruit (*Citrus paradisi*). Sugar apple (*Annona squamosa*), pomegranate (*Punica granatum*), sweet banana (*Musa x paradisiaca*) and grape vine (*Vitis vinifera*) were found to a lesser degree. Only in one or two home gardens the species papaya (*Carica papaya*), black mulberry (*Morus nigra*), sweet orange (*Citrus sinensis*) and fig (*Ficus carica*) occurred.

Interesting was the presence of several wild trees and shrubs with edible fruits. These trees/shrubs are grown in the home gardens for different purposes like food, construction materials, fodder, firewood, medicinal uses, amenity and for providing shade.

Beside the uses of the fruits the ginger bread palm (*Hyphaene thebaica*) and the manila tamarind (*Pithecellobium dulce*) are mainly used for construction materials, the white crossberry (*Grewia tenax*) for fodder, the christ thorn (*Ziziphus spina-christi*) and the desert date (*Balanites aegyptiaca*) for firewood, the bark of the baobab (*Adansonia digitata*) for fibres, the toothbrush tree (*Salvadora persica*) for medicinal purposes and the neem (*Azadirachta indica*), the tamarind (*Tamarindus indica*) and the horse radish tree (*Moringa oleifera*) for amenity and shade.

Vegetables such as pigeon pea (*Cajanus cajan*), chilli (*Capsicum annuum*), eggplant (*Solanum melongena*) and tomato (*Lycopersicon esculentum*) were rarely planted.

In more than 50% of the home gardens ornamentals were present. Ornamental plants most frequently found in different home gardens were bougainvillea (*Bougainvillea glabra*), christ plant (*Euphorbia milii*), sand olive (*Dodonaea angustifolia*), oleander (*Nerium oleander*) and shrub verbena (*Lantana camara*). The shrub sand olive was mainly used as a hedge plant to separate different parts within the home gardens.

Domestic animals kept at the compound were chickens (*Gallus gallus*), pigeons (*Columba livia*), goats (*Capra hircus*), ducks (*Anas platyrhynchos*), geese (*Anser anser*), rabbits (*Oryctolagus cuniculus*), one donkey (*Equus africanus*) and one dog (*Canis (lupus) familiaris*) in the home garden surveyed. In some cases the animals were kept exclusively within the home garden, in other cases they had the possibility to roam outside the garden.

Most plant products are exclusively used for self-consumption or as animal fodder. Only in few years with excess yields, fruits were given away to neighbours or relatives. Nobody reported to sell their own products on the local markets.

Irrigation of the horticultural plants is essential in all home gardens. Fruit trees are irrigated on average every two to tree days. However, wild fruit trees and shrubs are not irrigated or to lesser extent. No chemical fertilisers or insecticides are used in any of the studied home gardens. Pruning of the trees and shrubs is also not practised. 67% of the households reported that they bought the fruit trees as juvenile plants from local nurseries. However, knowledge about varieties was very low. The remaining 33%

Table 1: Used plant species and domestic animals in home gardens of El Obeid.

Scientific name	*Species presence (%)*	*Local name*	*Family*
	Fruit trees		
Citrus aurantifolia	51.85	lemon	Rutaceae
Psidium guajava	50.62	guava	Myrtaceae
Mangifera indica	19.75	manga	Anacardiaceae
Phoenix dactylifera	16.05	nachal	Palmae
Citrus paradisi	9.88	grapefruit	Rutaceae
Annona squamosa	8.64	gishta	Annonaceae
Punica granatum	4.94	roman	Punicaceae
Musa × *paradisiaca*	3.70	mouse	Musaceae
Vitis vinifera	3.70	enab	Vitaceae
Carica papaya	2.47	babaj	Caricaceae
Morus nigra	2.47	tuthe	Moraceae
Citrus sinensis	1.23	burtugal	Rutaceae
Ficus carica	1.23	tin	Moraceae
	Wild fruit trees/shrubs		
Ziziphus spina-christi	12.35	siddir	Rhamnaceae
Grewia tenax	11.11	gudiem	Tiliaceae
Azadirachta indica	4.94	neem	Meliaceae
Hyphaene thebaica	4.94	dome	Palmae
Adansonia digitata	3.70	tebaldi	Bombacaceae
Balanites aegyptiaca	3.70	heglig	Balanitaceae
Pithecellobium dulce	2.47	tamar-hindi	Mimosaceae
Tamarindus indica	2.47	aradeb	Caesalpiniaceae
Moringa oleifera	1.24	rawag	Moringaceae
Salvadora persica	1.24	arak	Salvadoraceae
	Vegetables		
Cajanus cajan	4.97	lubia adasi	Fabaceae
Capsicum annuum	2.47	shatta	Solanaceae
Solanum melongena	1.23	aswad	Solanaceae
Lycopersicon esculentum	1.23	tamatim	Solanaceae
	Ornamentals		
Bougainvillea glabra	27.16	jahanamia	Nyctaginaceae
Euphorbia milii	19.75	subbar	Euphorbiaceae
Dodonaea angustifolia	17.11	akawit	Sapindaceae
Nerium oleander	11.88	ward el hameer	Apocynaceae
Lantana camara	8.94	lantana	Verbenaceae
	Domestic animals		
Gallus gallus	11.11	gedad	Phasianidae
Columba livia	4.94	hamam	Columbidae
Capra hircus	2.47	mahiz	Bovidae
Anas platyrhynchos	1.23	bat	Anatidae
Anser anser	1.23	wissin	Anatidae
Oryctolagus cuniculus	1.23	arnab	Leporidae
Equus africanus	1.23	humar	Equidae
Canis (lupus) familiaris	1.23	kalib	Canidae

of the households said that they raised the fruit trees by themselves from seeds. Most multipurpose trees/shrubs grow spontaneously in the home gardens and were rarely planted.

4 Discussion

The total number of 32 different plant species found in the 81 home gardens is rather low compared with other home garden surveys in different parts of the world (De Clerck and Negreros-Castillo, 2000; Kehlenbeck and Maass, 2004; Wezel and Bender, 2003). However, in dry areas, gardens are often limited in diversity and complexity. In general potential garden complexity is often a function of climate, more specifically water and evaportranspirational balance, just as for forest ecosystems structure and function (Gillespie *et al.*, 1993).

26 species out of 32 plants surveyed in the home gardens of this study are woody perennial species. Only papaya, sweet banana, pigeon pea, chilli, eggplant and tomato are herbaceous crops. In the surveyed gardens no cereals, herbs, medicinal plants, tubers or spices are cultivated. A vegetative soil cover was also not found in any of the home gardens.

Fruit trees were the predominant horticultural crop. Fruits like lime, guava and mango are very popular in Sudan (Gebauer and Osman, 2004). 31% of the species found in the home gardens were wild fruit trees and shrubs. The value of the multipurpose uses beside the edible fruits was well recognised by the home garden owners. Species like the baobab, the christ thorn, the desert date, the ginger bread palm, the tamarind and the white crossberry are indigenous trees/shrubs and are also found in the rural areas outside town. They are well adapted to the harsh environmental conditions and can grow without irrigation. These arboreal species play also an important role in the diet of rural people in the Kordofan area especially during famines and food shortages (Gebauer *et al.*, 2002; El-Tahir and Gebauer, 2004).

All listed horticultural crops are not able to grow in this dry climate without frequent irrigation. However, in El Obeid especially in the dry season water is still scarce and irrigation sometimes not possible. Particularly in the years 1983 and 1984 annual rainfall was very low and water from the town reservoirs limited. During these years a lot of fruit trees died due to the lack of irrigation. In the last years the situation in El Obeid improved to some extend and in most home gardens new fruit trees were planted. However, today still the lack of sufficient irrigation water in some periods prevents the expansion of species number and species diversity.

In the study area vegetables were found only in six home gardens. The main reason for the low vegetable production is the lack of sufficient irrigation water since vegetables have a high demand of water.

It was evident that the home garden owners earn no additional income from the selling of home garden products, in contrast to the observations by Wezel and Bender (2003) in Cuba. Because of the low levels of salaries home gardens are used as an source of supplemental food for the family. However, the degree to which home gardens contribute to the provision of the household is rather low due to the small number of food plants per home garden. In addition yields are normally low as well. Beside the

scantiness of water, further reasons for the low yields are the lack of superior varieties, the low fertility of the sandy soil and the lack of cultural practices like fertilisation and pruning (Gebauer and Osman, 2004).

5 Conclusions

Plant species are very important components in El Obeid home gardens. Crop products are used for supplemental food in the households. Irrigation is necessary due to the semiarid conditions. However, water is also the factor limiting an increase in species number and species diversity in home gardens, because water is not always sufficiently available.

Acknowledgements
Many thanks to Ahmed Ali Ahmed and Mohammad Adam Mohammad Elhaj for the help during the home garden surveys and the interviews. I am also grateful to the 'Alexander von Humboldt Foundation' for awarding a Feodor Lynen Research Fellowship to me.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 105–112

Effect of Two Cowpea (*Vigna unguiculata*) Fodder Cultivars as Supplements on Voluntary Intake, Milk Yield and Manure Production of Bunaji Cows

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Abstract

The feeding value of fodder from two cowpea cultivars to a basal maize stover diet was investigated using fifteen lactating White Fulani (Zebu) cows. The two cultivars were IT-716 and 994-DP. Diet was constituted as 50g DM/kg live weight and each of the cultivars was supplemented at 50% of the daily dry matter requirement of individual animals. The experimental design was a complete randomize. The parameters measured included feed intake, milk yield and composition and manure production. In a separate trial, dry matter degradation of the fodder was assessed. There were no significant differences in dry matter intake of the supplements. However, the dry matter intake of stover in the control diet was higher than those on the supplemented groups.

The milk yields ranged from 887 to 1378 ml/day. Milk yield differed among treatments. Supplementation did not affect ($P > 0.05$) fat, protein, total solids and ash contents of the milk across the treatments. Manure productions were not significantly different among the treatments. Similarly, content of N, P and K in manure were comparable among the treatments except for N that was lower ($P < 0.05$) in the control group. The dry matter degradation was influenced by the fodder cultivars. The feeding of dual-purpose forage legumes residues could enhance milk production in lactating Zebu cows. This may be further increased by exploring other ways of improving feed residue utilization in the dry season.

Keywords: Lactating Zebu cows, forage legume, milk yield, milk composition, cowpea, Vigna unguiculata

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1 Introduction

Poor nutrition remains the most widespread technical constraint to good animal performance in sub-Saharan Africa (Mohammed Saleem and Fitzhugh, 1995). This becomes more critical during the dry season when feed availability are not only inadequate, but the quality extremely poor. Various options have been advocated as possible solutions to this perennial problem. This includes feeding of treated and, untreated crop residues or integration of forage legumes into the feeding strategies (Nnadi and Haque, 1988). Although feeding of forage legumes has been found easily adoptable, the practice is not attractive to the farmers. This perhaps may be due to their limited immediate benefits that do not go beyond soil maintenance and nitrogen economy of biomass (Ibrahim, 1994). Farmers do not pay particular attention to the planting of pure legume stands rather greater emphasis is on the cultivation of food crops. In an emerged (Jabbar, 1993) integrated crop-livestock farming systems of derived savannah, planting of dual-purpose legumes is gaining popularity. Apart from its grains that yield immediate economic returns, it is a good source of dietary protein. It's fodder is also a good dry season feed supplement to livestock. While ample information are available on the use of forage legumes as supplement (Larbi *et al.*, 1993; Umunna *et al.*, 1983; Said and Adugna Tolera, 1993) information on fodders from cowpea cultivars grown as pure stand after grain harvest as a feed supplement to poor quality crop-residues is very scanty. This study was designed to investigate variation in the quality of fodder from two cowpea cultivars on lactating Bunaji cows fed on poor quality basal diet of maize stover in the dry season.

2 Materials and Methods

2.1 Site

The study was conducted in the dry season between November and February 1997 at the International Livestock Research Institute Sub-humid zone (International Institute of Tropical Agriculture campus) Ibadan, Nigeria (latitude 7° 30'N and longitude 3°4'E). Annual rainfall averages 1250mm and occurs from April to November with a marked dry season from December to March. The wet season can be divided into major-wet (April to July) and minor-wet (September to November) seasons.

2.2 Animal Feeds and Feeding

Fifteen white Fulani (Zebu) cows with a mean body weight of 270kg$\pm$2.5 were used for the study. They were selected from a herd of cows synchronized for oestrus using prostaglandin (PGF2α) and bred by a white Fulani bull. The calves were allowed to suckle their dams for the first three weeks post partum. At the start of the experiment, 30 days post partum, the calves were separated from their dams. The cows were randomly allocated to three treatments using a complete randomized design of five animals per treatment. The treatments were 100% maize stover, 50% maize stover + 50% cowpea 716 and 50% maize stover + 50% cowpea 994. Both feeds were offered in the same trough after proper mixing. Feeds were offered twice daily at 08.00h and 14.00h, and orts were removed daily at 07.30h and separated and weighed. Diet was constituted as

50g DM/kg body weight. Salt mineral block and fresh water were provided for the cows in each pen through out the trial.

2.3 Milk and Milking

Milk yield of the cows were measured daily using a calibrated measuring cylinder and recorded. Milking was done twice at 08.00h and 18.00h by manual extraction. Milk samples were taken at each milking, bulked for the number of days and stored in the deep freezer until required for analysis. The calves were fed with part of the extracted milk.

2.4 Manure collection

Animals were kept in individual cubicles with concrete floor covered with wood shavings. Each animal was fitted with harness and bags for manure collection. Manure was collected for two days every week at 7.00h in the morning bofore the feeding. The animals had been previously trained.

2.5 Degradation study

The degradation characteristics of the stem and leaf of the fodders were assessed by the nylon bag technique (Orskov *et al.*, 1980). Duplicate bags containing 3g of the samples ground to pass through a 2.5mm sieve were incubated for 6, 12 and 48h in three rumen- fistulated Bunaji castrates.

The animals were individually housed and fed fresh guinea grass (*Panicum maximum*) and wheat bran at a ratio of (3:1) of their daily dry matter requirement as supplement. They had free access to drinking water and salt licks.

2.6 Chemical Analysis

The feed sub samples were ground in a hammer mill to pass through a 1.00mm sieve and oven dried at 60°C for 48h to determine dry matter contents. Protein in feed and milk samples was determined by the Kjeldahl method (AOAC, 1980) while milk fat was measured by the Gerber's method (Davis, 1959). NDF and ADF in the feed were determined by the method described by Goering and Van Soest (1970).

2.7 Statistical Analysis

he experimental design was a complete randomized. Voluntary feed intake, milk yield and composition as well as manure production were subjected to analysis of variance technique using general linear model (GLM) procedure (S.A.S. Institute, 1987). Differences between the treatment means were considered to be significant at $P < 0.05$.

3 Results and Discussion

3.1 Chemical Composition

The nutrient composition of the basal diet (maize stover) and the two supplementary feeds is shown in Table 1.

The crude protein (CP) content of the supplements were generally higher than the basal diet. In contrast, the neutral detergent fibre (NDF) of maize stover was higher than the two supplements.

The neutral detergent fibre (NDF) values of the samples ranged from 635 to 771g/kg DM. Fodder from cultivar 716 had higher CP and lower NDF contents than 994-cowpea cultivar. The ADF values were similar among the supplements but lower in the basal diet.

The CP level in the basal diet was lower than that of the legume supplements partly due to the poor quality maize stover used for the study. The CP value is however typical of matured tropical grasses (Preston and Leng, 1987) which limits feed intake (Milford and Minson, 1968).

Table 1: Chemical composition (g/kg DM) of experimental diets.

	Fodders		
Component	*Maize stover*	*994-DP*	*IT-716*
Crude protein	47.8	115.0	137.8
Neutral detergent Fibre (NDF)	771.2	668.0	634.8
Acid Detergent Fibre (ADF)	475.4	533.5	510.8

3.2 Degradation Study

Within each cultivar, leaf was better degraded than the stem (Fig. 1). However, a distinct higher degradation pattern was observed for stem and leaf of the cultivar 716 than that of 994.

In comparing the two cultivars (Fig. 2), the leaf of 716 was better degraded than that of 994. Similarly, stem of 716 showed a higher dry matter degradation value than the stem of 994. The higher DM degradation of leaf than the stem within and between the cultivars was probably due to a higher CP content in the leaf. Higher CP encouraged proliferation of microbes, which led to a better degradation (Preston and Leng, 1987). Similarly, the higher DMD of 716 was probably a reflection of differential nutrient quality especially the CP. This agreed with the report (Larbi *et al.*, 1996) that a significant rumen degradation variation occurred among *Calliandra calothyrsus* provenances.

3.3 Manure Production

Manure production was higher for animals on 994-DP fodder than IT-716 and the control group. Except for N, the nutrient contents of manure were higher for 994-DP group. The high nutrient contents probably indicated a low nutrient utilization by animals fed on 994-DP compared with animals on IT-716.

3.4 Feed intake and milk production

There were significant ($P < 0.05$) cultivar effects on voluntary intake, daily milk yield (Table 2) and manure output (Table 3). An inverse relationship between dry matter

Figure 1: Comparative dry matter degradability pattern of leaf and stem within each cowpea cultivar.

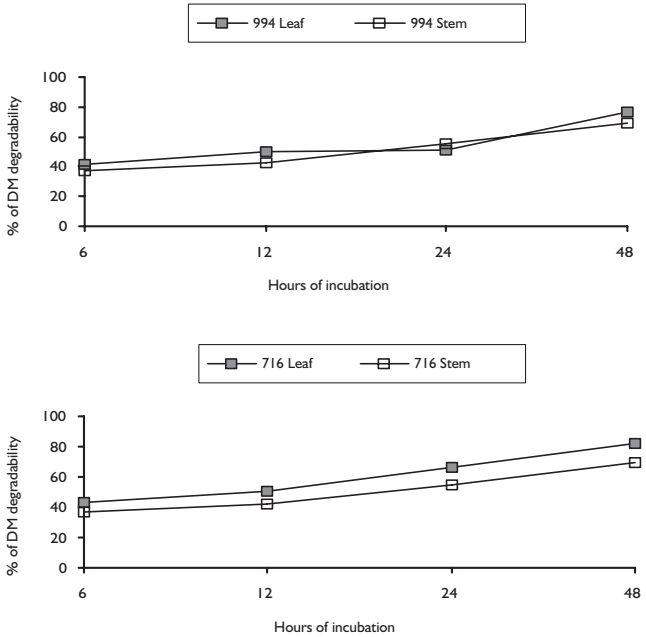
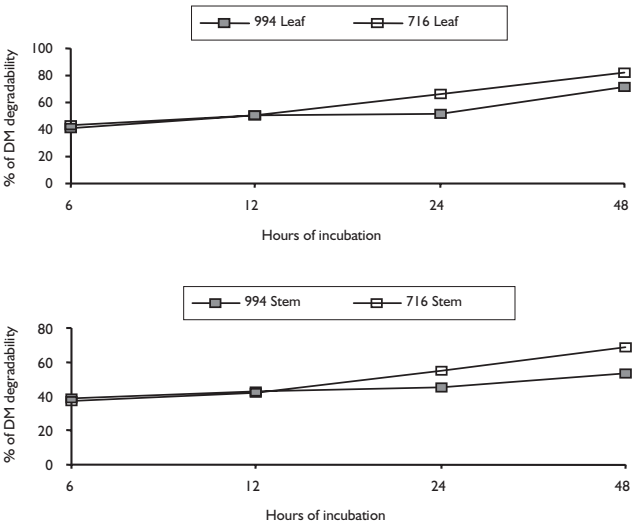


Figure 2: Comparative dry matter degradability pattern of leaf and stem between the two cowpea cultivars.



intake of maize stover and supplement was observed. Basal DM intake by animals in the supplemented groups was more than 48% units lower compared with the control. Animals on cowpea fodder 994-DP cultivar recorded the highest total dry matter intake.

Cultivar influenced ($P < 0.05$) daily milk production. Animals supplemented with 716 produced high milk yield (1.4 l/day), which was 20% units higher than 0.9 l/day recorded in the unsupplemented group.

Generally, consumption of cowpea fodder by lactating Bunaji cows improved ($P < 0.05$) daily milk yield over the control by more than 30%. However, milk quality parameters of protein, total solid, fat and ash contents were not influenced ($P > 0.05$) by the intake of the two cultivars. The trend observed in feed intake of protein from supplemented diets that depressed the dry matter intake from the maize stover was in contrast to the finding of Muinga *et al.* (1993) who reported that additional feed intake from leucaena foliage did not affect the basal fodder consumption. The higher DMI of the basal diet agreed with the findings of Anindo and Potter (1986); Khalili *et al.* (1992) on protein concentrate supplements. They observed that intake of concentrate supplements depressed voluntary intake of basal forage. The improved daily milk yield from animals on 716 cultivar can be explained by the combination of its higher CP and low NDF relative to the other two diets. This was supported by the report of Ruiz *et al.* (1995) that an increased milk yield was supported by decreased dietary NDF concentration.

Table 2: Voluntary feed intake, milk yield and composition of Bunaji cows given a basal diet of maize stover supplemented with two cultivars of cowpea fodder.

	Treatments			
Parameters	*Control*	*994-DP*	*IT-716*	*SED*
Intake (g/kg $BW^{0.75}$)				
Maize stover	67.9	41.1	34.2	1.3
Supplement	-	42.7	41.8	1.8
Total	67.9	83.8	76.0	4.6
Intake (g/h/d)				
Maize stover	4834	2720	2786	694.8
Supplements	2845	2115	368.7	
Total	4934	5565	4901	233.6
Milk yield (ml/day)	885.8	1049.9	1377.8	74.6
Milk composition (%)				
Fat	3.2	3.2	3.3	0.5
Protein	4.1	4.3	4.2	0.7
Total solid	17.3	15.2	16.5	1.4
Ash	0.9	0.9	0.8	0.1

Table 3: Effect of fodders on manure production and nutrient composition.

	Treatments			
	Control	*994-DP*	*IT-716*	*SED*
Manure production (kg/D/day)	0.89	1.14	0.83	0.32
Nutrient composition (%)				
N	1.39	1.51	1.53	0.10
P	0.46	0.48	0.39	0.13
K	1.18	1.33	1.08	0.32

The milk yield recorded in this study compared favorably to the values obtained in a study by Olaloku and Oyenuga (1997) in which lactating zebu cows grazed on improved tropical grass/legume pasture mixture. However, the production levels were low compared to supplementing lactating zebu cows with concentrate while grazing natural or sown pasture (Schuman, 1968; Adeneye, 1993). The low production obtained suggested that the level of nutrients available in the feeds offered could not meet the nutrients required to sustain high milk production. Nevertheless, dry season supplementation of lactating Bunaji cows with dual-purpose legumes could be a sustainable way of improving the feeding values of poor quality crop residue and enhancing the anticipated benefits from crop-livestock integration by poor African smallholder farmers.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 113–118

Host Suitability of Crops under Yam Intercrop to Root-knot Nematode (*Meloidogyne incognita* Race 2) in South-Western Nigeria

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Abstract

Twelve crops commonly grown in association with yam in South-Western Nigeria were evaluated for resistance to root-knot nematode *Meloidogyne incognita* (Kofoid and White 1919) Chitwood 1949, race 2 infection using the quantitative modification by Sasser *et al.* (1984) of host suitability designations of Canto-Saenz (1983) for plants infected with root-knot nematode in 1998 and 1999 planting seasons. Observations, based on gall indices and recovery of the juvenile larvae from the roots and soil indicated that *Abelmoschus esculentus*, *Corchorus olitoris* cv Angbadu and *Sphenostylis stenocarpa* cv Nsukka Brown were highly susceptible, while *Arachis hypogaea* cv UGA 4, *Cajanus cajan* cv Cita-2, *Cucumis melo* cv Bara To139, *Manihot esculenta* cv TMS 30572, *Sorghum bicolor* and *Zea mays* cv DMR-LSR-Y were hyper-susceptible to *Meloidogyne incognita* race 2 with reproductive factor and gall index of $\leq$1 and $\geq$2 respectively. *Crotalaria juncea*, *Mucuna cochinchinensis* and *Stylosanthes gracilis* were resistant to *Meloidogyne incognita* race 2 with reproductive factor and gall index of $\leq$1, $\leq$2 and $\geq$2 respectively. These intercrops if planted on yam mounds will play a prominent role in altering the populations of root-knot nematode *Meloidogyne incognita* race 2.

Keywords: *Meloidogyne incognita* race 2, yam, intercropped species, root-galls indices, host-suitability, south-western Nigeria

1 Introduction

A large number of plant-parasitic nematodes associated with yam cultivation have been reported from various yam producing areas of the world (Ayala and Acosta, 1971; Bridge, 1972; Thompson *et al.*, 1973; Adesiyan and Odihirin, 1977; Caveness, 1982; Hahn *et al.*, 1989; Lowe, 1992; Green and Florini, 1996; Agbaje *et al.*, 2002, 2003). These are the yam nematode *Scutellonema bradys*, the root-knot nematode *Meloidogyne* spp. and the lesion nematode *Pratylenchus* spp., which are all field and post-harvest pests (Hahn *et al.*, 1989; Lowe, 1992; Agbaje *et al.*, 2002).

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Green and Florini (1996) noted that planting yam with crops susceptible to root-knot nematodes would increase the nematode population and reduce yield and tuber quality in both field and storage. In fields, where root-knot nematodes are problems, the use of intercrops which have some root-knot resistance will help to control the pest (Hahn *et al.*, 1989; Sasser and Taylor, 1978; Atu and Enyinnia, 1983; Singh *et al.*, 1974). This paper reports on the host status of crops commonly intercropped with yam in South-Western Nigeria to *Meloidogyne incognita* race 2.

2 Materials and Methods

The two-year study was carried out at Institute of Agricultural Research and Training, Moor Plantation, Ibadan and Ilora derived Savanna Research Station in 1998 and were repeated in 1998 and 1999. The twelve crops most commonly intercropped with yam in South-Western Nigeria (Table 1): *Abelmoschus esculentus* cv V35, *Arachis hypogaea* cv UGA4, *Cajanus cajan* cv Cita-2, *Corchorus olitorus* cv Angbadu, *Crotalaria juncea*, *Cucumis melo* cv Bara To139, *Manihot esculenta* Crantz cv TMS 30572, *Mucuna cochinchinensis*, *Sorghum bicolor* cv CSH9, *Sphenostylis stenocarpa* cv Nsukka Brown, *Stylosanthes gracilis* and *Zea mays* cv DMR-LSR-Y were sourced locally together with hybrid yam TDr 89/02665 obtained from International Institute of Tropical Agriculture (IITA), Ibadan.

Table 1: Scientific, common and local names of 12 intercropped species and yam cultivar used in the experiment.

Scientific name	*Common name*	*Local name*
Abelmoschus esculentus cv V35	Okra	Ila
Arachis hypogaea cv UGA4	Groundnut	Epa/Yere
Cajanus cajan cv Cita- 2	Pigeon pea	Otili/Sese
Corchorus olitorus cv Angbadu	Vegetable jute	Ewedu-Angbadu/Ooyo
Crotalaria juncea	Croto	Payin-Egba
Cucumis melo cv Bara To 139	Mellon	Egusi-Bara
Manihot esculenta cv TMS 30572	Cassava	Ege/Gbaguda
Mucuna cochinchinensis	Buffalo bean	Yerepe/Ewe-ina
Sorghum bicolor cv CSH9	Guinea corn	Oka-Baba
Sphenostylis stenocarpa cv Nsukka Brown	Yam bean	Feregede
Stylosanthes gracilis	Stylo/Forage crop	Saworo/Koropo
Zea mays cv DMR-LSR-Y	Maize	Agbado
Dioscorea rotundata cv TDr89/02665	Yam	Isu/Ako-isu

Sandy-loam soil obtained from the field was heat-sterilized in an electric sterilizer and rested for four weeks to restore stability in polyethylene bags.
Approximately 10kg of sterile soil were weighed into each of one hundred and thirty

(130) 15 litre plastic buckets used for the experiment. Five seeds of each intercrop together with yam setts with an average weight of 250g were sown in each plastic buckets, ten plastic buckets for each treatment. Seedlings were thinned to one per plastic bucket five days after germination. The seedlings were then inoculated with 5000 eggs of *Meloidogyne incognita* race 2 the next day. The eggs were extracted from a culture of the nematode maintained on *Celosia argentea* L. roots through the HUSSEY and BARKER (1973) sodium hypochlorite ($NaOCl$) method. The identity of *M. incognita* race 2 was confirmed using perenial pattern as described by EISENBACK *et al.* (1981). Uninoculated units served as control. There were twenty-six treatments replicated five times, the experiment being a randomized block design.

Thirty weeks after inoculation three of the five replicates per treatment were randomly selected for assessment of root galls by turning the buckets upside down and carefully freeing the root system of each intercrop and the yam of soil. The roots were washed carefully under a gentle stream of tap water, mopped dry and assessed under a stereoscopic microscope for galls.

Eggs were extracted from the roots and estimated using the HUSSEY and BARKER (1973) sodium hypochlorite method. A sample of 250 cm^3 soil from each bucket was assayed for juveniles of *M. incognita* race 2 using WHITEHEAD and HEMMING (1965) tray modification of the Baermann technique. Data obtained were used for host status rating with the quantitative method of SASSER *et al.* (1984) of rating plants for resistance to root-knot nematode (RKN) (Table 2).

Table 2: Quantitative scheme for assignment of Canto-Saenz's host suitability (resistance) designations (SASSER *et al.*, 1984)

Plant damage (Gall Index)	*Host Efficiency (Reproductive factor)*	*Degree of resistance.*
≤ 2	≤ 1	resistant
≤ 2	≥ 1	tolerant
≥ 2	≤ 1	hypersusceptible
≥ 2	≥ 1	susceptible

3 Results and Discussion

The intercrops differed in their status as hosts to *M. incognita* race 2 (Table 3). The root-gall index ratings indicated that *M. incognita* race 2 reproduced highly on *Abelmoschus esculentus* cv V35, *Corchorus olitorus* cv Angbadu and *Sphenostylis stenocarpa* cv Nsukka Brown while no appreciable root-gall index occurred on soil sample containing *Crotalaria juncea*, *Mucuna cochinchinensis* and *Stylosanthes gracilis*.

In 1999, gall indices for *A. hypogaea* cv UGA4, *C. cajan* cv Cita-2, *C. melo* cv Bara To 139, *M. esculenta* cv TMS 30572, *S. bicolor* CSH 9 and *Zea mays* cv DMR-LSR-Y were significantly ($P < 0.05$) lower from those of *A. esculentus* cv V35, *C. olitorus*

Table 3: Root galling and reproductive factor on roots of plants commonly intercropped with yam following inoculation with 5000 eggs of *Meloidogyne incognita* race 2 in the pot experiment.

	Root-gall Indices *				*Reproductive factor* †	*Degree of resistance*
	Ibadan		*Ilora*		(R=P_f/P_i)	
	1998	*1999*	*1998*	*1999*		
Abelmoschus esculentus cv V35	5.0^a	5.0^a	4.8^a	4.7^a	2.85	susceptible
Arachis hypogaea cv UGA4	2.6^b	3.8^b	2.8^b	3.8^b	0.85	hypersusceptible
Cajanus cajan cv Cita-2	3.0^b	4.0^b	3.2^b	4.0^b	0.95	hypersusceptible
Corchorus olitorus cv Angbadu	4.6^a	4.8^a	4.8^a	4.8^a	2.95	susceptible
Crotalaria juncea	1.0^c	0.0^c	1.0^c	0.0^c	0.60	tolerant
Cucumis melo cv Bara To139	2.5^b	3.8^b	2.3^b	3.8^b	0.95	hypersusceptible
Manihot esculenta cv TMS30572	2.4^b	3.8^b	2.6^b	3.8^b	0.90	hypersusceptible
Mucuna cohinchinensis	1.0^c	0.0^c	1.0^c	0.0^c	0.55	tolerant
Sorghum bicolor	2.4^b	3.8^b	2.5^b	3.7^b	0.95	hypersusceptible
Sphenostylis stenocarpa cv Nsukka Brown	5.0^a	5.0^a	4.8^a	4.8^a	2.80	susceptible
Stylosanthes gracilis	1.0^c	0.0^c	1.0^c	0.0^c	0.60	tolerant
Zea mays cv DMR-LSR-Y	2.4^b	3.7^b	2.6^b	3.8^b	0.85	hypersusceptible
Discorea rotundata cv TDr 89/02665	2.4^b	2.2^b	2.1^b	2.3^b	0.90	hypersusceptible

* Mean of five replicates. Means followed by the same letters are not significantly different at ($P < 0.05$) according to DMRT. Gall indices on scale of 0-5 where 0 ≙ no gall; 1 ≙ 1-2 galls; 2 ≙ 3-10 galls; 3 ≙ 11-30 galls; 4 ≙ 31-100 galls; 5 ≙ > 100 galls.

† Reproductive factor $R = P_f/P_i$, where P_i is the initial nematode population and P_f is the final nematode population.

cv Angbadu and *S. stenocarpa* cv Nsukka Brown (Table 3). Observation in both years showed that the root-gall indices were lowest for *C. juncea*, *M. cochinchinensis* and *S. gracilis*. The possible reasons for the differences were due to increase in number of both wet and intensity of the rain fall observed during the period of the experiment. Another factor of significant is the nutrient status of the various treatments, which indicated that the nutrient status of the various treatment plots was in the range suitable for most arable crops including yam. This high soil fertility possibly contributed to the significant differences in the gall indices.

In 1999, no galling was observed on the roots of *C. juncea*, *M. cochinchinensis* and *S. gracilis* in the two locations used for the experiment (Table 3) but their nodulation was profuse. This type of response had been reported by other studies (Caveness,

1982; RHOADES, 1964; RHOADES and FORBES, 1986; AYALA *et al.*, 1967; HAROON and SMART, 1983). Also these crop species can be use specifically to attract root-knot nematodes thereby diverting or reducing the nematode population and increasing yield of the subsequent crops planted.

The number of *M. incognita* juveniles (J_2) extracted from the plant roots and soil rhizosphere reflected the susceptibility of the host.

Using the host suitability rating of SASSER *et al.* (1984), where the reproduction factor was determined, *A. esculentus* cv V35, *C. olitorus* cv Angbadu and *S. stenocarpa* cv Nsukka Brown could be classified as susceptible because the gall-index (G.I) is greater than 2 while the host efficiency (reproductive factor in Table 2) is greater than 1.

From this study, *A. hypogaea* cv UGA4, *C. cajan* cv Cita-2, *C. melo* cv Bara To139, *M. esculenta* cv TMS 30572, *S. bicolor* cv CSH-9 and *Zea mays* cv DMR-LSR-Y could be classified as hyper-susceptible in which the (G.I) is greater than 2 and the host efficiency (R-factor) is $\leq$1 while *C. juncea*, *M. cochinchinensis* and *S. gracilis* could be classified as resistant with gall index $\leq$2 and the host efficiency $\leq$1 (Table 2).

If susceptible crops such as *A. esculentus*, *C. olitorus* and *S. stenocarpa* are planted before or after yam plants, attack on yam by *M. incognita* race 2 will be more severe by increasing the nematode population and reducing the quality and market value of the tubers (GREEN and FLORINI, 1996; AGBAJE *et al.*, 2002).

In South-Western Nigeria, several crops are incorporated into yam cultivation and planting of resistant intercrops like *Crotalaria juncea*, *Mucuna cochinchinensis* and *Stylosanthes gracilis* would prevent nematode populations build-up around yam plants.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 119–129

Assessing NGDOs' Targeting Performance and Characteristics of Households Participating in Child Development Programmes in Rural Eastern Kenya

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Abstract

Targeting beneficiaries of development interventions in the context of poverty alleviation remains a challenge to most development agencies and policy-makers. Due to limited resources and the small scale of operations, most non governmental development organisations' (NGDOs) practice targeting in order to limit themselves to interventions that only select a group of individuals considered to be most in need. This paper analyses the targeting performance of two child-safety net programmes operating in rural Kenya and examines the factors influencing it. In addition, an econometric model is developed to identify the characteristics of the households participating in these programmes. Data for this paper was collected through a household survey of 120 randomly selected households, stratified equally into participants and non-participants. The targeting performance of the studied NGDOs' interventions was found to be poor due to reliance on local social structures that led to under-representation of the poorest group of households in programme activities. The paper further shows that although the case study NGDOs and their child programmes could be supporting households with characteristics that indicate that they are not among the well-off in the society, such households do not necessarily belong to the poorest group of community members in relative terms.

Keywords: rural poverty, targeting performance, participants' characteristics, NGDOs, Kenya

1 Introduction

In the last two decades, non-governmental development organisations (NGDOs) have become increasingly important players in the field of international development. Their growth, particularly in many of the developing countries, has been very prolific (Clarke, 1998). In Kenya, the numbers of registered NGDOs grew from about 124 in 1975 to about 3000 in 1999 (Daily Nation, 1999). With the reduction of state support in the

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provision of social services and following the implementation of the structural adjustment programmes, NGDOs in the country are active in many of the service roles carried out by governments in the developed world (Ndegwa, 1996; Daily Nation, 1999).

One of the major strengths of NGDOs, as mentioned in the literature, is their ability to reach the poor and marginalised members of the society. This fact has made them gain credibility in the eyes of the donors, resulting in a trend of donor shift, from governments to NGDOs. In Africa, for example, the total official development assistance (ODA) fell from US$ 17.3 to 15.1 billion between 1993 and 1997, while funds flowing through NGDOs rose from less than US$ 1 billion dollars in 1990 to over US$ 3.5 billion in 1999 (Chege, 1999). A number of criticisms have, however, been raised with respect to the NGDOs effectiveness in reaching the poorest members of the society. Vivian and Maseko (1994) point out that few NGDOs in Zimbabwe ever target the poorest of the rural poor. This could result from a number of factors. For one, targeting or reaching the poorest and particularly those in some remote poor locations is more resource intensive compared to reaching those who are marginally poor and the non-poor, as well as those located in more strategic locations. Secondly, most NGDOs in the South depend totally on donor funds and therefore performance is a key determinant of continued funding. In such cases, NGDOs and other development agencies are therefore likely to work with a clientele that is easily accessible and has some resources that would enhance programme impact and quicker results.

Targeting the poorest is particularly important in child development programmes since such programmes are often tailor-made for the most needy in the rural communities. Many large international NGDOs are involved in these activities, but there is little research done on their outreach performance (percentage of the poorest participants reached out of the total participants) beyond the rhetoric. There is also scarce knowledge on the characteristics of the households who end up participating in such programmes as a result of adopting particular targeting approaches. This study therefore seeks to contribute to the existing knowledge of targeting performance of NGDOs, with special attention to two child development programmes in Eastern Kenya. Its specific objectives are:

(a) to analyse the relative poverty levels of client households of two child safety net programmes in rural Kenya in order to assess factors influencing outreach performance of the NGDOs involved, and

(b) to identify the characteristics of the local households participating in these programmes.

The two NGDOs studied in this paper are treated as an entity since they employ almost a similar targeting approach. They also operate in areas that have similar agro-ecological conditions and communities with similar ethnic backgrounds.

2 Conceptual and Empirical Issues: Targeting and Participation

Targeting is defined as "the practice of limiting access to an intervention to a select group of individuals" (HODDINOTT, 2001, p. 89). Though widely recognised as an attempt to reach the poorest of the poor, targeting is however not always a straight forward practice to implement and a poorly targeted intervention could end up being more costly and less effective than one that is randomly allocated or made available to all households. There are basically two main targeting strategies: administrative targeting and self-targeting (HODDINOTT, 2001). The former refers to the application of targeting criteria in such a way that participation includes particular individuals but effectively excludes others while in the latter, the intervention is available to all but is fashioned in such a way that it is less attractive to certain groups of people. The NGDOs' programmes discussed in this paper apply the administrative type of targeting. The performance of a certain targeting strategy is hypothesized to depend on wide range of factors including geographical conditions, infrastructural developments and local communities' power structure. Further, some targeting strategies could have adverse effects, e.g. undermining the local political base of the programme if the affluent feel left out (WORLD BANK, 2001).

Studies on the determinants of household participation in rural development programs identify a number of household characteristics as potential determinants. These include: age and gender, household status, education level, social divisions (heterogeneity in the community), occupation, income level and sources, distance of residence from the project centre, land tenure and employment status (COHEN and UPHOFF, 1977; EVANS *et al.*, 1999). In addition, a strong relationship is expected between targeting approaches and characteristics of those selected to participate in a particular programme.

3 Research Methodology

3.1 Description of the Case Study NGDOs and their Programmes

The Christian Children Fund, Kenya (CCF/K), and Compassion International, Kenya (CIK/K), are the NGDOs studied in this paper. The two have a long history of working in Kenya, having started their operations in the 1960 and 1980 respectively. They implement child based safety net programmes which are intended to support poor children through individual sponsorship in order to help them get a better chance in life than they would have otherwise had. They do this mainly through support for formal education, provision of basic health care, and other programmes that each NGDO considers important for the survival, development and protection of children. The case study CCF/K programme is located in Meru South District, Eastern Kenya, and had about 790 registered children at the time of the survey. The case study CIK/K programme, on the other hand, supports 15 child development centres (CDCs) in the neighbouring Mbeere District (also in Eastern Kenya), each with its own committee and staff. However, due to the vastness of the area, only three such CDCs with about 800 sponsored children were included in the survey.

The CCF/K and the CIK/K implement their programmes through local partners, the Mutonga Development Project and the Mbeere Diocese of the Anglican Church of Kenya, respectively. These partners act as the programmes' managers on the ground, but they are provided with technical and financial support by the two NGDOs. They form programme coordination committees[1] and recruit the programmes' technical staff locally. The technical staff is accountable to the committees and is not considered as belonging to the NGDOs. As regarding targeting, both programmes explicitly state in their operation guidelines that they aim at assisting children from the poorest families. For the purpose of analysis, the two programmes of the CCF/K and the CIK/K will hereafter be referred to as CCF-Mutonga and CIK-Mbeere, respectively.

3.2 Data Collection and Analysis

The analysis of relative poverty in order to identify the target groups and assess the targeting performance of the two programmes, and the determination of characteristics of participating households are conducted at the household level for two key reasons: first, the programmes being studied targeted the households and not the community units. Second, it is at the household level where decisions concerning resource allocation, including participation in development programmes, are made.

The empirical data analysed in this paper was collected in the two operational regions of the case study NGDOs in 2000. This was accomplished through a household survey, which was complemented with information gathered through detailed interviews of key informants. The latter were very useful in explaining factors influencing the targeting performance of the case study programmes. The household survey involved a standardised questionnaire covering household socio-economic profile, participation in the two programmes, and involvement in other community level development activities and organisations. For each programme, a sample consisting of 60 randomly selected households, stratified equally into participants and non-participants, was selected.

The relative poverty of the households targeted by the programmes is analysed using a poverty index which is developed through the principal component analysis (PCA) of a set of selected indicators (Zeller *et al.*, 2001) [2]. These included household demographics and dwelling indicators, types and number of meals served over a seven-day period, and type and value of assets. Each household is assigned a score depending on the relative poverty level. The score indicates its poverty level in relation to the others. Based on this index, households are classified into three relative poverty groups: poorest, poor and not so poor (see Table 1). Poverty is thus assessed in relative terms whereby comparison is made between the lowest tercile of a population against the upper terciles. This methodology was preferred due to the high costs of conducting a comprehensive expenditure-based household survey as well as the fact that NGDOs usually work intensively in small geographical areas and therefore use of local indicators

[1] Unlike the technical staff who earned a monthly salary, the committee members were not remunerated.

[2] Due to space limitations we do not discuss in details or show the generation of the poverty index in this paper. The reader could get more information on this in Zeller *et al.* (2001).

would have a more direct relevance to them. Results in Table 1 are discussed further in Section 4.2.

Table 1: Distribution of households across the relative poverty groups.

Relative Poverty Group	*Child development programme*			
	CCF-Mutonga		*CIK- Mbeere*	
	Participant	*Non-participant*	*Participant*	*Non-participant*
Poorest	13.3	33.3	20.0	33.3
Poor	70.0	33.3	60.0	33.3
Not So Poor	16.7	33.3	20.0	33.3
Total	100.0	100.0	100.0	100.0
χ^2 test	8.141***		8.571***	

Source: own survey

To determine the characteristics of the households that participated in the child development programmes, an econometric model is developed. Since our sample consisted of both participants and non-participants, participation in the programmes is modelled as a binary variable which takes a value of 1 if household is a participant and 0 if otherwise. The probability to participate is assumed to be a function of household characteristics, spatial location of the household and programme characteristics (see Table 2). This could be expressed as a probit model:

$$Y = \alpha + \beta X_i + \mu_i \tag{1}$$

where $Y = 1$ if a household is a participant and $Y = 0$ if otherwise. X_i is the vector for response variables for the i^{th} household and μ is the disturbance term. The meanings of the response variables, descriptive data and hypothesis are presented in Table 2.

4 Research Findings and Discussion

4.1 Assessing the Targeting Performance

The targeting performance of the case study programmes is assessed in terms of how they are able to reach the poor or even the poorest in the targeted regions. This is achieved through the evaluation of the depth of outreach, which refers to how deep in the pool of the under-privileged a programme has been able to reach (Navajas *et al.*, 2000; Zeller *et al.*, 2003). In this paper it is assessed as the percentage of the poorest participants reached out of the total participants. To analyse the depth of outreach or targeting performance, the relative poverty of participant households was compared with that of the non-participants since they represent the general community. The results for the two programmes are presented in Table 1. The χ^2 results show that, in both programmes, there were significant differences at one percent (1%) level

Table 2: Meaning and description of the variables used in the models.

Variable name	*Variable description*	*Mean* *	*Std. dev.* σ	*Expected sign*
HHSIZE	Household size (no. of household members)	6.28	2.27	+
PROGRAM	NGO program (dummy = 1 if CCF-Mutonga, 0 otherwise)	0.5	0.5	?
GENDHHH	Gender of household head (dummy = 1 if male, 0 otherwise)	0.85	0.36	-
AGEHHH	Age of household head in years	44.12	11.89	+
DEPEND †	Dependency ratio (no. of members <15 years and >65 years divided by household size)	0.42	0.20	+
ADULTEDU	Average education of adults in years	6.87	3.09	-
EDUCHHH	Education level of household head in years	6.89	4.09	-
EDUCHSD	Education level of household head squared	64.08	58.55	-
POVINDEX	Poverty index of the household (the higher the wealthier)	-0.65	0.62	-
POVISQD	Poverty index squared	0.80	0.71	-
SOCCAP	Social capital index	12.96	16.29	+
REGION 1-4 ‡	Regional dummies for 4 of the 5 regions			

* $n = 120$

† Dependent variable is participation in the child programmes

‡ Regions 1- 4 in ascending order are Kanyuambora, Kavengero Kathigagaceru and Mutino. Reference region is Kanjuki

Source: own survey

in the distribution of the participant households and the general population across the three poverty groups. In both programmes the middle tercile group ('poor') was over represented in the participant population, while the 'poorest' and 'not so poor' groups were almost equally under-represented. The depth of outreach of the programmes is thus 13.3% and 20.0% for the CIK-Mbeere and CCF-Mutonga programmes, respectively. This was rather poor performance given that they are supposed to explicitly target the poorest[3]. Thus, the question arises as to what might have been the underlying causes (factors) of this unintended result as the goal of the NGDOs was to assist the poorest children. This question is addressed in the following section.

4.2 Description and Assessment of the Targeting Approaches

We attempt to find out why the two programmes had a poor targeting performance by looking at how they were initiated and what kinds of targeting approaches they adopted.

[3] It should however be clarified that poverty in this case is in relative terms. Given the incidence and severity of poverty in the study areas, it is possible that children supported could all be from poor households in absolute terms as measured by the national poverty line.

Both programs were started after community leaders from each area approached the NGDOs on behalf of the respective communities. Based on the information provided by these rural elite, the NGDOs' staff visited the programme areas, conducted some rapid rural appraisals and later the programmes were started. After the identification of the program localities, the next step was to select the program participants. In the case of CIK-Mbeere, this step began with the formation of local child development centre committees whose membership was drawn exclusively from members of the partnering evangelical church. The committees together with the locally recruited project staff identified the children to benefit from the programme. The process was not so different for the CCF-Mutonga programme. During an initial phase, the programme was managed through an intermediary organisation, the local Catholic Church. It was then handed over to a committee elected by the parents of the sponsored children. Thus, just like with the CIK-Mbeere, the local committee, alongside the project staff, was involved in the selection of the children to benefit from the programme. The only unique characteristic is that the local administration personnel of the government were assisting in the selection process.

In both programmes, selection of the participants is based on the local knowledge of who is poor and therefore deserves to be enlisted for the programme. Theoretically, local community targeting agents have advantages of having better information on the household characteristics, needs, and even any economic developments that may not be so obvious to an outsider. This better placement of local targeting agents can thus reduce the targeting errors of inclusion and exclusion, as well as the administration costs. However, this approach of depending on the existing local social structures for targeting purposes was not successful, in terms of enabling the programmes to reach the most needy in the study areas. The participating households[4] felt that the children selection approach was far from being transparent and fair.

About 16.7% and 36.7% of the participants of CCF-Mutonga and CIK-Mbeere, respectively, were not satisfied with the targeting approach of the programmes. They were thus of the opinion that there was need for the selection approach to be more open and hence more effective in reaching the poorest. In-depth interviews with participants and key informants revealed that selection flaws emanated from either one of the following three key areas. First, in some instances committee members were reported to include their own children or their relatives' or friends' children as an indirect mode of compensation for time spent in programme-related activities, even though they may not be the most needy. Second, despite the policy to target all community members irrespective of religious affiliation in Mbeere District, households which were members of the partner denomination (Anglican Church of Kenya) dominated the programme at the expense of other more deserving cases. Third, there were cases of nepotism and even corruption depicted by use of bribery to have unqualified children included. Eventually most of

[4] The non-participants were not asked to comment on the programmes since it was anticipated they might be biased in one way or the other. The point however is that if some of the participants could agree that there some irregularities in the selection process, how much more would the rest of the community have lamented?

the children included in the programmes were from households with some established social links to the local committees. The households expressed the fact that they did not know the NGDOs' rules and guidelines of targeting the needy children and therefore could not disapprove the qualifications of those selected irregularly. Thus their desire was that such criteria should be clearly spelt out and made public to all the community members in order to have an open selection process.

4.3 Characteristics of Households Participating in the Child Development Programmes

The results of the econometric model (Table 3) provide us with the characteristics of households that are likely to participant in the case study programmes. For brevity, only the significant variables are discussed. As the coefficient of household size (HHSIZE) is positive and significant at the 10% level we can say that larger households had a higher possibility of participating in the programmes. When all is constant, larger households are likely to be poorer than smaller ones due to stretching of available resources per household member (World Bank, 2001). Another aspect in relation to the programmes is that a larger household size, especially where it is directly related to the number of children, increases the chances of at least one child being selected.

Although the coefficient of the level of education (EDUCHHH) is not significant, it is positive, and the coefficient of its squared value (EDUHHSQ) is negative and significant meaning that the relationship to participation increases at a diminishing rate. Those with high education, and hence not so poor, are less likely to participate in the programmes. Given that ceteris paribus higher education translates into more wealth, this result shows an apparent success of the programmes in screening out the highly educated and well-off households.

The coefficient of the poverty index (POVINDEX) is not significant but has the expected negative sign. However, the coefficient of its squared value (POVISQD) coefficient is negative and significant at 1% level. This shows that poverty is one of the considerations in the selection process as most of the participing households are likely to have a lower index. The positive and significant coefficient of social capital (SOCCAP) indicates that households with more social networks and social responsibilities ended up benefiting by having their children selected into the programmes. This result supports our earlier findings that households with social links to the programmes' committee members and local leaders could easily benefit from the programme irrespective of their poverty status.

Although the case study programmes showed under-representation of the poorest relative group, the result of the econometric analysis indicates that most of the households likely to become participants are not likely to be well-off. This finding is congruent to earlier results that showed that most of the participating households (more than 60%) belonged to the poor relative group (Table 1). Thus, although the programmes did not reach the 'poorest', they never targeted the well-off members of the community.

Table 3: Characteristics of participants of CCF-Mutonga and CIK-Mbeere programmes.

Variable	*Coefficient*	*t-value*
Constant	-0.947	-0.678
PROGRAM	-0.835	-0.850
HHSIZE	0.188	2.47**
GENDHHH	-0.665	-1.574
AGEHHH	0.012	0.668
DEPEND	0.970	1.098
ADULTEDU	0.003	0.632
EDUCHHH	0.158	1.160
EDUHHSQ	-0.017	-1.858*
POVINDEX	-1.121	-1.590
POVISQD	-1.420	-2.68***
SOCCAP	0.020	1.681*
REGION1	-0.256	-0.390
REGION2	-0.261	-0.325
REGION3	-0.645	-0.677
REGION4	0.115	0.281

$n = 120$; $log\ Likelihood = -59.908$; $\chi^2 = 46.539$
***,**,* ≙ significant at 1%, 5% and 10% levels respectively

Source: own survey

5 Conclusions

This paper uses a simple methodological tool to generate the relative poverty groups of households in order to assess the outreach performance of two child development programmes. The results of our analysis show that the two case study programmes had an under-representation of the 'poorest' households though this had not been the intention of the funding NGDOs. This poor performance can be traced from a combination of factors that emanated from adoption of a targeting approach that relied on the existing local social structures without stipulating clear guidelines for the identification of poorest households. As the econometric results also show, there was a higher likelihood of households endowed with higher levels of social capital to participate in the programme than those with less social ties. This confirmed the finding that households which were more socially active and had closer ties to the local programme committees and their proxies were easily included as participants. The paper thus demonstrates that existing social structures can sometimes be responsible for perpetuation of social exclusion and

exploitation of the poor in socio-economic development initiatives, and thus cannot always be expected to be pro-poor. An important policy implication is that NGDOs' and programmes' technical staffs wishing to operate in the study districts should seek to first understand the limitations of depending on the local social structures for targeting purposes before taking it for granted that they would facilitate reaching of the most needy or poorest in the community.

The other results of the econometric analysis, other than that of social capital, show that the households participating in the case study programmes are not likely to be among the well-off in the community. This is because they are likely to come from larger and less educated households and those depicted to belong to lower groups in terms of relative poverty. Therefore the results of this econometric analysis provide the evidence that the case study NGDOs did target the worse-off members of the community though they had an under-representation of the poorest relative group. Thus, this paper shows that although the case study NGDOs and their child programmes could be supporting households with characteristics that indicate that they are not among the well-off in the society, such households do not necessarily belong to the poorest group of community members in relative terms.

Acknowledgement
The authors would wish to acknowledge the financial support of the Ecumenical Scholarship Programme of the German Protestant Church (ÖSW), Bochum, Germany.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 131–141

Integrated Use of Farmyard Manure and NP fertilizers for Maize on Farmers' Fields

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Abstract

A study was initiated in 1997 to introduce the culture of supplementing low rates of NP fertilizers with farmyard manure (FYM) in the maize based farming system of western Oromia. The treatments were 0/0, 20/20, 40/25 and 60/30 kg N/P ha^{-1} and 0, 4, 8, and 12 t FYM ha^{-1} in factorial arrangement in a randomized complete block design with three replications. The experiment was conducted at Laga Kalla, Walda, Shoboka, Harato, and Bako Research Center using BH-660 hybrid maize. The FYM used for the experiment was well decomposed under shade and spot applied together with the P fertilizer at planting; N was applied in split form. The residual effects of FYM were investigated for Laga Kalla, Walda and Shoboka during the 1998 cropping season. Statistical analysis revealed that the N/P fertilizers and FYM significantly ($p < 0.05$) increased grain yield in all locations except for Walda in 1997. Interactions of FYM and NP fertilizer rates were significant ($p \leq 0.05$) at all locations except for Shoboka. The application of FYM alone at rates of 4, 8, and 12 t ha^{-1} produced average grain yields of 5.76, 5.61 and 5.93 t ha^{-1}, respectively, compared to 3.53 t ha^{-1} for the control treatment in 1997. There were significant residual effects of FYM and NP fertilizers applied in 1997 on maize grain yields in 1998. Laboratory analysis confirmed that considerable amounts of macronutrients and small amounts of micronutrients were supplied by FYM. Based on the results of this study, the integrated use of properly managed FYM and low rates NP fertilizers could be used for maize production in the areas under consideration. Moreover, sole applications of FYM on relatively fertile soils like Walda and Harato are useful in maintaining soil fertility and are encouraging for resource poor farmers.

Keywords: farmyard manure, integrated nutrient management, NP fertilizers, residual effects, Ethiopia

1 Introduction

Low soil fertility is one among the major factors limiting maize production and productivity in western Oromia, Ethiopia. This is common in many tropical cropping systems

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where fertilizer use is low and little or no agricultural residues are returned to the soil for maintaining soil fertility. Alfisol is the dominant soil type in the region. This soil is characterized by low cation exchange capacity (CEC), and low contents of organic matter, available phosphorus (P) and total nitrogen (N) (Asfaw Negassa *et al.*, 1997; Wakene Negassa, 2001). Several natural and socioeconomic factors are involved in aggravating the decline in soil productivity under the farming community in the region with the result that the relatively common practice of sole application of low rate of NP fertilizers has not sustained maize production and productivity in the region.

The recommended rates of inorganic fertilizers for hybrid maize production in western Oromia are 110 kg N and 20 kg P ha^{-1}. The recommendation was initially used by some farmers but when the fertilizer subsidy was removed and the price of inorganic fertilizers doubled, the farmers failed to use even one-third of the recommended rates. Therefore, to maintain soil fertility and productivity, the use of other alternative options of soil fertility replenishment is indispensable. Farmyard manure (FYM) is one potential source of nutrients as a result of the high cattle population in the region where on average there are 6.1 cattle per family (Legesse Dadhi *et al.*, 1987). There exists a large volume of literature reporting the efficiency and effectiveness of FYM and other organic nutrient sources in maintaining soil fertility, improving crop yields and sustaining productivity, and that display their increased potential when integrated with inorganic fertilizers (Inckel *et al.*, 1996; Asfaw Belay *et al.*, 1997, 1998). For instance at Uyole in Tanzania, application of low rates of NP fertilizers with FYM produced 7.10 t ha^{-1} of maize grain compared to 4.03 t ha^{-1} when the same rates of NP were used alone (Lyimo and Temu, 1992).

Despite the high number of cattle per household and the availability of cheap family labor that could be used for FYM collection, incubation and transportation, the use of FYM for soil fertility maintenance is limited to homestead. Besides, due to the relatively higher availability of firewood, unlike the central and eastern highlands of Ethiopia, FYM is not used for fuel in the region. These and the low rates of NP fertilizers currently being used for maize production under farmers' conditions have aggravated the situation of soil fertility degradation and declining maize production. Consequently, training the farming community on the proper handling and use of FYM together with low rates of inorganic fertilizers could be one alternative solution for fertility management. The objective of this study was to introduce the culture of integrating FYM and NP fertilizers for maize production in western Oromia.

2 Materials and Methods

2.1 Description of the Study Area

The study sites are located in East Wollega Zone of Oromia National Regional State, western Ethiopia, in the sub humid agro-ecology of the country at 260-290 km west of Addis Ababa. The locations lie within a 30 km radius of 9° 6' N latitude and 37° 9' E longitude with altitude range of 1650-2000 m.a.s.l. Long-term weather data (1961-2001) at the Bako Research Center (BRC) indicate that the study area has a unimodal rainfall pattern and average annual total rainfall of 1244 mm. The rainy season occurs

during April to December and maximum rain is received in the months of June, July and August. The minimum, maximum and average air temperature is 14.1°, 27.9° and 20.6 °C, respectively. The average soil temperature at 1-m soil depth is 24°C (Zewude, personal communication). The dominant soil type in the study area is Alfisol with clayey texture, acidic reaction, low total N, organic carbon, and available P (WAKENE NEGASSA, 2001).

2.2 Sampling and Laboratory Analysis of Soils and Farmyard Manure

Composite soil samples were collected from the plow layers at each experimental site before applications of the treatments in 1997 and from the plots that received 12 t FYM ha^{-1}, 60/30 N/P kg ha^{-1} and 60/30 N/P kg ha^{-1} plus 12 t ha^{-1} of FYM at the end of the experiment in 1998. Standard laboratory procedures for each parameter were followed in analyzing the composite surface soil samples and the FYM. Determination of soil particle size distribution was carried out using the hydrometer method. Soil pH was measured potentiometrically using digital pH meter in 1:2.5 soil to solution ratio with H_2O and 1 M KCl solution. Exchangeable bases were extracted with 1.0 M-ammonium acetate at pH 7 and were measured by atomic adsorption spectrophotometry. Cation exchange capacity (CEC) of the soil was determined with the ammonium acetate saturated method (CHAPMAN, 1965). Exchangeable acidity was determined by extracting the samples with 1 M KCl solution and titrating with NaOH as described by MCLEAN (1965). Organic carbon was determined following the wet digestion method as described by WALKLEY and BLACK (1934). Total N was determined by the Kjeldahl procedure as described by JACKSON (1958). Available P in the soil samples was determined by the Olsen (OLSEN *et al.*, 1954) and Bray II (BRAY and KURTZ, 1945) methods whereas only the Bray II method was used for available P in compost. Total P in the FYM was extracted using aqua regia digestion technique. The P different extracts was measured by spectrophotometer following the procedure described by MURPHY and RILEY (1962). Available Fe, Mn, Zn and Cu in the composts were extracted with DTP A as described by LINDSAY and NORVELL (1978) and were measured by atomic absorption spectrophotometry.

2.3 Treatments and Experimental Design

The experiment was conducted during the 1997 and 1998 cropping seasons in five locations (Shoboka, Laga Kalla, Walda, Harato and BRC) in the maize-based farming system of western Oromia. The treatments used were 0/0, 20/20, 40/25, and 60/30 kg N/Pha^{-1} and 0, 4, 8 and 12 t FYM ha^{-1} in factorial arrangement using the BH-660 hybrid maize. Treatments were laid out in a randomized complete block design with three replications. The FYM used for the experiment was well decomposed under shade and applied all at planting in spots with P fertilizer; N fertilizer was applied in split form with half of the dose applied at planting and the remaining half at 30 to 40 days after planting. The residual effects of FYM on maize grain yields at Shoboka, Laga Kalla and Walda were evaluated during the 1998 cropping season. All the necessary cultural practices recommended to the hybrid maize production were used for the management of the experimental plots throughout the cropping seasons. The farmers with the close

Table 1: The soil pH, texture, total N (TN), organic carbon (OC) and available P of the experimental sites before and after treatments application.

Location	*Yr*	*N/P+FYM* (*kg+t* ha^{-1})	*pH (1:2.5)*		*OC* (%)	*TN* (%)	*Particle size*			*Texture*	*Avail. P* (*mg* kg^{-1})	
			H_2O	KCl			*Sa*	*Si*	*Cl*		*Olsen*	*Bray*
Bako Research	97	0/0 + 0	5.24	4.10	2.03	0.18	39	29	32	CL	2.68	2.80
Center	98	0/0 + 12	5.17	3.99	2.15	0.18	40	31	29	CL	4.18	5.20
	98	60/30 + 0	5.05	3.67	1.56	0.13	33	29	28	CL	9.48	10.12
	98	60/30 + 12	5.65	4.30	1.88	0.14	38	25	27	SCL	7.62	8.33
	97	0/0 + 0	5.30	4.04	2.57	0.22	29	37	34	CL	3.06	2.80
	98	0/0 + 12	5.05	4.00	1.76	0.14	30	36	34	CL	4.21	6.71
Shoboka	98	60/30 + 0	5.20	4.12	1.76	0.13	31	37	32	CL	3.86	4.20
	98	60/30 + 12	5.42	4.20	2.35	0.23	29	38	23	L	3.10	4.21
	97	0/0 + 0	5.25	4.35	2.17	0.20	39	33	28	CL	3.86	4.50
	98	0/0 + 12	5.73	4.24	2.87	0.26	40	32	28	CL	4.46	12.41
Laga Qalla	98	60/30 + 0	5.71	4.42	2.85	0.24	38	36	26	L	7.64	7.26
	98	60/30 + 12	5.33	4.21	3.25	0.33	39	34	27	L	10.3	8.25
Walda	97	0/0 + 0	5.64	4.12	2.21	0.24	39	31	30	CL	3.20	2.50

CL = Clay loam, SCL = Sandy clay loam, L = Loam, S = Sand, Si = Silt, C = Clay, Bray = Bray II method, Yr = year, 97 = 1997 = soil samples collected before treatments application, 98= 1998 = soil samples= taken after treatments application

supervision of the technical assistants and researchers managed the experimental fields. The yield data were subjected to statistical analysis using MSTATC computer software and the least significant difference (LSD) was used to separate significant treatment means.

3 Results and Discussion

3.1 Soil Physical and Chemical Properties

Laboratory analytical results of selected physicochemical properties of the soils on which these on-farm experiments were conducted are presented in Tables 1 & 2. Soils in the study areas are dominantly clay loams while some are loamy in texture and vary from medium to moderately acidic. The use of acid forming inorganic fertilizers in the region could lead to soil acidity constraints in the weakly buffered Alfisol. Based on criteria defined by LANDON (1991), the soil organic carbon contents at all locations are low whereas total N was medium except for the BRC, indicating the low fertility status of the soils. This could be due to continuous cultivation, and lack of incorporation of organic materials into the soils.

The cation exchange capacity of the soils ranged from 15.0 $cmol_c\ kg^{-1}$ at the BRC to 37.2 $cmol_c\ kg^{-1}$ at Shoboka (Table 2). The exchangeable bases at all sites were sufficient for crop production, although the lowest was recorded in the soil of the Research Center. This could be attributed to the cropping history of the Center, which is quite different from that of the farmers' fields. In both the farmers' fields and the research station,

Table 2: The soil pH, texture, total N (TN), organic carbon (OC) and available P of the experimental sites before and after treatments application.

Location	*Yr*	N/P+*FYM* (*kg* + *t* ha^{-1})	*Exchangeable bases, acid and CEC* (cmol$_c$kg^{-1})							*PBS* (%)
			Na	K	Ca	Mg	*Acid*	al	*CEC*	
Bako Research	97	0/0 + 0	0.44	0.47	4.59	1.92	0.56	Tr.	24.6	30
Center	98	0/0 + 12	0.63	1.38	4.99	1.33	0.45	Tr.	25.2	33
	98	60/30 + 0	0.39	0.72	2.94	0.83	0.36	Tr.	15.0	40
	98	60/30 + 12	0.79	1.99	3.79	1.25	0.52	Tr.	19.4	62
	97	0/0 + 0	0.38	1.23	15.0	6.50	0.12	Tr.	37.2	62
	98	0/0 + 12	0.39	0.59	4.14	1.08	0.32	Tr.	20.2	31
Shoboka	98	60/30 + 0	0.47	0.87	3.99	1.00	0.51	Tr.	21.0	30
	98	60/30 + 12	0.55	1.28	7.88	2.50	0.40	Tr.	33.8	36
	97	0/0 + 0	0.31	1.91	4.69	2.08	0.16	Tr.	23.2	30
	98	0/0 + 12	0.87	2.32	7.83	1.83	0.23	Tr.	31.4	39
Laga Qalla	98	60/30 + 0	0.63	1.79	8.78	2.08	0.12	Tr.	30.6	31
	98	60/30 + 12	0.79	2.09	6.24	1.75	0.21	Tr.	35.0	41
Walda	97	0/0 + 0	0.40	1.64	8.48	2.25	0.24	Tr.	24.0	53

PBS = percent base saturation, Yr = year, 97 = 1997 = soil samples collected before treatments application, 98 = 1998 = soil samples taken after treatments application, Tr = trace

available P (Olsen and Bray II extractable P) was deficient. In general, the low available soil P is presumably attributed to the high P fixing capacity of the Alfisols in these areas. In line with this, WAKENE NEGASSA (2001) reported results indicating considerable fixation of available P by Al and Fe in Alfisol of the same region.

3.2 Chemical Composition of Farmyard Manure

The chemical composition of the FYM used in the field experiments is shown in Table 3a. The FYM contained considerable amounts of essential macronutrients and small amounts of micronutrients. In terms of total nutrients applied per hectare (see Table 3b), the FYM supplied high amount of total N as well as substantial proportion of the maize crops' K and Mg requirements. However, not all of the total N and P are immediately available for crop uptake. In terms of available P, 4 t FYM ha^{-1} supplied only 9% of the recommended P rate from inorganic fertilizer; 12 t FYM ha^{-1} thus supplied only 26% of the requisite available P. However, much of the P in unavailable forms is expected to become slowly available both during the current growing season to the crop to which it is applied as well as to subsequent crops through residual effects. The FYM supplied the soil with rather minor amounts of the micronutrients, in each case never more than 1 kg nutrient ha^{-1} (Table 3b). Thus, FYM is a source of most essential plant nutrients and, hence, is a complete fertilizer for sustaining production of maize and other crops provided that other abiotic and biotic factors are favorable. Moreover, FYM application helps to maintain soil organic matter content and soil biological activity. In other words, the application of FYM continuously could improve the soil physicochemical properties and sustain production and productivity. In the present study, the application

of FYM alone or with low rates of NP fertilizers did not bring about significant changes on the selected soil properties. This may be due to the treatments were spot applied to feed the crop, not to feed the soils. Soil sampling did not target the spot application points.

Table 3: Elemental composition of the FYM used as organic fertilizer in the experiment.

A) Nutrient element composition of the FYM

Total N (%)	Total P (%)	*Available nutrient content* (mgkg^{-1})					*Exchangeable bases* (cmol$_c$kg^{-1})			
		P (Bray-II)	Fe	Mn	Zn	Cu	Na	K	Ca	Mg
2.34	0.678	427	31	145	29	3.5	0.88	17.1	15.3	15.7

B) Nutrient quantity (kg) in 4,8 and 12 t ha^{-1} *of the applied FYM*

FYM (t)	Total N	Total P	P (Bray-II)	Fe	Mn	Zn	Cu	Na	K	Ca	Mg
4	94	27	1.7	0.13	0.58	0.12	0.01	0.8	27	12	8
8	187	54	3.4	0.26	1.16	0.24	0.03	1.6	54	24	15
12	281	81	5.1	0.39	1.74	0.36	0.04	2.4	80	37	23

3.3 Maize Grain Yield

The grain yields of maize produced under different integrated rates of FYM and NP fertilizers at five locations in western Oromia are presented in Tables 4, 5, and 6. Maize grain yields at all locations in the 1997 cropping season were significant ($p \leq 0.05$) affected by both applied FYM and NP fertilizers except for Walda and Harato (Table 4). Except for Shoboka, interactions between FYM and NP fertilizers on maize grain yield were also significant ($p \leq 0.05$) (Table 5). The combined statistical analysis over locations also revealed significant main effects of FYM and NP fertilizers ($p \leq 0.05$) and interactions between these factors (Tables 4 and 5). The average grain yield of maize increased consistently with increasing rates of NP fertilizers and FYM. Yields of control plots ranged from <1.0 t ha^{-1} at BRC to almost 6.0 t ha^{-1} on farmers' fields at Harato (Table 5), indicating a fairly high level of soil fertility at some sites. This could be due to the differences in cropping history, cropping systems, land management and variations in socio-economic circumstances among the farmers. For instance, the host farmer from Walda was educated to a certain level, and knows the consequences of soil degradation on crop productivity. At Harato monoculture of maize is not commonly practiced; farmers are accustomed to growing diversified crops which help to maintain soil fertility.

No significant response to NP or FYM was observed at Shoboka. At Walda, Harato and Laga Kalla, the first 4 t ha^{-1} increment FYM alone was generally sufficient to achieve maximum maize yield; only at BRC did maize respond to higher rates of FYM without NP fertilizer application (Table 5). Similarly, there was generally no significant response to increasing rates of NP fertilizer alone beyond the first increment of 20/20 kg NP ha^{-1}. At the least fertile (most responsive) sites, maximum yield was only obtained

Table 4: Main effects of FYM and NP fertilizers on maize grain yield (t ha^{-1}) during the 1997 cropping season.

Main effect	*t maize grain* ha^{-1}					
	*BRC**	*Walda*	*Shoboka*	*Harato*	*Laga Kalla*	*Mean*
N/P *(kg* ha^{-1}*)*						
0/0	3.61	6.14	6.08	6.51	3.70	5.21
20/20	5.37	6.69	7.16	7.35	4.28	6.17
40/25	5.32	6.67	7.44	7.35	5.06	6.37
60/30	6.09	6.97	7.12	8.07	5.54	6.76
LSD(.05)	0.62	NS	0.91	NS	0.66	0.36
FYM (t ha^{-1}*)*						
0	3.38	6.00	6.13	7.19	4.03	5.35
4	4.78	6.71	7.43	7.29	4.24	6.09
8	6.18	6.97	7.12	7.40	5.07	6.55
12	6.05	6.79	7.14	7.41	5.24	6.53
LSD(.05)	0.62	NS	0.91	NS	0.66	0.36
CV (%)	14.5	16.9	15.6	16.6	17.1	16.4

* BRC: Bako Research Center

with combined application of NP fertilizer (sub-optimal levels) and FYM. This implies that nutrients (especially N and P) in FYM are not immediately available during the season of application to fully nourish a maize crop even though the total quantities applied were in excess of recommended requirements based on inorganic NP fertilizer rates. Low sub-optimal rates of NP fertilizers alone were as effective as high rates of N and P from heavy FYM applications. Under conditions of low soil fertility, combined application of NP fertilizer and FYM are most effective because the supply of nutrients from both sources is additive (Paustian *et al.*, 1992). Moreover, a readily available supply of N and P from fertilizer may enhance mineralization of unavailable organic N and P forms supplied in FYM providing a synergy in which the whole is greater than the sum of the parts.

There were significant main effects on grain yield in 1998 of NP fertilizer and FYM residues applied in 1997 at two of the three sites observed (Table 6). NP fertilizers showed significant residual effects ($p < 0.05$) on grain yield at Walda and Shoboka whereas FYM produced significant residual effects on grain yield at Shoboka and Laga Kalla (Table 6). However, interactions of the residues of NP fertilizers and FYM on maize grain yield were not significant at any site (data not presented). In agreement

Table 5: The effects of FYM and NP fertilizers on maize grain yield at five locations in the 1997 cropping season.

N/P + *FYM* (*kg* ha^{-1}+ *t* ha^{-1})	*t maize grain* ha^{-1}					
	*BRC**	*Walda*	*Shoboka*	*Harato*	*Laga Kalla*	*Mean*
0/0 + 0	0.90^{h}	4.68^{e}	4.44	5.79^{d}	1.86^{f}	3.53^{g}
0/0 + 4	3.61^{g}	6.68^{ab}	6.43	7.72^{abed}	4.37^{cde}	5.76^{ef}
0/0 + 8	4.87^{cdef}	6.50^{abc}	6.52	5.74^{d}	4.41^{cde}	5.61^{f}
0/0 + 12	5.05^{cde}	6.71^{ab}	6.95	6.78^{d}	4.17^{de}	5.93^{def}
20/20 + 0	3.79^{fg}	6.70^{ab}	6.88	6.20^{d}	4.75^{bcd}	5.66^{ef}
20/20 + 4	4.69^{defg}	7.44^{ab}	7.82	6.96^{cd}	3.27^{e}	6.04^{def}
20/20 + 8	6.50^{ab}	6.88^{ab}	7.44	8.94^{abc}	4.35^{de}	6.82^{bc}
20/20 + 12	6.50^{ab}	5.76^{bc}	6.52	7.28^{bcd}	4.75^{bcd}	6.16^{cdef}
40/25 + 0	4.33^{efg}	6.12^{abc}	6.70	9.06^{ab}	4.46^{cde}	6.13^{cdef}
40/25 + 4	5.05^{cde}	5.71^{bc}	8.00	6.78^{d}	4.66^{bcd}	6.04^{def}
40/25 + 8	5.96^{bc}	7.98^{a}	7.64	7.57^{abcd}	5.67^{abc}	6.96^{ab}
40/25 +12	5.96^{bc}	6.88^{ab}	7.44	6.00^{d}	5.44^{abcd}	6.34^{bcde}
60/30 + 0	4.51^{efg}	6.52^{abc}	6.52	7.68^{abcd}	5.04^{bcd}	6.06^{def}
60/30 + 4	5.77^{bcd}	7.05^{ab}	7.47	7.68^{abcd}	4.67^{bcd}	6.53^{bcd}
60/30 + 8	7.40^{a}	6.52^{abc}	6.88	7.34^{bcd}	5.85^{ab}	6.80^{bc}
60/30 + 12	6.78^{ab}	7.80^{a}	7.64	9.58^{a}	6.61^{a}	7.68^{a}
LSD (5%)	1.24	1.86	NS	2.02	1.32	0.72
CV (%)	14.54	16.87	24.00	16.59	17.05	16.45

* BRC: Bako Research Center; means within a column followed by the same letter(s) are not significantly different at the 0.05 level

with the results of this study, various other studies have also shown the importance of organic nutrient sources particularly when integrated with mineral fertilizers in improving crop yields and land productivity under Ethiopian conditions (Asfaw Belay *et al.*, 1997, 1998; Heluf Gebrekidan *et al.*, 1999).

Generally, the wide gaps between the grain yields of maize produced on the control plots and on the treatments supplied with FYM alone or together with NP fertilizers across locations and cropping seasons in this study are expected to attract the attention of the farmers and help them to have a better understanding about the value of FYM in sustaining maize production.

Table 6: Main effects of FYM and NP fertilizer residues applied in 1997 on maize grain yield in 1998.

Main effect	*t maize grain* ha^{-1}			
	Walda	*Shoboka*	*Laga Kalla*	*Mean*
N/P (*kg* ha^{-1})				
0/0	5.82	3.31	4.35	4.49
20/20	6.81	4.48	4.67	5.32
40/25	6.77	5.18	4.95	5.63
60/30	6.86	5.64	4.30	5.60
LSD(.05)	0.78	0.92	NS	0.47
FYM (*t* ha^{-1})				
0	6.45	3.64	3.88	4.66
4	6.36	4.85	4.25	5.15
8	6.41	4.38	4.95	5.25
12	7.04	5.74	5.19	5.99
LSD(.05)	NS	0.92	0.80	0.47
CV (%)	14.27	23.67	21.06	19.05

4 Conclusions

According to the study, the integrated use of various rates of FYM and low rates of NIP fertilizers are better than the application of either NP fertilizers or FYM alone. However, the sole application of FYM at the rates of 4-12 t ha^{-1} is also encouraging for resource poor farmers on relatively fertile soils like Walda and Harato areas. As indicated in its chemical composition, the applied FYM supplied the crop with considerable amounts of different essential macronutrients and small amounts of micronutrients usually deficient in acid soils. However, in this study, the FYM was applied in spots with the maize seed with the intention to feed the crop. Therefore, it is not expected to bring significant change on soil physicochemical properties after crop harvest. As a long-term strategy in the future, locally available sources of organic fertilizers should be used on a continuous basis for replenishing the degraded physicochemical properties of the soils in the region.

Acknowledgements
The authors gratefully acknowledge the CIMMYT/CIDA East Africa Cereals Program (EACP) and the Oromia Agricultural Research Institute for funding this study. The host farmers are highly appreciated for their collaboration and active participation in executing the experiments.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 143–153

Frutos de rambután (*Nephelium lappaceum* L.) no son hospederos de moscas de la fruta: *Anastrepha* spp. y *Ceratitis capitata* (Wied.) – resultados de 10 años en el Soconusco, Chiapas, México

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Resumen
El rambután todavía es un cultivo exótico para los países latinoamericanos. A México fue introducido desde hace 40 años, con gran expectativa para el futuro, sin embargo el área comercial todavía es mínima, debido a un desconocimiento del cultivo, por parte de investigadores y productores, y por falta de promociones profesionales en cuanto al cultivo, manejo de poscosecha y comercialización de este cultivo. Un obstáculo importante fueron las restricciones en cuanto a contar durante décadas este cultivo como planta hospedera para Ceratitis capitata y el complejo de moscas de la fruta Anastrepha spp. En estudios minuciosos y a largo plazo algunos fruticultores trataron a entregar el comprobante científico que el fruto del rambután nunca es infestado por estas plagas. Desde 1993 hasta 2002 fueron realizados estudios de muestreo de frutos y de trampeo en plantaciones frutícolas con rambután. Los resultados demuestran de manera significativa que se puede encontrar moscas mediterráneas y del complejo Anastrepha spp. en las plantaciones sin embargo no se ha reportado ningún caso de un fruto de rambután infestado con larvas de estas moscas. Por esto fue posible lograr en septiembre de 2003 la cancelación de la ley que prohibió la exportación de frutas de rambután a Japón y a las EE.UU.

Palabras Clave: Nephelium lappaceum, no hospedero del fruto de rambután, complejo de moscas de la fruta Anastrepha spp., Ceratitis capitata, Chiapas

1 Introducción

El rambután (*Nephelium lappaceum* L.), originario del archipiélago malasio, es uno de los cultivos exóticos tropicales que han llamado mucho interés por los agricultores de zonas subhúmedas y húmedas de América Latina y del Caribe en los últimos veinte años (Ramírez *et al.*, 2003; Pohlan *et al.*, 1996; Tindall, 1994). En México el cultivo de rambután todavía es muy poco difundido a excepción de Chiapas, donde en

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el Soconusco hoy en día se cultivan más de 200 hectáreas con plantaciones frutícolas comerciales (Pérez Romero y Pohlan, 2004). El rambután fue introducido a México desde hace mas de 40 años, sin embargo la siembra comercial todavía es mínima, la mayoría se encuentra en huertos de traspatio o familiares, debido prácticamente a un desconocimiento del cultivo, por parte de investigadores y productores, y por falta de promociones profesionales en cuanto al cultivo, manejo de poscosecha y comercialización de este cultivo (van der Linden *et al.*, 2004; Pohlan *et al.*, 1997). Las condiciones edafo - climáticas que prevalecen en altitudes entre 150 y 700 m.s.n.m. de los municipios de la región del Soconusco son muy similares a estos de origen asiático de este cultivo. Por esto se considera que una diversificación productiva con rambután de las regiones menos aptas para el cultivo de café, plátano, y mango, que en los últimos años han presentado problemas técnicos y de comercialización, es una promoción muy accesible en cuanto a producir rambután como fruta fresca con un alto potencial de producción y comercialización (Pérez Romero y Pohlan, 1996).

En contra de esta oportunidad funcionaron leyes de cuarentena parcial durante las ultimas dos décadas por parte de USDA y MOSCAMED y la Norma Oficial Mexicana NOM-EM-033-FITO-2000, que los frutos de rambután eran hospederos de moscas de frutas del complejo *Anastrepha* spp. y de la mosca del mediterráneo, Ceratitis capitata (Wied.) y por esto no expedían permisos para la exportación. Estas normas se basaron en trabajos realizados por Nicanor *et al.* (1991), quien cita al rambután como hospedero de la mosca del mediterráneo, pero su reporte se basa en un listado de hospederos publicado por el departamento de Agricultura de los Estados Unidos en 1983, no existiendo evidencia de una infestación natural o artificial. McQuate *et al.* (2000) realizaron en Hawai infestaciones artificiales de huevecillos y larvas noenatas de Ceratitis capitata en frutos de rambután que fueron desarrollados hasta llegar a adultos, sin embargo nunca detectaron infestaciones naturales en campo. Estos autores mencionan que en infestaciones inducidas de frutos de rambután en Hawai de huevecillos y larvas neonatas de mosca del mediterráneo lograron desarrollarse hasta llegar a adultos, sin embargo nunca se detectaron larvas en condiciones de campo. La Fundación hondureña de investigación agrícola (FHIA) condujo mediante 1990, 1991 y 1994 series de experimentos de exposición forzada, donde frutas de rambután fueron evaluadas contra las especies de mosca de la fruta: *C. capitata*, *Anastrepha ludens* Loew y *Anastrepha obliqua* (Macquart). En ninguna de las 13,460 frutas de rambután evaluadas durante los tres años del estudio se pudo constatar la presencia de marcas de oviposición o presencia de larvas en la pulpa (Vasquez *et al.*, 2002). Los resultados demostraron que el rambután no es un huésped susceptible a las especies de moscas de la fruta de Centro América. Tejada (1980), en un estudio sobre hospederas potenciales de Ceratitis capitata, con énfasis en las presentes en el área del Soconusco, Chiapas, México aunque incluye a la familia de las sapindáceas, no hace mención del rambután como un hospedero potencial de esta temible plaga. Vasquez *et al.* (2002) mencionan que durante tres años de estudio Ante esta situación se realizaron investigaciones participativas de Instituciones educativas e iniciativas privadas desde el año 1993, para determinar las interacciones entre diferentes especies de moscas de la fruta, su presencia en áreas frutícolas e infestación de frutos

del rambután con larvas de estas moscas. Los resultados manifestaron exclusivamente que no existe ninguna oviposición y por esto a partir de octubre de 2000 hasta el 2003 se iniciaron las exportaciones a Japón y en septiembre de 2003 entró el reconocimiento de parte de USDA de los EE.UU. que la fruta del rambután no es hospedera de las diferentes especies de moscas de fruta y por esto fue posible iniciar exportaciones a Florida y otros sitios en los EE.UU. (VAN DER LINDEN *et al.*, 2004).

2 Materiales y Métodos

Los primeros muestreos se llevaron a cabo entre 1993 y 1995 en los municipios Cacahoatán y Tuxtla Chico del Soconusco, Chiapas, de acuerdo con las normas del manual de las operaciones de campo del programa MOSCAMED y ENKERLIN (1984). Para esto fueron seleccionados frutos para obtención de semilla, por lo que únicamente se hacia disección del fruto, y estos no se metieron en jaulas de maduración.

La segunda fase de los estudios se ha desarrollado en el año 1996 en los municipios de Cacahoatán y Tuxtla Chico los cuales están ubicados en la región del Soconusco, Chiapas, México. Cacahoatán, tiene las coordenados 14°59' de latitud Norte y 92°10' de longitud Oeste y Tuxtla Chico se localiza entre 14°56' y 14°58' de latitud Norte y 92°46' y 92°52' de longitud Oeste. El clima es Am(w) y Aw2(w) que corresponde a los climas cálido húmedo con lluvias entre mayo y noviembre, con una época seca marcada en el invierno y una corta en el verano, con precipitaciones promedios anuales de 1,334 a 3,269 mm distribuidos principalmente de mayo a noviembre y una temperatura media anual de 25.8 a 28.0°C con muy poca oscilación de las temperaturas medias mensuales. Los cultivos de rambután se encuentran entre 400 a 700 metros en el municipio de Cacahoatán y en Tuxtla Chico entre 100 a 430 metros respectivamente. Suelos del tipo andosoles húmedos son predominantes. En base al inventario de árboles frutales se instaló una red de 60 trampas en huertas de rambután de las cuales treinta eran del tipo Jackson (que es específico para la mosca del mediterráneo) y treinta Mc Phail (para el complejo de las moscas de la fruta Anastrepha), entre los municipios de Tuxtla Chico y Cacahoatán. Estas trampas fueron colocadas exclusivamente en árboles de rambután desde el 29 de junio hasta el 6 de septiembre de 1996, correspondiendo con la época de la cosecha del rambután. Las trampas se inspeccionaron cada siete días. Paralelamente se muestrearon frutos de rambután, los cuales se llevaron al laboratorio en donde se mantenían en jaulas de maduración para su estudio. Todos los días se revisaban las jaulas y se disectaban frutos para determinar si estaban infestados por Ceratitis capitata y/o Anastrepha spp. Se utilizó otra vez la metodología del programa MOSCAMED y para el control integrado de la mosca de la fruta de sanidad vegetal de SAGAR (GUTIÉRREZ *et al.*, 1992). Las moscas capturadas en ambos tipos de trampas se llevaron preservadas en alcohol al 70 % a los laboratorios de MOSCAMED para su identificación taxonómica y de esterilidad o fertilidad.

Un estudio complementario fue realizado entre agosto y octubre de 2002 en plantaciones comerciales del Soconusco en Metapa (Rancho El Herradero), Huehuetán Estación (Rancho La Chinita), y en huertos con rambután en Tuxtla Chico y Cacahoatán. El estudio tenia como objetivo principal la determinación de la calidad externa e interna de los

frutos de rambután, en base de 140 muestras con 10 frutos cada una, incluyendo la inspección de la presencia y de daños causados por Ceratitis capitata y moscas del género *Anastrepha* (VAN DER LINDEN *et al.*, 2004).

3 Resultados

Las investigaciones durante el período de 1993 y 2004 indican que se debe aceptar la diferencia entre la presencia de las moscas de la fruta en un huerto y/o plantación frutícola y su ataque a los frutos de rambután. En los muestreos en los años 1993 a 1995 no se encontró ninguna larva de la mosca del mediterráneo, ni del grupo *Anastrepha* en los frutos de rambután (cuadro 1). Para poder verificar entre la presencia y probables oviposiciones por Ceratitis capitata y moscas del género *Anastrepha* los experimentos fueron amplificados en el sentido de exponer trampas por dentro de huertos con rambután y analizar durante la misma época frutas de diferentes especies frutales.

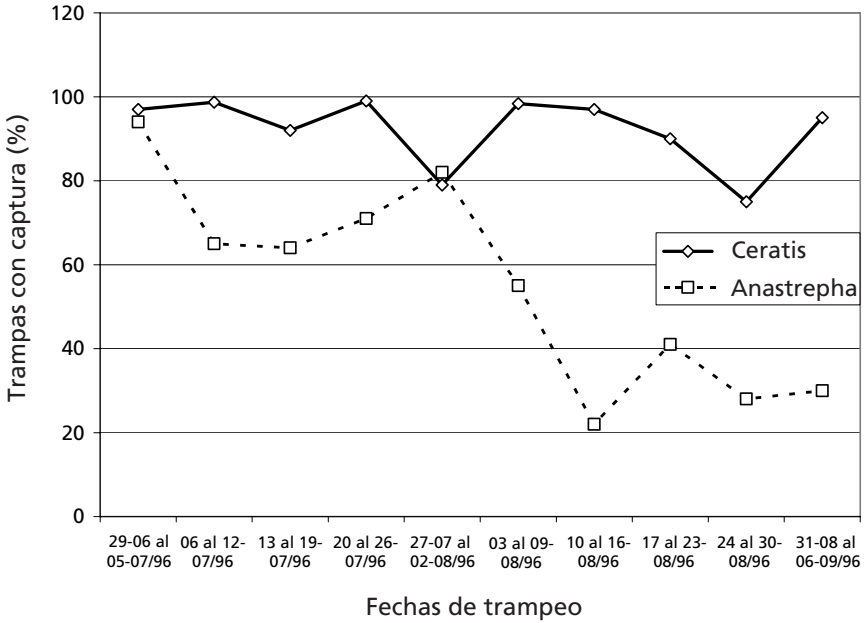
Cuadro 1: Resultados de muestreos de frutos de rambután realizados entre los años 1993 y 1996 (Municipio Cacahoatán y Tuxtla Chico) y 2002

Año	*Volumen de frutos (kg)*	*Numero de larvas encontradas*
1993	45	0
1994	202	0
1995	377	0
1996	1542	0
2002	145	0
Metapa:	50	0
Rancho El Herradero		
Huehuetán Estación:	65	0
Rancho La Chinita		
Tuxtla Chico	15	0
Cacahoatán	15	0

Los resultados del año 1996 demuestran una alta frecuencia en la captura de *C. capitata*, la cual se encontró en un 75 a 98.7 % de las trampas instaladas (tipo Jackson) que fueron inspeccionados con una exposición de cada 7 días. Las moscas del género Anastrepha fueron detectado en 28 a 94 % de las trampas Mc Phail (figura 1). Cabe mencionar que el tipo de trampa Mc Phail no funciona específicamente como la trampa Jackson, que únicamente captura moscas del mediterráneo. Al contrario a esta en trampas Mc Phail ya en la primera fecha fueron capturados cualquier especie de mosca de la fruta o insectos, que son atraídos por la proteína hidrolizada que se utiliza como cebo alimenticio.

En trampas Jackson fueron capturados entre 0.5 y 7.8 moscas del mediterráneo estéril por trampa y día (MTD), (cuadro 2). Esto es debido a la liberación masiva de moscas

Figura 1: Porcentaje de trampas con captura de moscas, *Ceratitis* (Jackson) y *Anastrepha* (Mc Phail), en huertos de rambután en la región del Soconusco, Chiapas.



que tenía el programa de MOSCAMED en estos municipios que frecuentemente son infestados por moscas del mediterráneo procedentes de Guatemala. Las trampas Mc Phail capturaron un total de 715 moscas del mediterráneo, que todas fueron estériles. Además se encontraron en las mismas trampas 290 moscas del género Anastrepha de las cuales 131 pertenecen a Anastrepha obliqua, 92 a A. ludens, 22 a A. striata, 32 a A. serpentina y 13 a A. fraterculus. El número de moscas/trampa/día (MTD) osciló entre 0.08 y 1.2 (cuadro 3).

Para determinar la ausencia o presencia de la mosca del mediterráneo y de moscas del género *Anastrepha* en frutos del rambután, se realizó entre el 15 de julio al 7 de septiembre de 1996 un muestreo intensivo de frutos con un total de 1541.8 kilogramos, representando 435 muestras de 365 lugares diferentes. De estos el 91.3 % se disectó en el laboratorio y el 8.7 % se metió en jaulas de maduración para su estudio. No fueron encontrado ninguna larva de *C. capitata* ni del género de moscas de la fruta (*Anastrepha* spp.), sino únicamente 116 larvas de la familia Drosophilidae, Dermastidae y Otitidae, que ovipositaron en el interior de las jaulas con fruto (cuadro 4).

Los resultados del año 2002 manifiestan la resistencia de los frutos del rambután en contra de ataques de cualquier especie de las moscas de fruta. Otra vez más no fue encontrado en las 140 muestras de los cinco sitios diferentes ningún fruto infestado (van der Linden *et al.*, 2004).

Cuadro 2: Mosca del mediterráneo capturada por 30 trampas Jackson en huertas de rambután en la época de fructificación en 1996.

Período	*estériles*		*fértiles*		*MTD*
	machos	*hembras*	*machos*	*hembras*	
29-06 al 05-07/96	299	16	0	0	1.50
06 al 12-07-96	1550	82	0	0	7.80
13 al 19-07-96	397	21	0	0	2.00
20 al 26-07-96	318	17	0	0	1.60
27-07 al 02-08/96	330	17	0	0	1.50
03 al 9-08-96	603	32	0	0	3.02
10 al 16-08-96	675	36	0	0	3.40
17 al 23-08-96	98	5	0	0	0.50
24 al 30-08-96	118	6	0	0	0.60
31-08 al 06-09-96	237	13	0	0	1.20
Total	4605	245	0	0	-

Cuadro 3: *Ceratitis capitata* y *Anastrepha* spp. capturadas por 30 trampas Mc Phail en huertas de rambután en la época de fructificación en 1996.

	Moscas capturadas							
	estériles	*fértiles*						
Período	*C. capitata*	*A. obliqua*	*A. ludens*	*A. striata*	*A. serpentina*	*A. fraterculus*	*total de moscas*	*MTD*
29-06 al 05-07/96	194	31	19	2	2	1	249	1.20
06 al 12-07-96	77	20	12	5	6	2	122	0.60
13 al 19-07-96	36	31	13	3	9	0	92	0.40
20 al 26-07-96	84	9	9	3	4	1	110	0.50
27-07 al 02-08/96	179	26	14	1	3	4	227	1.10
03 al 9-08-96	94	9	4	4	6	5	122	0.60
10 al 16-08-96	14	4	3	3	0	0	24	0.10
17 al 23-08-96	6	1	14	1	0	0	22	0.10
24 al 30-08-96	15	0	2	0	0	0	17	0.08
31-08 al 06-09-96	16	0	2	0	1	0	19	0.09
Total	715	131	92	22	32	13	1004	-

Cuadro 4: Resultados del muestreo realizado en 1996 en frutos de rambután en los municipios de Cacahoatán y Tuxtla Chico, Chiapas.

Período cosecha 1996	*Numero de muestras*	*Numero lugares visitados*	*Volumen total de frutos (kg)*	*Destino de la muestra (kg)*		*Larvas extraídas*	
				Laboratorio	*Jaula*	*Moscas*	*DDO**
15.7.-20.7.	6	2	63,0	40,0	23	0	25
22.7. 27.7.	81	81	156,1	147,1	9	0	0
29.7.-3.8.	96	71	308,0	293,0	15	0	35
5.8.-10.8.	66	53	273,1	264,1	9	0	0
12.8.-17.8.	42	42	209,2	196,2	13	0	6
19.8.-24.8.	36	26	213,2	193,2	20	0	44
26.8.-31.8.	73	61	228,2	203,2	25	0	6
2.9.-7.9.	35	29	91,0	88,0	3	0	0
Total	435	365	1541,8	1424,8	117	0	116

* larvas de la familia Drosophilidae, Dermastidae y Otitidae

4 Discusión

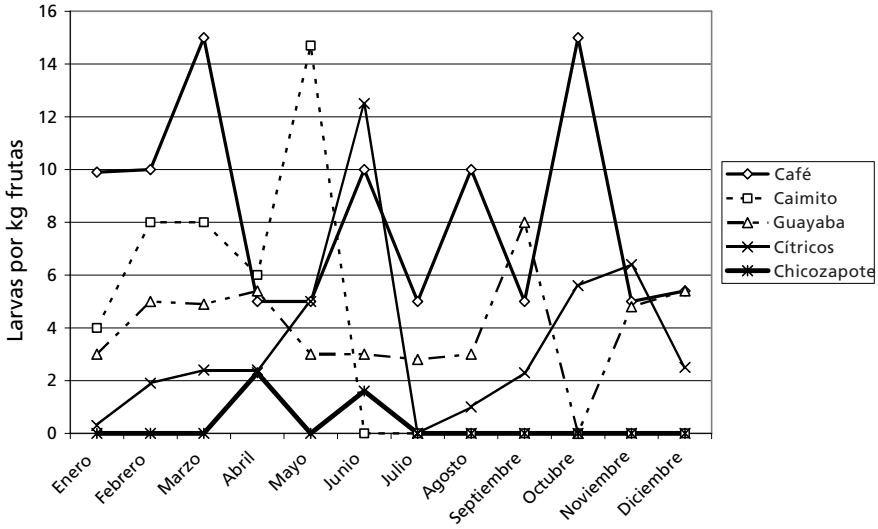
La mosca del mediterráneo (*C. capitata*) y el complejo del género *Anastrepha* representada por cuatro especies: *Anastrepha ludens* (Loew), mosca mexicana de la fruta; *Anastrepha obliqua* (Macquart), mosca de la ciruela; *Anastrepha serpentina* (Wiedemann), mosca de los zapotes; y *Anastrepha striata* (Schiner) mosca de la guayaba, fueron detectadas en estado adulto, en los árboles de rambután durante el periodo de fructificación. Sin embargo la no presencia o infestación de estas moscas en su estado larvario por dentro del fruto de rambután, confirma que el rambután no es hospedero de la mosca del mediterráneo ni de especies del complejo de moscas de la fruta del genero Anastrepha spp. Para reafirmar esta observación se analizó una cantidad grande de frutos de los principales especies frutales hospederos de *C. capitata* y del género *Anastrepha* (cuadro 5). En todas las especies frutales que se evaluaron se registraron infestaciones de una o mas larvas de especies del complejo de la mosca de la fruta a excepción del rambután, a pesar de que en estos árboles se tenia la presencia del adulto de estas moscas, que se encontraban muchas veces en los mismos lugares en donde existían otros frutales fuertemente infestados en estado larvario, en los mismos o diferentes períodos de fructificación. Es notable mencionar que en estudios de MOSCAMED (1996) la fruta de café fue la más apreciable como fruta hospedera para las diferentes moscas de fruta, en cada kilogramo de café en uva se encontró depende de la época del año entre 5 y 15 larvas (figura 2). En los meses de cosecha para el caimito esta cifra osciló entre 4 y 14,7 larvas / kg, en guayaba entre 2,8 y 5,4 larvas / kg y en cítricos entre 0,3 y 12,5 larvas / kg de frutas.

Es importante recordar que aun cuando el rambután compartía el mismo período de fructificación con otros frutales del mismo lugar, se podía argumentar que el otro fruto

Cuadro 5: Volumen de fruta muestreada (kg) y numero de larvas (L) de *C. capitata* y del género *Anastrepha* (Cacahoatán y Tuxtla Chico, según MOSCAMED (1996)).

Mes		Volumen de frutas (kg)/ numero de larvas								
		Café *Coffea arabica*	*Caimito* *Chrysophyllum cainito*	*Guayaba* *Psidium guajava*	*Pomelo* *Citrus grandis*	*Naranja dulce* *Citrus sinensis*	*Naranja agria* *Citrus aurantium*	*Mandarina* *Citrus reticulata*	*Chicozapote* *Manilkara zapota*	*Rambután* *Nephelium lappaceum*
Enero	Frutas	39,9	12,5	55,0	18,5	15,5	20,5	15,5	0	0
	Larvas	394	50	165	25	127	34	39	0	0
Febrero	Frutas	23,7	407,5	9,0	0	0	9,0	6,0	0	0
	Larvas	237	3260	45	0	0	13	15	0	0
Marzo	Frutas	16,1	468,7	7,0	0	0	7,0	3,0	0	0
	Larvas	241	3749	34	0	0	17	7	0	0
Abril	Frutas	33,1	400,0	7,0	0	0	0	2,5	3,0	0
	Larvas	165	2400	38	0	0	0	6	7	0
Mayo	Frutas	110,0	1,5	480,5	0	8,0	8,0	8,0	0	0
	Larvas	550	22	1440	0	73	21	25	0	0
Junio	Frutas	99,0	0	314,3	0	1,0	1,0	0	5,0	0
	Larvas	990	0	942	0	8	17	0	8	0
Julio	Frutas	76,5	0	118,6	0	0	0	0	0	0
	Larvas	382	0	332	0	0	0	0	0	0
Agosto	Frutas	42,0	0	62,5	2,5	11,7	0	1,0	0	0
	Larvas	420	0	187	4	7	0	4	0	0
Septiembre	Frutas	7,8	0	4,0	45,0	77,3	43,0	35,5	1,0	0
	Larvas	39	0	32	65	26	67	78	3	0
Octubre	Frutas	6,8	0	0	86,5	97,5	103,5	8,0	0	0
	Larvas	102	0	0	210	900	515	19	0	0
Noviembre	Frutas	14,0	0	10,0	81,5	123,5	127,5	28,0	0	0
	Larvas	70	0	48	78	2122	47	72	0	0
Diciembre	Frutas	5,0	0	8,0	31,0	44,5	94,0	33,0	0	0
	Larvas	27	0	43	77	1	178	7	0	0
Total	Frutas	473,5	1290,2	1075,9	265,0	379,0	413,5	140,5	9,0	0
	Larvas	3617	9481	3306	559	3264	509	352	18	0

Figura 2: Larvas de moscas (numero por kg) en diferentes especies de frutas hospederas (según MOSCAMED (1996)).



atraía preferentemente a las moscas de la fruta en comparación con el rambután, sin embargo se debería presentar aunque en menor grado cierta infestación lo cual queda de manifiesto ya que no se encontró larva alguna en los frutos de rambután, ya que la mayoría de los cítricos no están en fructificación, el mango y el caimito están apenas terminando sus cosechas cuando el rambután está iniciando su fructificación. En esta época la población de moscas de la fruta en estado adulto ha proliferado notablemente en busca de hospederos alternantes para su reproducción, por ausencia de los primarios y cuando el rambután esta en producción y sin embargo, las moscas no lo infestan, si acaso llegan a los árboles de rambután, en busca de sombra y refugio, y por esto fueron capturados en las trampas.

La causa de este fenómeno de no atacar los frutos del rambután son las zetas de la fruta del rambután que tienen de 1.5 a 3.3 centímetros de longitud en todo el pericarpio del fruto, tienen como finalidad proteger a la fruta de diversas plagas que pudieran atacar al fruto, entre las que se incluyen las moscas del mediterráneo y del complejo del género *Anastrepha* en la que su ovipósitor es más corto que las zetas del pericarpio del fruto. Además apoya la interacción clima y fenología en tal manera que la fructificación del rambután se lleva a cabo en el período de lluvias abundantes las cuales son el principal enemigo de estas plagas.

Es importante referirse que la mosca del mediterráneo no se ha reportado al rambután como hospedero de moscas del mediterráneo, debido que el ovipósitor de esta mosca es mucho mas corto en relación a otras moscas de la fruta y al tamaño de las zetas del pericarpio del fruto de rambután.

Adicionalmente hay que mencionar que durante los últimos 12 años, en los viveros del Rancho San Alberto, El Herradero y La Chinita, los frutos para obtención de semilla siempre fueron observado en cuanto a la presencia de larvas de la mosca de mediterráneo y de moscas del género *Anastrepha*, y en ningún caso fue encontrado un fruto infestado con larvas de estas moscas.

5 Conclusiones

Los estudios han demostrado categóricamente que el fruto de rambután no es hospedero de la moscas del mediterráneo (*C. ceratitis*) ni de especies del complejo de moscas de la fruta del género *Anastrepha*. Muy importante en este sentido es el ejemplo que actividades del sector privado en la investigación participativa son valiosas en cuanto a lograr defender sus derechos y principios delante de restricciones e interpretaciones equivocados por falta de datos comprobados y confiables. Los datos obtenidos en los estudios durante 10 años obligaron a cambiar las leyes sobre la sanidad del cultivo y facilitar sin restricciones la exportación de frutos de rambután también a Japón a partir del 2000 y los Estados Unidos de América a partir del 2003.

Rambutan fruits (*Nephelium lappaceum* L.) are not attacked by fruit flies, neither by *Anastrepha* spp. nor by *Ceratitis capitata* – results of 10 years in the Soconusco, Chiapas, Mexico

Abstract
The rambutan was introduced to Mexico 40 years ago with great perspectives for the future, but still is an exotic fruit due to a shortage of practical experience and of theoretical knowledge by both farmers and scientists, and due to inefficient marketing strategies. The most important obstacle was the prohibition of rambutan fruit export caused by the assumption of rambutan plant hosting the Mediterranean fruit fly and the fruit flies of the *Anastrepha* species. A small group of farmers and scientists developed defense arguments against this wrong restriction during the last 10 years investigation in the rambutan areas of the Soconusco, in three different rambutan nurseries and under laboratory conditions. The results demonstrated that it is possible to capture the Mediterranean fruit fly and the fruit flies of the *Anastrepha* species in the rambutan fruit area, but these fruit flies however never attacked the rambutan fruits. This proven observation resulted in the cancellation of export prohibition for rambutan fruits to Japan and United States as from September 2003.

Keywords: *Nephelium lappaceum*, no host of fruit flies, fruit fly complex *Anastrepha* spp., Mediterranean fruit fly, *Ceratitis capitata*, Chiapas

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 155–165

Influence of Topping, Side Branch Pruning and Hill Spacing on Growth and Development of Cotton (*Gossypium barbadense* L.) in the Southern Guinea Savanna Location of Nigeria

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Abstract

Two field experiments were carried out at the Teaching and Research Farm, University of Agriculture, Makurdi, Nigeria, during 2000 and 2001 seasons on Pima S2 cotton cultivar, to study the effects of hill spacing of 30, 35 and 40cm (plant population) and plant growth alteration treatments i.e. topping, side branch pruning at 120cm height, topping + pruning at 100cm height, topping + pruning at 120cm height on some vegetative and fruiting habits, earliness and seed cotton yield and its components.

Generally the combined data clarified that wider hill spacing increased number of monopodia, main stem internodes, sympodia, additional fruiting branch bolls, retended bolls, fruiting sites, percentage of bolls on vegetative branches, open bolls, boll weight and seed cotton yield. While it decreased final plant height, number of aborted sites, days to first open boll, earliness percentage and number of unopen bolls. However, plant alteration treatments had a positive effect on most studied traits and reversely depressed number of monopodia, aborted sites and earliness percentage compared with the control. Within plant alteration treatments, there were significant divergences. The results indicated that topping plants at 120cm height increased number of retended bolls, fruiting sites, days to first open boll, open boll, unopen bolls and seed cotton yield. Side branch pruning at 120cm height increased final plant height, monopodia, main stem internodes, sympodia, earliness percentage and boll weight. Topping + pruning at 100cm height only decreased number of aborted sites. Topping + pruning at 120cm height increased additional fruiting branch bolls, percentage of bolls on vegetative branches, boll weight and seed cotton yield. Topping at 120cm height and 40cm hill spacing resulted in the highest number of retended bolls and seed cotton yield.

Keywords: cotton, Gossypium barbadense, hill spacing, topping, side branch pruning, Nigeria

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1 Introduction

Lodging in cotton plant is known to vary according to nature of varietal growth, nutritional and environmental conditions. In this respect, removing the terminal main stem bud (topping) and side pruning of branches are considered as important adjustment for plant geometry of cotton plants grown on fertile soils of high nitrogen rates whether under dense or low plant population to eliminate lodging. Hosny *et al.* (1995) reported that lint yield increased due to topping of cotton plants. Naguib *et al.* (1987) found that topping of Pima cotton at 15 days intervals (starting from mid July) decreased plant height and number of main stem nodes, increased boll set on top sympodia and caused additional branch nodes and bolls on top of fruiting branches. However, topping did not affect boll weight, lint yield and days to boll maturity, and was less effective when applied later in the season. El-Ganayni *et al.* (1984) found that topping at 15 days intervals later in the season produced the highest seed cotton yield while boll weight was not affected by topping. Roy *et al.* (1989) topped cotton plants after 45, 60 and 75 days from emergence at different plant populations. Their results indicated that one plant per hill at spacing of 60 x 30cm produced the highest seed cotton yield whereas the topping at 60 days produced the highest yield. The interaction effect showed that two plants per hill spaced 60 x 20cm and topped at 45 days gave the highest seed cotton yield whereas the lowest one was 89obtained by two plants per hill at spacing of 63 x 20cm and topped at 75 days after emergence.

Considerable data have been collected on the effects of fruit structure removal on growth and yield of cotton. Kennedy *et al.* (1991) indicated that prolonged removal of fruiting structures (i.e. flower buds or young bolls) increased plant size, plant height, number of sympodial branches and fruit set. Ahmed and Abdel-Al (1990) deflowered cotton plants cv. Giza 81 (leaving one flower every 2, 3, 4, 5 or 7 days) which showed positive response for plant height, number of inter-nodes and boll weight but negative response with number of open bolls and seed cotton yield per plant. The basal 3, 5 or 7 fruiting branches of cotton plants were removed at square stage by Gu Benkang *et al.* (1990) and forty days after treatment they found that the number of sympodia per plant gradually decreased in the three treatments compared with the control. However, seed cotton yield was increased particularly when 3 fruiting branches were removed. Also, the number of fruiting nodes was not affected, while the squares and young bolls shedding were decreased and boll number per plant was increased by the treatments. Kennedy *et al.* (1991) observed that removal of early squares delayed the initiation of fruiting and crop maturity whereas fruiting occurred more rapidly with prolonged fruiting period in the growing season. Thus, the effect of square removal on seed cotton yield was variable from year to year. Pettigrew (1994) applied partial fruit pruning and found 16% greater boll mass than the control. The objective of this study was to characterize the growth and development of the plants of cotton cultivar Pima - S2 topped and pruned at different plant populations; plant height and under higher nitrogen level of 200kg ha^{-1} at Makurdi, Nigeria.

2 Materials and Methods

2.1 Experimental Design and Treatments

Two field experiments were conducted on Pima-S2 cotton cultivar (*Gossypium barbadense* L.) in 2000 and 2001 seasons at the Teaching and Research farm of the University of Agriculture, Makurdi, located at Lat. 7.41°N and long. 8.37°E and 97m above mean sea level. The location falls within the southern guinea savanna agroecological zone of Nigeria. The experiment was set up in split plot design with four replications. The main plots were assigned to plant population in the term of hill spacing, i.e. 30, 35 and 40cm, while the subplots were occupied with plant alteration treatments as: topping at 120cm height, side branch pruning when plants reached 120cm height; topping + side branch pruning when plants reached 100cm height, and topping + side branch pruning when plants reached 120cm height besides the control (normal plants). Topping as well as side branch pruning were made by hand cutting of the terminal bud of main stem and monopodia or squares of sympodia along the plant up to the determined height, respectively. The plot size was 38.25m^2, including 5 ridges 65cm apart and 5m long.

2.2 Cultural Practices

Four cotton seeds were sown per hill on 25th May 2000 and 1st June 2001. Calcium ammonium nitrate at 200kg N ha^{-1} was applied split at 3 and 8 weeks after sowing. Boronated superphosphate at 140kg $\mathrm{P_2O_5}$ ha^{-1} was added during land preparation without K fertilizer in order to create imbalanced fertilization which may induce more vegetative growth. Thinning to two seedlings per stand was done three weeks after sowing. The cotton plots were weeded manually twice before the second fertilizer application and at 50% of split boll. The plants were sprayed forthnightly with carbaryl (1-naphthyl methylcarbamate) insecticide at the rate of 1.1kg chemical per 225 litres of water per hectare starting from 9 weeks after sowing to minimize insect damage by bollworms, boll weevils, leaf rollers, stainers, grasshoppers and aphids.

2.3 Measurements

Ten guarded plants from the three inner ridges of each plot were randomly chosen at the end of the season to determine the following criteria:

(1) **Vegetative growth habits:** final plant height (cm); number of monopodia and number of main stem internodes per plant.

(2) **Fruiting growth habits:** number of sympodia, additional fruiting branch bolls, number of aborted sites, number of retended bolls (additional fruiting branches: bolls + opened + unopened bolls) and number of fruiting sites (aborted sites + bolls retended).

(3) **Earliness measurements:** days to first open boll; percentage of bolls on vegetative branches (number of bolls produced on fruiting branches arising from vegetative side branches, expressed as a percentage of total number of bolls produced) and earliness percentage $= \frac{\text{firstpicking}}{\text{first+secondpicking}\times 100}$

(4) **Seed yield and its components:** number of open bolls, number of unopen bolls; boll weight and seed cotton yield (t ha^{-1}).

The interaction effects between plant population and plant alteration treatments on the above mentioned traits were also studied.

2.4 Statistical analysis

All data collected were analysed statistically using the analysis of variance procedure described by STEEL and TORRIE (1980). The mean values were compared at the 5% level of significance (SNEDECOR and COCHRAN, 1967).

3 Results and Discussion

3.1 Influence of Plant Population (hill spacing)

Data presented in Tables 1 - 4 exhibited pronounced effect of plant population (hill spacing) on both vegetative and fruiting habits; earliness measurements and seed cotton yield and its components for the combined data. Final plant characteristics indicated that wide hill spacing significantly increased final plant height, number of monopodia, main stem internodes, sympodia additional fruiting branch bolls, retended bolls, fruiting sites, percentage of bolls on vegetative branches, number of open bolls, boll weight and seed cotton yield (t ha^{-1}). On the other hand, narrow hill spacing markedly increased number of aborted sites, days to first open boll, earliness percentage and number of unopen bolls. These results could be ascribed to the basis that dense stands (narrow hill spacing) increase between-plant and within-plant competition resulting to more susceptible plants with more demand for sunlight, water and nutrients. So, the end result of this competition is taller plants with more boll infestation and more shedding of reproductive forms and this is accompanied by the lack of boll formation and opening, predisposing it to delay in maturation and finally yield reduction. These results are in agreement to those obtained by GUTHRIE and MCCARTY (1993) and MAKRAM *et al.* (1994) for plant height, number of main stem internodes: NIKOLOV (1980) for number of monopodia; ABDEL-MALIK *et al.* (1995) for number of sympodia, number of bolls retended, aborted sites, fruiting sites, percentage of bolls on vegetative branches and earliness percentage and RISHA (1993) for number of open and unopen bolls, boll weight and seed cotton yield.

3.2 Influence of Plant Growth Alteration Treatment (Topping) and Side Branch Pruning

3.2.1 Vegetative growth habits

The combined data presented in Table 1 showed that topping and side branch pruning had a highly significant effect on this group of characters. It is obvious that topping cotton plants at a certain height i.e. 100cm or 120cm ceased plant height up to this limit of growth. On the other hand, side branch pruning only enhanced cotton plants for growth continuity resulting in tallest plants with highest main stem node number followed descendingly by the control and both topping + side branch pruning at 120cm respectively. Number of monopodia was depressed as topping, side branch pruning or

Table 1: Effect of hill spacing and plant growth alteration treatments and their interaction on vegetative growth habits of Pima S2 cotton cultivar (combined data of 2000 and 2001 seasons).

Vegetative growth habits	*Season*	*Plant Density (D) (hill spacing)*			*Plant growth alteration (A)*					D × A *interact.*
		30cm	*35cm*	*40cm*	*Control*	*T* 120cm*	*SBP† 120cm*	*T+SBP 100cm*	*T+SBP 120cm*	
Final plant height (cm)	2000	127.21	127.01	125.88b	141.57b	120.00c	148.90a	100.00d	120.00c	*
	2001	128.08	127.28	126.48b	143.01b	120.00c	150.34a	100.00d	120.00c	**
	comb.	127.65	127.15	126.18b	142.29b	120.00c	149.62a	100.00d	120.00c	**
Number of monopodia	2000	0.31c	0.46b	1.04a	0.91a	0.55c	0.68b	0.41e	0.48d	**
	2001	0.37c	0.60b	1.37a	1.09a	0.73c	0.84b	0.57d	0.68c	**
	comb.	0.34c	0.53b	1.21a	1.00a	0.64c	0.76b	0.49d	0.58c	**
Number of main stem internodes	2000	24.54b	24.54b	25.94a	27.57b	23.57c	29.34a	21.01d	23.57c	NS
	2001	25.41b	25.34b	27.01a	28.79b	24.12c	30.90a	21.45d	24.34c	NS
	comb.	24.98b	24.94b	26.48a	28.18b	23.85c	30.12a	21.23d	23.96c	NS

* T 120cm: topping at 120cm height
† SBP 120cm: side branch pruning at 120cm height
**,* and NS indicate $P < 0.01, 0.05$ and not significant, respectively.
Means followed by the same letter are not significantly different at 0.05 level according to L.S.D. test.

both were applied compared with the control. Irrespective to the control, side branch pruning at 120cm had the highest monopodia while topping + side branch pruning at 100cm gained the lowest one leaving topping at 120cm height in between values. These results could be ascribed to the basis that topping cotton plants usually ultimates plant height at a specific or a required height bases on determining vertical growth as apical dominance is intercepted while fruiting capacity is enhanced, modifying plant geometry into cone shape. As side branch pruning was applied, plant geometry was also modified but into arrow-like shape, whereas the unpruned top sympodial branches (above 120cm height) grew vertically and horizontally up to the end of season. Similar results were obtained by Ahmed and Abdel-Al (1990) for plant height and main stem nodes and Kennedy *et al.* (1991) for plant size and plant height.

3.2.2 Fruiting growth habits

Results presented in Table 2 revealed that cotton plants pruned to plant growth alteration treatments significantly exceeded those of control plants concerning this group of traits except for number of aborted sites whereas the superiority was assigned to the check plants. Cotton plants exposed to side branch pruning significantly surpassed those of both topping + side branch pruning at 120cm and topping at 120cm and topping + side branch pruning at 100cm height in descending order. Concerning additional fruiting branch bolls which arise besides the principal or on the bottom of sympodial branches, were significantly higher on plants pruned to topping + side branch pruning at 120cm followed descendingly by those exposed to topping + side branch pruning at 100cm and topping at 120cm height. Cotton plants topped and pruned at 100cm height had the

Table 2: Effect of hill spacing and plant growth alteration treatments and their interaction on fruiting growth habits of Pima S2 cotton cultivar (combined data of 2000 and 2001 seasons).

Fruiting growth habits	*Season*	*Plant Density (D) (hill spacing)*			*Plant growth alteration (A)*					D × A *interact.*
		30cm	*35cm*	*40cm*	*Control*	*T* 120cm*	*SBP† 120cm*	*T+SBP 100cm*	*T+SBP 120cm*	
Number of sympodia	2000	15.68c	17.74b	19.94a	20.23b	16.12c	22.34a	13.79d	16.45c	NS
	2001	16.41c	18.34b	20.94a	21.45b	16.79c	23.57a	14.12d	16.90c	NS
	comb.	16.05c	18.04b	20.44a	20.84b	16.46c	22.96a	13.96d	16.68c	NS
Additional branch nodes	2000	3.10c	4.14b	5.58a	2.74e	3.69d	4.61c	4.93b	5.40a	NS
	2001	3.28c	4.29b	5.79a	2.93e	3.84d	4.80c	5.09b	5.60a	NS
	comb.	3.19c	4.22b	5.69a	2.84e	3.77d	4.71c	5.01b	5.50a	NS
Number of fruiting sites	2000	47.15c	51.32b	59.95a	52.47b	56.70a	52.34b	49.30c	53.22b	NS
	2001	48.04c	51.99b	60.07a	52.98b	57.52a	52.95b	49.90c	53.48b	NS
	comb.	47.60c	51.66b	60.01a	52.73b	57.11a	52.65b	49.60c	53.45b	NS
Number of aborted sites	2000	12.74a	12.47ab	12.31b	21.51a	10.93b	10.51b	8.98c	10.61b	NS
	2001	13.28a	12.68b	12.88c	21.34a	11.23b	10.68b	9.12c	10.68b	NS
	comb.	13.01a	12.58ab	12.60b	21.43a	11.08b	10.60b	9.05c	10.65b	NS
Number of retended bolls	2000	33.32c	36.73b	44.08a	30.23d	44.10a	39.24b	37.41c	39.23	**
	2001	33.70c	37.04b	44.42a	30.72d	44.47a	39.50b	37.71c	39.55	**
	comb.	33.51c	36.89b	44.25a	30.48d	44.29a	39.37b	37.56c	39.39	**

* T 120cm: topping at 120cm height
† SBP 120cm: side branch pruning at 120cm height
**,* and NS indicate $P < 0.01, 0.05$ and not significant, respectively.
Means followed by the same letter are not significantly different at 0.05 level according to L.S.D. test.

highest aborted sites followed descendingly by topping at 120cm, side branch pruning at 120cm and topping + side branch pruning at 120cm.

Regarding number of retended bolls and fruiting sites, the superiority was valued for plants pruned to topping at 120cm followed by both side branch pruning at 120cm and topping + side branch pruning at 120cm and topping + side branch pruning at 100cm in descending order. From the above mentioned results, one of the most interesting observations was that the removal of the apical bud resulted in a large accumulation of assimilates in the root system, which suggests that there is an increase in the flow of nutrients to the sinks and consequently more assimilates towards the old fruits or for initiating new and additional fruits (El-Debaby *et al.*, 1995). Also, a combination of topping and pruning or pruning alone was probably involved including: better light penetration into plant canopy, increased air circulation among plants resulting in an improved CO_2 supply for photosynthesis (Waggoner and Moss, 1963), lower humidity, and a reduction in the amount of boll infestation on early set fruit (Bennett *et al.*, 1965). Such results were obtained by Kittock and Fry (1977) for boll set and additional branch bolls, by Kennedy *et al.* (1991) for number of sympodia and fruit set and Gu Benkang *et al.* (1990) for aborted sites and fruiting sites.

Table 3: Effect of hill spacing and plant growth alteration treatments and their interaction on earliness traits of Pima S2 cotton cultivar (combined data of 2000 and 2001 seasons).

Earliness traits	*Season*	*Plant Density (D) (hill spacing)*			*Plant growth alteration (A)*					D × A *interact.*
		30cm	*35cm*	*40cm*	*Control*	*T* 120cm*	*SBP† 120cm*	*T+SBP 100cm*	*T+SBP 120cm*	
Days to first open boll	2000	124.4a	123.5b	123.1b	126.4a	123.5b	123.0c	122.3d	123.0c	NS
	2001	124.6a	123.8b	123.4b	126.7b	123.7b	123.3c	122.6a	123.3c	NS
	comb.	124.5a	123.7b	123.3b	123.6b	123.6b	123.2c	122.5d	123.2c	NS
Percentage of bolls on vegetative branches	2000	6.52c	7.72b	17.19a	7.40d	11.67b	9.69c	11.67b	12.32a	**
	2001	6.86c	8.00b	17.98a	7.82d	12.16b	9.99c	11.94b	12.68a	**
	comb.	6.69c	7.86b	17.59a	7.61d	11.92b	9.84c	11.81b	12.50a	**
Earliness percentage	2000	70.95a	69.26b	60.92b	73.21a	64.96c	67.36b	66.53b	63.52d	**
	2001	69.13a	68.03a	59.98b	70.97a	64.38c	66.39b	64.88c	62.32d	**
	comb.	70.04a	68.65a	60.45b	72.09a	64.67c	66.88b	65.71c	62.92e	**

* T 120cm: topping at 120cm height
† SBP 120cm: side branch pruning at 120cm height
**,* and NS indicate $P < 0.01, 0.05$ and not significant, respectively.
Means followed by the same letter are not significantly different at 0.05 level according to L.S.D. test.

Table 4: Effect of hill spacing and plant growth alteration treatments and their interaction on seed cotton yield and yield components of Pima S2 cotton cultivar (combined data of 2000 and 2001 seasons).

Fruiting growth habits	*Season*	*Plant Density (D) (hill spacing)*			*Plant growth alteration (A)*					D × A *interact.*
		30cm	*35cm*	*40cm*	*Control*	*T* 120cm*	*SBP† 120cm*	*T+SBP 100cm*	*T+SBP 120cm*	
Number of open bolls	2000	17.62c	22.55b	30.99a	20.79d	26.92a	23.99c	21.40d	25.49b	**
	2001	18.15c	23.06b	31.55a	21.41d	27.43a	24.49c	21.80d	26.01b	**
	comb.	17.89c	22.81b	31.27a	21.10d	27.18a	24.24c	21.60d	25.75b	**
Number of unopen bolls	2000	16.95a	15.37b	14.28b	10.72d	18.37a	16.44b	17.20b	14.93c	**
	2001	16.75a	15.17b	14.13c	10.61d	18.22a	16.20b	16.99b	14.73c	*
	comb.	16.85a	15.27b	14.21b	10.67d	18.30a	16.32b	17.10b	14.83c	*
Boll weight (g)	2000	3.31b	3.47a	3.41a	3.30b	3.31b	3.47a	3.44a	3.46a	**
	2001	3.38b	3.54a	3.50a	3.38b	3.40b	3.53a	3.52a	3.53a	*
	comb.	3.35b	3.51a	3.46a	3.34b	3.36b	3.50a	3.48a	3.50a	*
Seed cotton yield ($t\ ha^{-1}$)	2000	1.279c	1.413b	1.651a	1.220d	1.581ab	1.500b	1.341c	1.595a	**
	2001	1.353c	1.479b	1.734a	1.289d	1.664a	1.572b	1.415c	1.671a	**
	comb.	1.316c	1.446b	1.693a	1.255d	1.623a	1.536b	1.378c	1.633a	**

* T 120cm: topping at 120cm height
† SBP 120cm: side branch pruning at 120cm height
**,* and NS indicate $P < 0.01, 0.05$ and not significant, respectively.
Means followed by the same letter are not significantly different at 0.05 level according to L.S.D. test.

3.2.3 Earliness measurements

In general, earliness measurements indicated by days to first open boll, percentage of bolls on vegetative branches and earliness percentage were significantly different with plant growth alteration treatments (Table 3). It is well noticed that the control plants were more late for opening of the first boll than the treated plants. Reversely, based on higher percentage of bolls on vegetative branches and lower earliness percentage, topped, pruned or both plants markedly tended to be later in maturation than the control plants. These results could be ascribed to the basis that altering plant growth with topping and pruning increased fruiting attributes (Table 2), so boll production period was prolonged although boll opening was accelerated. Bennett *et al.* (1965) found that topping did not affect days to boll maturity.

3.2.4 Seed cotton yield and its components

Data presented in Table 4 showed that altering plant growth by topping, pruning or its combination significantly increased seed cotton yield and some yield components compared with the control. Cotton plants topped at 120cm height alone surpassed those pruned at 120cm, topped + side branch pruning at 120cm height concerning number of open and unopen bolls per plants, while it had the lowest magnitude regarding boll weight. Cotton plants topped at 120cm or topped and pruned at 120cm height resulted in the highest seed cotton yield followed descendingly by those pruned at 120cm alone and topped + pruned at 100cm height. Such results could be explained on the basis that topping the apical bud of cotton plant particularly later in the season usually resulted in limited sympodial branches carrying more bolls on top ones which utilizes more assimilates. However, side branch pruning either alone or combined with topping lead to removing terminal squares of sympodia which may move excess flow of assimilates towards the remaining fruit forms that allow more and heavier bolls as well as it minimize boll infestation and maximize boll set. Such findings were obtained by Bennett *et al.* (1965) and Gu Benkang *et al.* (1990) for seed cotton yield; Ahmed and Abdel-Al (1990) for boll weight, but reversely with number of open bolls and yield, Gu Benkang *et al.* (1990) for number of open bolls, Pettigrew (1994) for boll weight.

3.2.5 Influence of the Interaction between plant population and plant growth alteration treatments

Data presented in Table 5 revealed noticeable effects for this factor on most traits studied except for number of main stem internodes, sympodia, additional fruiting branch boll, aborted sites, fruiting sites and days to first open boll per plant indicating the independent response of the later criteria for these factors. The remaining data could be summarized as follows:

(1) Pruning at 120cm height and 40cm hill spacing gave the highest plant height while lowest one was obtained with topping + side branch pruning at 100cm height for the three hill spacings used.

(2) The control plants of 40cm hill spacing gave the highest monopodia while the lowest one was gained with topping + side branch pruning at 100cm height and 30cm hill spacing.

Table 5: Means of some traits of Pima S2 cotton cultivar significantly affected by the interaction between hill spacing and plant growth alteration treatments (combined data of both 2000 and 2001 Seasons).

Hill Spacing	*Control*	*T 120cm**	*SBP 120cm†*	*T+SBP 100cm*	*T+SBP 120cm*
			Final plant height		
30cm	144.34b	120.00d	150.85a	100.00a	120.00d
35cm	141.68c	120.00d	146.18b	100.00a	120.00d
40cm	140.84c	120.00d	151.85a	100.00a	120.00d
			Number of monopodia		
30cm	0.38gh	0.33gh	0.41fg	0.25h	0.35gh
35cm	0.66de	0.49fg	0.58ef	0.45fg	0.50fg
40cm	1.96a	1.11c	1.29b	0.78de	0.90cd
			Number of retended bolls		
30cm	24.23j	39.81d	34.78g	32.76h	36.00fg
35cm	27.66i	42.90c	37.81e	37.76ef	38.31de
40cm	39.55de	50.14a	45.53b	42.16c	43.88bc
			Percentage of bolls on vegetative branches		
30cm	5.11i	7.47f	5.72h	7.65f	7.87f
35cm	6.43g	8.90e	7.27f	7.90f	9.17e
40cm	11.30d	19.37b	16.54c	19.87a	20.47a
			Earliness percentage		
30cm	74.10a	67.22ef	69.97cd	71.92bc	67.22ef
35cm	73.13ab	66.97f	68.80de	68.07ef	66.60f
40cm	69.00de	59.79h	61.77g	57.09i	54.92j
			Number of open bolls		
30cm	14.49m	19.87ij	17.97	16.57l	20.54hi
35cm	18.39jk	25.77de	23.52	22.17gh	24.22ef
40cm	30.44c	35.90a	31.24	26.27d	32.50b
			Number of unopen bolls		
30cm	11.07ef	21.14a	18.00bc	17.38bc	16.65cd
35cm	10.47f	18.32b	15.48d	16.82bcd	15.29d
40cm	10.47f	15.43d	15.49d	17.07bc	12.57e
			Boll weight (g)		
30cm	3.20e	3.22e	3.40d	3.44cd	3.47bcd
35cm	3.42d	3.44cd	3.65a	3.50bc	3.54b
40cm	3.40d	3.42d	3.45cd	3.52bc	3.48bcd
			Seed cotton yield (t ha^{-1}*)*		
30cm	1.009i	1.380fg	1.349fg	1.263gh	1.577cde
35cm	1.132h	1.580cd	1.569cde	1.403f	1.548de
40cm	1.622cd	1.908a	1.690bc	1.469ef	1.775b

* T 120cm: topping at 120cm height; † SBP 120cm: side branch pruning at 120cm height
Means followed by the same letter are not significantly different at 0.05 level according to L.S.D. test.

(3) Topping plants at 120cm height and 40cm hill spacing resulted in the highest number of retended bolls, open bolls and seed cotton yield while the lowest ones were obtained with control plants and 30cm hill spacing.

(4) Topped and pruned plants at 120cm height and 40cm hill spacing produced the highest percentage of bolls on vegetative branches while the lowest one was obtained with the control plants and 30cm hill spacing.

(5) Control plants and 30cm hill spacing gave the highest earliness percentage while the lowest one was obtained with topping + side branch pruning at 120cm height and 40cm hill spacing.

(6) Cotton plants topped at 120cm height and 30cm hill spacing induced the highest number of open bolls while the lowest one resulted from the control plants and 30cm hill spacing.

(7) Pruned plants at 120cm height and 35cm hill spacing gave the highest boll weight while the lowest one was obtained with the control plants and 30cm hill spacing.

Roy *et al.* (1989) observed that the interaction effect of two plants per hill having spacing 60 x 20cm and topping at 45 days gave the highest seed cotton yield whereas the lowest one was obtained by two plants per hill having spacing 63 x 20cm and topping at 75 days after emergence.

4 Conclusions

The study has demonstrated that wider hill spacing and plant alteration treatments had beneficial influence on some vegetative and fruiting growth habits, seed cotton yield and its component. Topping at 120cm height increased the number of fruiting sites and retended bolls. Hill spacing of 40cm reduced final plant height but increased number of fruiting sites, retended bolls and seed cotton yield. Topping at 120cm height and 40cm hill spacing gave the highest number of open bolls, retended bolls and highest seed cotton yield.

Acknowledgement
I thank the Institute for Agricultural Research (IAR) Samaru, Zaria and Department of Crop Production, University of Agriculture, Makurdi, Nigeria, for providing the materials and facilities used in the study.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 167–176

Contracting Tobacco Growing in Turkey

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Abstract

Tobacco is a very important product in Turkish agriculture and economy. As a result of a change in the privatization policies, the support of the state in tobacco (production) is abrogated. With the introduction of the new law (No: 4733) the marketing system of tobacco has totally changed and has been replaced with the auction system and contract production. In this study the tobacco production in the year 2002 is scrutinized in order to evaluate the effect of the contract production system on tobacco production by means of a field research in Manisa. The auction system will be launched in 2003, that is why it is not included in this study. According to the research findings the majority of the producers are not satisfied with the contract production system as the contractions are being prepared one-sided and producers do not have the right to haggle. The problems that occured in the application of this new law are suggested to be eliminated by adapting the auction system, akin to the one in the USA, which enables producers to partake in the marketing of the product.

Keywords: tobacco, contracting tobacco, marketing, contract production, tobacco production, Turkey

1 Introduction

Tobacco is one of the most talked about and debated agricultural products not only in Turkey but in the whole world. The reason why the auction system is used in the USA and in many other countries is that it gives even chances to producers and provides buyers with complete opportunity to select what kind of product they want (Güler, 1999). In India, since 1985, a new kind of structure has been established by adapting the auction system similar to the ones in the USA, Canada, and Zimbabwe, taking the conditions of producers and merchants into consideration (Anonymous, 2002). It could clearly be seen in these experiences that in contract production the price is mostly dictated to the producers, however, on the other hand, the auction system brings about a fairer price (Anonymous, 2003b,a).

As to a research on contract/non-contract farming and auction system, it is suggested that contract system is likely to back up big producers and will gradually eliminate the

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small scale producers. In short, in the U.S.A producers will either accept to act in accordance with the policies of the firms, or will take the risk of being market surplus. It is stated that in the U.S.A, under the regulations of the auction system, selling tobacco is bound to the level of competition in the market and to the amount of the support buyings, and at the meantime there has begun to emerge new cooperatives or agents (haggling on behalf of producers) who take part in the dispute whether the auction system is a genuine cure or not. It is stated that in recent years the tobacco quotas in the southeast regions of the U.S.A have reduced, and producers have begun to make contracts directly with firms, and as a result less amount of goods has been auctioned (APAC, 2002). According to another research, though the extend of producers working with contracts were 10% in 2000, the estimated percent for 2001 is 80% (Anonymous, 2003c).

Main constituents of tobacco sector in Turkey are: growers, in production phase; buyers-public or private-, in buying and upkeeping; and public and private organizations dealing with tobacco based industrial products, and their workers (Mercimek, 2002).

Being a country which has an important place in oriental tobacco production, the crop has a distinctive importance in Turkish economy as Turkey has 400.000 families with 40.000 sectoral workers whose main income is from tobacco production (The Official Journal of the Turkish Republic, 2002). In 2002, with the introduction of the new law which aims to regulate the production and marketing of tobacco, the privatization of TEKEL (The General Directorate of Tobacco, products of tobacco, salt and alcohol management) (the tobacco monopoly) was decided. The new law abolishes the support buyings, and, instead, brings contract farming and auction system into effect. In this study the primary focus is on the effects of the change in the law on tobacco producers and the method of making contracts, and there is an evaluation of contract farming from the producer's point of view by the help of a public survey that has been done in Manisa which is the most important / leading tobacco production area in Turkey.

TEKEL has always had a key role in marketing of tobacco. It is also one of the most important State Economic Enterprises. TEKEL holds 75% of the cigarette market and 95% of the alcohol market. Its proportion in Turkey's gross national product is approximately 3%. On the other hand its contribution in the tax and fund income provided by the treasury is 5%. The below chart shows the share in import and the amount of goods bought in the tobacco market of TEKEL and the private sector between the years 1995 – 2002.

Between 1995 – 2000 the share of TEKEL's buyings in tobacco was in a constant rise, however, for the first time in 2001, the private sector surpassed TEKEL with 56%. According to the contracts made in 2002 the shareof private sector in contract farming is 61.8%. The reason of the rise in the amount in private sector's buyings is that the prices were at their lowest in the recent years and the gradual increase in import of the private sector, this can be traced in Table 1. Another reason is the anouncement of TEKEL that no support buyings will be made from the year 2002 onwards and that

Table 1: The share of TEKEL and private sector in the tobacco market.

Production year	*Tobacco purchasing (%)*			*The share in export (%)*		
	Tekel	*Private sec.*	*total*	*Tekel*	*Private sec.*	*total*
1995	59.9	40.1	100.0	58.0	42.0	100.0
1996	52.3	47.7	100.0	53.9	46.1	100.0
1997	54.6	45.4	100.0	51.7	48.3	100.0
1998	68.0	32.0	100.0	39.1	60.9	100.0
1999	73.6	26.4	100.0	30.1	69.9	100.0
2000	72.5	27.5	100.0	33.4	66.6	100.0
2001	44.0	56.0	100.0	-	-	-
2002	38.2	61.8	100.0	-	-	-

Source: TEKEL, 2003

made an impact resulting a decrease of 25-35 % in the number of producers of tobacco. There were 550,000 growers in 1995. The number increased to 622,000 in 1998, but in 2001 It decreased to 478,000, and finally in 2002 it came down to 403,000. In 2002, 71.2 % of the producers had their contracts with TEKEL, 25.8 % of them had their contracts with the private sector, and 3 % of them produced independently without a contract (TEKEL, 2001).

2 Materials and Methods

The material of this study is obtained mainly from two sources. One of these is the original data gathered from field (district) research. The other is the TEKEL reports, the text of the new act, texts of the contracts, sketches of the contracts in preparation, and other studies made before on the subject. Manisa has been chosen as the area of the survey since oriental tobacco production is mostly done throughout this district. The producers registered to three Tobacco Management in Manisa have been chosen as the main body and by using the method of random sampling it has been calculated that 96 producers should be interviwed with. The people to be interviewed have been selected randomly from seven different settlements. In the evaluation of the data gathered from the survey, methods as arithmetical average and percentage calculations are used.

3 Results and Discussion

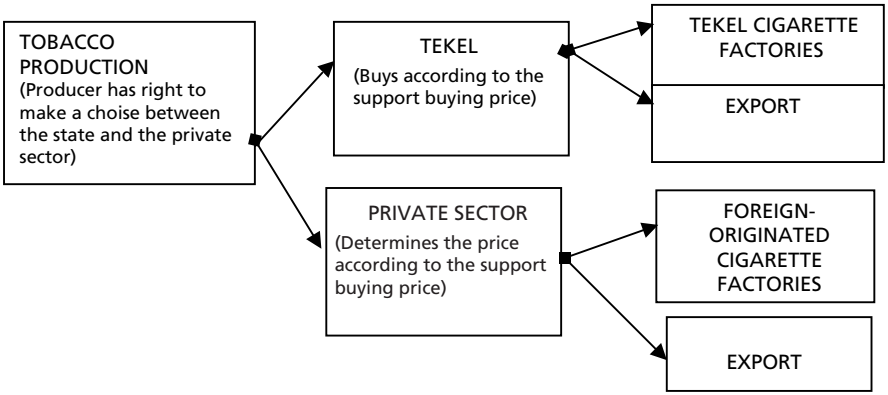
In Turkey the products which were supported either with price regulations or with support buyings have changed in time and today all support buyings except for the wheat are abolished. The products related with tobacco have always been regarded as a sector

that both private sector and the state are involved. In our country tobacco production is done by tobacco growers in the form of family farming.

Before the acceptance of the new act it could be assumed that there was an oligopson market in tobacco production. In this system both private sector and the state used to determine the value of tobacco, depending on its quantity and quality, and then the grower would sell his product either to TEKEL or to the private sector on the basis of the price of the support buying. Tobacco which remained was bought by the state. The major shortcoming of this system was that the surplus tobacco, usually of lesser quality and untreatable, was bought by the state.

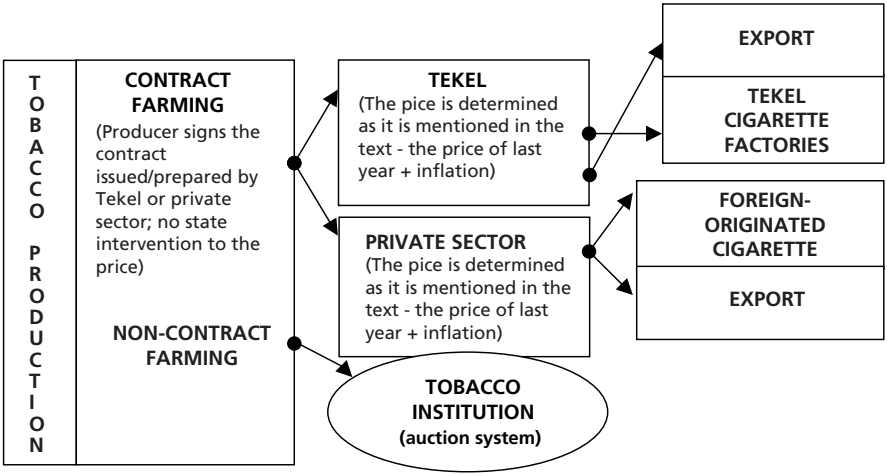
The marketing system in tobacco has changed totaly after the release of the new law 4733 (The Official Journal of the Turkish Republic, 2002). The support buyings have abolished and the producers have obliged to continue production with the contract farming system as the alternative that they had not been involved in the process of its formation. Another alternative is to produce without a contract and to sell their products in the Auction centers arranged by TEKEL. In 2001, with the new

Figure 1: The marketing channel before contracting tobacco growing in Turkey.



law the producers were able to market their products by signing the contracts prepared by tobacco merchants. In 2002 they again had the chance to make a contract with merchants and TEKEL. When the texts of these contracts are examined it can be seen that the regulations are almost always in favour of the buyers, such as that the producers shouldn't grow tobacco in the fields other than the ones appointed as the areas of tobacco production, that the contract could be repealed in case a certain dose of disinfectant higher than the acceptable limit is detected on the product, that the quality of the product will be determined by buyers and in the event of an objection the decision will be made by a commision consisting of members from the Tobacco Company, Aegean Tobacco Export Union, and an expert appointed by the producer himself. Finally in 2003 the "Tobacco Production and Purchase Contract" is prepared by The Association of Tobacco, Tobacco products and Alcoholic Drinks but this contract is announced to be in effect in 2003 (Tiller, 2001).

Figure 2: The marketing channel after contracting tobacco growing in Turkey.



Contracting and non-contracting tobacco production amounts in Manisa province in which the survey conducted and in Turkey are given in Table 2.

Table 2: The percentage of the numbers of the tobacco growers and the production amounts in the research area and in Turkey.

Tobacco production center	*Number of producers (%)*		*Production amount (%)*	
	contracting	*non-contracting*	*contracting*	*non-contracting*
Akhisar	92.4	7.6	94.0	6.0
Manisa Center	95.2	4.8	94.3	5.7
Saruhanli	99.8	0.2	99.8	0.2
Manisa Total	94.1	5.9	94.7	5.3
Turkey	97.0	3.0	96.8	3.2

Source:TEKEL, 2003

In 2002 the 94.1% of the producers of three "Tobacco Purchasing Center" were in the scope of contract farming and the share of the production done with contract farming was 94.7%. the share between the state and the private sector in the research area are given in Table 3. Although the shareof the producers doing contract farming with TEKEL is 42.4 % throughout Manisa, the amount of the product produced in this way is as low as 13.8% the reason being that TEKEL limits its buyings to 200 kg the most per grower and he goes into the market late, and also the private sector had already

Table 3: Contract farming share of Tekel and private sector within the research area.

Farm central	*Number of producers (%)*			*Production amount (%)*		
	Tekel	priv. sec	total	Tekel	priv. sec	total
Akhisar	24.3	75.7	100.0	6.4	93.6	100.0
Manisa	71.0	29.0	100.0	37.2	62.8	100.0
Saruhanli	4.1	95.9	100.0	0.9	99.1	100.0
Total	42.4	57.6	100.0	13.8	86.2	100.0

Source:TEKEL, 2003

made the next year's contracts in 2002 by inreasing the amount of the advance. The avarage total of agricultural area of 96 growers in the research area between 1998-2002 is 12 da, and its output is 80 kg/da. At the same period of time 48% of the producers sold their products to TEKEL and 52% sold theirs' to the private sector.

In Table 4, prepared to show the reasons behind the producers' decisions in determining which institution to make a contract, it can be seen that the 40.6 percent of the producers made contracts with TEKEL and the rest renewed their contracts with their previous firms.

Table 4: The producers' decisions in determining the instituon to make a contract in examined tobacco farms.

Producers preference	*Number of producers (%)*
1.The firm he used to work with	41.7
2.TEKEL (without an agent in between)	40.6
3.Both TEKEL and private sector	5.2
4. Another	2.1
5.Working with a firm for the first time	10.4
TOTAL	100.0

After they began contract farming, the 73% of the producers examined kept their farming areas as they had been (Table 5). It has been revealed that 61.5% of the managements examined read the texts of the contracts, and 88.5% of them were not satisfied with contract farming. The 90.7% of the producers's answer to the question which was to evaluate the effect of the new tobacco law on them was that it would affect them negatively and highly negatively (Table 6).

Table 5: The effects of contract farming on the farming area in the examined tobacco farms.

The effects of contract farming on the farming area	*Number of producers (%)*
1. Remained the same	73.0
2. Decreased	23.9
3. Increased	3.1
TOTAL	100.0

Table 6: The producers' decisions on the effect of the new tobacco law to the growers.

The effect of the new tobacco law on grower	*Number of producers (%)*
1. Positive	4.1
2. Negative	16.7
3. Highly negative	74.0
4. No idea	5.2
TOTAL	100.0

The 87.5% of the producers are against the privatization of TEKEL. The 94.8% of the producers who are against the privatization are also in favour of the previous marketing system before the new tobacco act. When it comes to the producers opinion concerned with the determination of the price; 72.9% stated that the price should be determined by the state (TEKEL)(Table 7).

87.5% of the managements examined regard The Union of the Turkish Agricultural Chambers, the professional association of farmers, as insufficient. Ones who find it sufficient is only 1%. In 1969 with the introduction of the act 1196 it was permitted to found "tobacco sale cooperatives" and the act regulated its activities, then in june 16, 2000, this act was abolished and replaced with the act 4572. According to the data provided by The Ministery of Industry and Commerce only 29 of the tobacco sale cooperatives are active out of the existing 67, and it came out that there was no active cooperatives left in our research area after the year 2000 due to the inconvenient conditions such as the recent economic crisis and the privatization preparetions of the "turkish bank of agriculture" whose primary function is to provide farmers with bank loans.

The problems of the managements related with tobacco and organization are given at Table 8. When the table is examined it can be seen that the problems are mostly due to the abolishment of the support of the state.

Table 7: The producers' opinion concerned with the determination of the price.

Tobacco price	*Number of producers (%)*
1. Should be determined by TEKEL	72,9
2. Auction	19,8
3. By merchant	6,3
4. By the haggling of state and private sector on the price	1,0
TOTAL	100.0

The solutions suggested by the growers to overcome these problems are given at Table 9. The reason why 67.7% of the producers are in favour of the continuation of the support buyings is the fact that they are deprived of the opportunity to haggle and the contracts are prepared one-sidedly. Only 17.7% of them came up with suggestions related to organizations like cooperatives or labour/trade unions,and this can be interpreted as their distrustfulness to organizations of this kind. 6.3% of the producers suggestions based on auction system or tobacco stock exchange, this can be interpreted as their insecureness towards this kind of marketing.

Table 8: Major problems concerning tobacco sector in the examined tobacco farms.

Problems	*Number of producers (%)*
1. Abrogation of state support	47.9
2. Lack of alternative product to tobacco	19.8
3. Contracts being one-sidedly	17.7
4. Lack of confidence to cooperatives	8.3
5. Lack of leadership	5.2
TOTAL	100.0

Table 9: The suggestions to the problems of examined tobacco farms.

The suggestions by the growers	*Number of producers (%)*
1. State support should continue	67.7
2. There should be organisations such as cooperatives and unions	17.7
3. Tobacco stock exchange should be established	6.3
4. Other	8.3
TOTAL	100.0

4 Conclusions

The privatization of TEKEL, one of Turkey's most important kamu iktisadi kuruluşu, has long been debated. With the regulations in 2002, this process has gained acceleration and in that same year support buyings in tobacco production were abolished. The contract farming brought by the new law began in 2002, and production took place by the contracts which had been prepared by buyers one-sidedly.

The contract farming system applied for the first time was not adapted by the majority of producers in Manisa which had been chosen as the research field. They reported that they were obliged to sign those one-sidedly prepared contracts since they had no alternatives.Approximately 70% of the producers emphasized that TEKEL must remain as a part of the Tobacco marketing system and 6.3% of the producers came up with the suggestion that a new tobacco stock market must be established. It can clearly be seen that producers are not very much fond of organizations like cooperatives and unions.

The new marketing system foresees a production planning in the tobacco growing and no more excessive product left on hand. An important part of about 400,000 tobacco producers, whose number has decreased by 25-30% comparatively to the past, will probably continue producing tobacco until they produce an alternative product. It is quite difficult for thousands of producers to make contracts with a few number of buyers one by one. The experienced tobacco experts who will have been left the TEKEL after the privatization migth be employed in the present Tobacco Agricultural Sale Cooperatives. While some growers are keeping on the contract farming, the others might take place in the auction system, so marketing their products in the auction tobacco purchasing centers. Thus, it is thought that such an approach would be more useful in terms of a competitive market economy.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 177–192

Effect of Irrigation Regime on Growth and Development of Two Wheat Cultivars (*Triticum aestivum* L.) in the Nigerian Savanna

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Abstract
Field trials were conducted at irrigation research stations of the Institute for Agricultural Research, Kadawa (11° 39'N, 08° 27'E, 500m asl). The objective was to study the effect of irrigation regime (60, 75 and 90% Available Soil Moisture (ASM) on the growth and yield of two recently introduced wheat cultivars (Siete cerros and Pavon 76). The result revealed that increase of irrigation regime from 60 to 90% ASM did not significantly affect most of the growth, yield and yield parameters evaluated in the study. Each increase in irrigation regime however increased days to maturity, water use and thermal time but decreased water use efficiency. Pavon 76 produced superior grain yield than Siete ceros only in one season. Pavon 76 had a higher LAI, more tillers and spikes/m^2 and larger grain size, but had shorter plants, lower grain weight and grain number/spike and matured earlier than Siete cerros. Irrigation level of 60% ASM is recommended for both varieties in the Sudan savanna ecology. At this ASM the highest water use efficiency of 4.0-4.8kg/mm/ha was obtained and grain yield was not significantly compromised. Grain yield was more strongly correlated with grain weight per spike than with grain number per spike.

Keywords: irrigation regime, wheat growth, wheat yield,available soil moisture, Pavon 76, Siete cerros, Nigeria, savanna

1 Introduction

Plant response to varying degrees of water regime has been a subject of considerable study and review (Slayter, 1967; Kajdi, 1993; Khehr *et al.*, 1996). Yet the question of how water regime interacts with other cultural practices to affect growth, yield and quality of crops remain one of the important problems in crop agriculture. Conclusive explanations of these interactions have not been achieved. Current emphasis however appear to be on understanding the plastic responses of crop genotypes to soil water status and the determination of climate, plant and soil relationships (Benbi, 1994) that would improve appropriate scheduling of irrigation. Wheat cultivars respond differently to irrigation treatments. Studies by Kumar and Yayock (1980), Falaki (1994) and by Abubakar (1999) have shown considerable variations in yields between cultivars in Nigeria. Their reports and that of Negedu (1994) also show seasonal variations in yields of individual cultivars. The differences in yields among cultivars, and between seasons

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are commonly associated with differences in growth and yield attributes (NEGEDU, 1994; FALAKI, 1994; ABUBAKAR, 1999) and to genetic differences (RAJARAM and VAN GIMKEL, 1996).

Several workers have observed that the yield of wheat was enhanced if irrigation was sustained at 50% or higher available soil moisture levels (ERIE, 1962; BAPNA and KHUSPE, 1980; SINGH *et al.*, 1980). These results implicate the need for determination of the response of newly developed wheat varieties under different moisture regimes.

In the light of the above this study was initiated among other things to:

> Evaluate the effect of three irrigation regimes on water use, water use efficiency, growth and yield of two newly introduced wheat cultivars.

2 Materials and Methods

Field Experiments were conducted for three seasons, 1995/96, 1996/97 and 1997/98 dry seasons at the Institute for Agriculture (IAR/ABU) Irrigation Research Station at Kadawa (11° 39'N 08° 15'E and 500m above sea level) in the Sudan Savanna of Nigeria.

The soil was sandy loam, pH $>$ 7.2-8.0, CEC (meq/100) of 5.89–6.21, exchangeable Na^{++} of 0.152–0.182, K^{+} of 0.202–0.268, Ca^{++} of 2.16–2.93, total N of 0.041–0.048, and total P (ppm) 29.4–33.4. The water table depths of the sites used in the study determined by the method described by NWA (1982) on the 20th of each month of the study averaged 77 cm in 1995/96, over 100 cm in 1996/97 and 92 cm in 1997/98. Table 1 shows the trend of evaporation, maximum–minimum temperature and relative humidity that prevailed during the experiment. Rain did not fall throughout the period of the experiment.

Three irrigation levels (60%, 75% and 90% ASM) and two spring semi-dwarf wheat varieties (*Triticum aestivum* L.) viz, Siete cerros (maturing in about 110-115 days) and Pavon 76 (maturing in about 90 - 102 days) were evaluated in three replicates laid out in a randomized complete block design. Moisture levels were determined using a Toxler neutron probe in each plot. The experimental land was irrigated, ploughed and harrowed three times to obtain a fine tilt. Basins were constructed manually and its raised borders (70 cm height) were carefully compacted to minimize seepage. The internal basin dimensions were 4 $\times$ 3m. The seeds were treated with Apron plus 50DS at the rate of 10 g/kg of seed before sowing. Seeding rate adopted was 120 kg/ha. Corresponding quantity of seed for each plot was weighed and used completed. Planting was conducted based on the sowing date treatments. Seeds were sown in rows of 20 cm rows by drilling. The first and the third rows each side were treated as border rows while the second row was used for destructive sampling. Also along the length of the plot, 0.25 m was treated as border area. Therefore the net plot size was 7m^2. The first dose of 60 kg each of N, $P_2 0_5$ and $K_2 0$/ha was applied basally at planting. Compound fertilizer was used to supply the nutrient. A second dose of 60 kg N/ha was applied six weeks after sowing (WAS) using Urea (46% N) as source of nitrogen. The same fertilizer regime was adopted throughout the study. Weeds were controlled manually by hoe weeding at 3, 5 and 7 WAS. The crop was harvested at physiological maturity stage

Table 1: Mean maximum temperatures (℃), relative humidity (%) and pan evaporation at 10-day interval during 1995/96 dry season at Kadawa

Month	Temperature (℃)						Relative Humidity (%)			Pan Evaporation (mm/day)		
	1995/96		1996/97		1997/98							
	Max	Min	Max	Min	Max	Min	95/96	96/97	97/98	95/96	96/97	97/98
December												
1-10	34	11	32	12	38	13	65	59	32	6	5	6
11-20	33	14	33	11	34	12	57	73	35	6	5	5
21-31	30	12	33	11	38	13	61	59	39	6	6	5
January												
1-10	31	12	33	11	32	17	51	56	39	7	14	11
11-20	33	12	34	11	30	10	63	61	27	6	13	12
21-31	28	13	33	11	37	13	65	46	41	6	6	12
February												
1-10	34	13	32	10	41	16	67	39	37	7	8	12
11-20	33	12	33	11	37	16	63	30	30	6	15	12
21-31	33	13	34	12	35	15	65	28	24	6	8	10
March												
1-10	36	17	34	12	35	16	57	35	29	7	7	12
11-20	37	21	41	12	30	18	61	35	39	6	6	15
21-31	35	18	43	21	40	20	42	41	28	8	8	11

Source: IAR meteorological unit

11.4 on Feekes scale illustrated by LARGE (1954). Harvesting was conducted by cutting the crops with a sharp sickle as close as possible to the ground level. The harvested net plots were bundled into sheaves, dried on the field, weighed, threshed and winnowed. Dry matter per square meter was determined at 3, 6, 9 and 12 WAS. The plants in 0.5 m linear row were carefully uprooted and the roots washed. The samples were then oven dried at 60℃ until they attained constant weight. A balance (Metler 310) was used to weigh the samples. Leaf area index was determined by the method described by BELL and FISCHER (1994). The numbers of tillers and spikes per m^2, were recorded from the plants uprooted from a 0.5 m linear row at 6 WAS. Plant height was determined from the main shoot of three tagged plants in each plot from ground level to the tip of the spike excluding the awns. Plant height was measured at maturity. Length of the spike, the weight and number of grains per spike were determined from 5-tagged plants in each plot. Measurement of grain yield was conducted from yield samples from each plot. Three samples of 250 g each were carefully weighed and the 1000-grain mass determined. Grain yield was determined by weighing after threshing and winnowing from the $7m^2$ net plot. The grain yields per net plot were extrapolated to per hectare. Water use efficiency was derived from the ratio of grain yield from a plot to the total irrigation water applied to the same plot.

All data collected were subjected to analysis of variance described by SNEDECOR and COCKRAN (1967). Growth and yield component data were compared using Duncan multiple range test (DMRT) (DUNCAN, 1955).

3 Results

3.1 Growth

The varieties had no effect on the dry matter accumulation (Table 2). The effect of irrigation regime on dry matter accumulation was not significant. Pavon 76 produced higher LAI than Siete cerros only at 6 and 9 WAS (Table 3). The effect of irrigation on LAI manifested late as from 9 and 12 WAS at which irrigation level of 90% ASM produced higher LAI than the less irrigated treatments.

Pavon 76 produced more tillers than Siete cerros in the three seasons (Table 3). The effect of irrigation regime on tiller number was not significant throughout the experiment. All the interactions were not significant throughout the three seasons.

Siete cerros took longer time to mature than Pavon 76 in the three years. Increase of available soil moisture from 60 to 75% significantly increased the number of days to maturity (Table 4). The difference between 75 and 90% ASM was however not significant. When each of the varieties was examined across the irrigation levels (Table 5), it was found that the duration to maturity of both varieties at 60% was lower than at 75 and 90% ASM that were at par. When the two varieties were compared at each moisture level, it was observed that Pavon 76 matured earlier at all the levels than Siete cerros in the three years.

3.2 Grain Yield and Yield Components

The effect of variety on grain yield was significant only in 1996/97 season in which Pavon 76 produced a higher grain yield than Siete cerros (Table 6). The irrigation level had effect on grain yield only in 1997/98 season. Irrigation at 90% ASM resulted in a higher grain yield than irrigation at 60 and 75% ASM. Only in 1995/96 Pavon 76 produced more spikes/m^2 than Siete cerros (Table 4). Irrigation frequency did not affect the spike number /m^2 in the three seasons. All the interactions were not significant on this parameter in the three seasons.

Grain weight/spike of Siete cerros was higher than that of Pavon 76 in both 1996/97 and 1997/98 seasons (Table 6). The irrigation regime had no effect on the grain weight/spike.

Throughout the three seasons, Siete cerros consistently had higher number of grains per spike than Pavon 76. The irrigation levels evaluated in the study did not significantly affect the number of grains/spike. All the interactions were not significant.

Pavon 76 had heavier grains than Siete cerros in the three seasons (Table 6). Irrigation had no significant effect on the size of the grains in 1995/96 whereas in 1996/97 and 1997/98 seasons. Increase of irrigation regime from 60 to 90% ASM decreased the grain size.

The harvest index (HI) was only in 1996/97 slightly higher in Pavon 76 compared to Siete ceros (Table 5), whereas it was not affected by irrigation.

Table 2: Effect of variety and irrigation regime on wheat dry matter accumulation at 3, 6, 9 and 12 WAS in 1995/96-1997/98 dry seasons at Kadawa

Treatment	*Dry Matter Accumulation (g/cm^3)*											
	1995/96				*1996/97*				*1997/98*			
	3 WAS *	*6 WAS*	*9 WAS*	*12 WAS*	*3 WAS*	*6 WAS*	*9 WAS*	*12 WAS*	*3 WAS*	*6 WAS*	*9 WAS*	*12 WAS*
Variety												
Siete cerros	130.89^a	354.1^a	549.1^a	672.7^a	129.30^a	335.6^a	530.3^a	605.4^a	142.06^a	354.1^a	602.4^a	704.7^a
Pavon 76	130.56^a	355.3^a	553.5^a	675.0^a	130.41^a	324.6^a	530.7^a	610.1^a	140.92^b	356.76^b	604.3^a	708.9a
SE±	0.45	3.47	1.87	2.36	2.26	3.45	5.86	11.26	0 .177	2.62	4.74	9.20
Significance	NS	NS	NS	NS	NS	NS	NS	NS	*	*	NS	NS
Irrigation at												
60% ASM†	130.72^a	352.1^a	547.8^a	669.9^a	129.67^a	318.6^a	528.4^a	602.8^a	141.42^a	355.0^a	600.8^a	705.0^a
75% ASM	130.50^a	454.2^a	552.2^a	677.4^a	130.00^a	335.4^a	533.0^a	608.2^a	141.38^a	355.5^a	603.2^a	706.9a
90% ASM	130.74^a	357.84	554.0^a	678.2^a	129.89^a	336.3^a	530.1^a	612.4^a	141.67^a	355.6^a	606.1^a	708.5a
SE +	0.56	4.25	2.28	2.89	2.31	4.26	6.81	7.72	2.22	3.25	6.94	11.63
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction												
V.I	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**	**

* WAS ≙ weeks after sowing; † ASM ≙ Available Soil Moisture
Means followed by the same letter within the same treatment group are statistically the same using DMRT.
NS ≙ Not significant; ** and * ≙ significant at 1% and 5% level respectively.

Table 3: Effect of variety and irrigation regime on leaf area index of wheat at 3, 6, 9 and 12 WAS in 1995/96- 1997/98 dry seasons at Kadawa

Treatment	*Leaf Area Index*											
	1995/96				*1996/97*					*1997/98*		
	3 WAS *	*6 WAS*	*9 WAS*	*12 WAS*	*3 WAS*	*6 WAS*	*9 WAS*	*12 WAS*		*3 WAS*	*6 WAS*	*9 WAS*	*12 WAS*
Variety													
Siete cerros	1.24a	2.36b	4.01b	3.83a	1.20a	2.54b	3.83b	3.60a	1.36a	2.92b	4.02b	3.92a	
Pavon 76	1.24a	2.91a	4.03a	3.84a	1.22a	2.60a	3.85a	3.62a	1.35a	2.95a	3.06a	3.94a	
SE±	0.004	0.004	.006	.007	0.004	0.015	0.003	0.003	0.004	0.002	0.008	0.008	
Significance	NS	*	*	NS	NS	*	*	NS	NS	*	*	NS	
Irrigation at													
60% ASM†	1.24a	2.91a	4.00b	3.81b	1.21a	2.58a	3.83b	3.60c	1.35a	2.94a	4.02b	3.85b	
75% ASM	1.24a	2.91a	4.01ab	3.84ab	1.21a	2.56a	3.84ab	3.61b	1.35a	2.94a	4.05ab	3.88b	
90% ASM	1.24a	2.91a	4.04a	3.85a	1.21a	2.57a	3.85a	3.62a	1.35a	2.94a	4.06a	4.00a	
SE±	0.005	0.005	.008	.008	0.004	0.010	0.004	0.003	0.005	0.001	0.004	0.009	
Significance	NS	NS	*	*	NS	NS	*	*	NS	NS	*	*	
Interaction													
V.I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

* WAS ≙ weeks after sowing; † ASM ≙ Available Soil Moisture
Means followed by the same letter within the same treatment group are statistically the same using DMRT.
NS ≙ Not significant; ** and * ≙ significant at 1% and 5% level respectively.

Table 4: Effect of variety and irrigation regime on the number of tillers, days to maturity, number of spikes/m^2, length of spike (cm) of wheat in the 1995/96 - 1997/98 dry season at Kadawa.

Treatment	*Number of Tillers per m^2*			*Days to maturity*			*Number of spikes/m^2*			*Length of spike (cm)*		
	1995/96	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*
Variety												
Siete cerros	617.7b	413.4b	504.9b	98.59a	91.78a	93.14a	402.0b	403.9a	497.2a	7.24a	6.075a	7.134a
Pavon 76	656.2a	455.3a	532.1a	90.04b	86.93b	87.33b	412.3a	411.9a	515.7a	7.06a	5.824a	6.932a
SE±	11.57	10.52	8.501	0.0123	0.107	0.10	2.43	8.14	.09	.103	0.1454	0.072
Significance	**	**	**	**	**	**	*	NS	NS	NS	NS	NS
Irrigation at												
60% ASM†	622.8a	421.8a	510.3a	93.22b	88.61b	89.21b	404.1a	405.9a	492.0a	6.89b	5.7091b	6.782b
75% ASM	648.6a	443.3a	527.3a	94.81a	89.56a	90.63a	407.4a	413.4a	509.1a	7.27a	6.016ab	7.101a
90% ASM	639.4a	437.7a	517.8a	94.91a	89.89a	90.88a	410.0	404.3a	507.7a	7.30a	6.124a	7.215a
SE±	14.17	12.89	10.41	0.150	0.13	0.12	1.75	9.97	9.40	0.110	0.126	0.088
Significance	NS	NS	NS	*	*	*	NS	NS	NS	*	*	*
Interactions												
S. V.	NS	NS	NS	**	**	**	NS	NS	NS	NS	NS	NS

† ASM≙Available Soil Moisture
Means followed by the same letter within the same treatment group are statistically the same using DMRT.
NS ≙ Not significant; ** and * ≙ significant at 1% and 5% level respectively.

Table 5: Interaction between variety and irrigation regime on days to maturity and water use efficiency (kg/mm/ha) of wheat in the 1995/96 - 1999/98 seasons at Kadawa.

Irrigation level	*Days to maturity*						*Water use efficiency (kg/mm/ha)*					
	1995/96		*1996/97*		*1997/98*		*1995/96*		*1996/97*		*1997/98*	
	Siete cerros	*Pavon76*	*Siete cerros*	*Pavon76*	*Siete cerros*	*Pavon76*	*Siete cerros*	*Pavon76*	*Siete cerros*	*Pavon76*	*Siete cerros*	*Pavon76*
60% ASM[†]	97.22b	89.22d	90.67b	86.50d	91.67b	86.75d	4.039b	4.616a	3.234b	3.708a	4.161b	4.767a
75% ASM	99.22ab	90.40c	92.11a	87.00c	93.75a	87.50c	2.178d	3.346c	2.404d	2.689c	2.973d	3.372c
90% ASM	99.33a	90.49c	92.56a	87.22c	94.00a	87.75c	2.172f	2.469e	1.772f	1.991e	2.256f	2.522e
SE±	0.213		0.184		0.12		0.047		0.057		0.047	

[†] ASM≙Available Soil Moisture
Means followed by the same letter within the same treatment group are statistically the same using DMRT.

Table 6: Effect of variety and irrigation regime on the number and weight of grains per spike, 100-grain weight and harvest index of wheat in the 1995/96 - 1997/98 dry seasons at Kadawa.

Treatment	*Grain weight per spike (g)*			*Grain number per spike*			*1000-grain weight (g)*			*Harvest Index*		
	1995/96	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*
Variety												
Siete cerros	1.277a	0.911a	1.212a	41.96a	37.59a	40.84a	36.408b	33.49b	35.88b	0.35a	0.28b	0.35a
Pavon 76	1.263a	0.850b	1.176b	30.76b	26.26b	31.22b	42.134a	38.95a	41.47a	0.35a	0.29a	0.35a
SE±	0.646	0.007	0.008	0.226	0.219	0.253	.119	.165	0.210	.149	.009	.002
Sign.	NS	*	*	*	*	*	**	**	**	NS	*	NS
Irrigation at												
60% ASM†	1.2650a	0.8794a	1.2039a	36.14a	31.84a	35.77a	41.00a	36.80a	41.52a	0.35a	0.28a	0.33a
75% ASM	1.2639a	0.8772a	1.2073a	36.36a	31.86a	36.10a	41.18a	36.23ab	41.17a	0.35a	0.28a	0.33a
90% ASM	1.2706a	0.8844a	1.2075a	36.59a	32.08a	36.23a	41.08a	35.83b	38.33b	0.35a	0.30a	0.34a
SE±	0.011	0.009	0.009	0.279	0.279	0.310	.015	0.20	0.18	0.02	0.01	0.002
Sign.	NS	NS	NS	NS	NS	NS	NS	*	*	NS	NS	NS
Interactions												
I. V.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

† ASM≙Available Soil Moisture
Means followed by the same letter within the same treatment group are statistically the same using DMRT.
NS ≙ Not significant; ** and * ≙ significant at 1% and 5% level respectively.

Table 7: Effect of variety and irrigation regime on the number and weight of grains per spike, 100-grain weight and harvest index of wheat in the 1995/96 - 1997/98 dry seasons at Kadawa.

Treatment	*Grain yield (kg/ha)*					*Water Use Efficiency*				
	Year			*Combined*		*Year*			*Combined*	
	1995/96	*1996/97*	*1997/98*	*Y1 & Y3*	*Y2 & Y3*	*1995/96*	*1996/97*	*1997/98*	*Y1 & Y3*	*Y2 & Y3*
Variety										
Siete Cerros	2600a	2035b	2695a	2761a	2341a	2.996b	2.470b	2.886b	3.18b	2.732b
Pavon 76	2588a	2142a	2728a	2731a	2324a	3.499a	2.796a	3.345a	3.65a	3.079a
SE±	12.98	0.71	20.79	12.02	12.92	0.027	0.033	0.027	0.021	0.023
Sign.	NS	*	NS	NS	NS	**	**	**	*	*
Irrigation at										
60% ASM†	2584a	2070a	2696b	2640a	2383a	4.327a	3.471a	4.464a	4.567a	3.866a
75% ASM	2586.8a	2094a	2702b	2644a	2398a	3.062b	2.547b	3.173b	3.237b	2.784b
90% ASM	2598.4a	2102a	2736a	2667a	2419a	2.321c	1.882c	2.389c	2.444c	2.065c
SE±	15.90	12.12	5.66	14.72	15.83	0.032	0.041	0.031	0.024	0.035
Sign.	NS	NS	*	NS	NS	**	**	**	**	**
Interactions										
V.I	NS	NS	NS	NS	NS	**	**	**	NS	NS

† ASM≙Available Soil Moisture; Y1 = 1995/96, Y2 = 1996/97, Y3 = 1997/98
Means followed by the same letter within the same treatment group are statistically the same using DMRT.
NS ≙ Not significant; ** and * ≙ significant at 1% and 5% level respectively.

Table 8: Simple Correlation coefficient between grain yield, yield components sown growth parameters, water use and water use efficiency (WUE) in the 1995/96 1996/97 and 1997/98 dry seasons at Kadawa.

(a) 1995/96	Grain yield	No. of spike/m^2	No. of grain/spike	1000 grain weight	Tiller/m^2 at 7 WAS	Plant height	Grain filling period	Length of spike	LAI at 9 WAS	Grain wt/ spike	Harvest Index	Total aerial phytomass	Water use
Grain yield	1												
No of spike/m^2	0.842**	1											
No of grains/spike	0.254NS	0.121NS	1										
1000 grain wt	0.265NS	0.251NS	-0.846**	1									
Grain wt/spike	0.679**	0.632**	0.614**	0.178NS	0.374**	0.728**	0.411**	0.698**	0.553**	1			
Harvest Index	0.905**	0.802**	0.085NS	0.259NS	0.370**	0.271*	0.646**	0.297*	0.647**	0.555**	1		
WUE	0.288*	0.098NS	-0.307*	0.280	-0.037NS	-0.191NS	0.421**	-0.271*	0.034NS	-0.097NS	0.306*	0.204NS	-0.924**
(b) 1996/97													
Grain yield	1												
No of spike/m^2	0.373**	1											
No of grains/spike	0.221NS	0.214NS	1										
1000 grain wt	0.261NS	0.041NS	-0.799**	1									
Grain wt/spike	0.831**	0.408**	0.502**	-0.003NS	0.449**	0.638**	0.556**	0.631**	0.670**	1			
Harvest Index	0.221NS	0.074NS	-0.007NS	0.172NS	0.055NS	-0.120NS	0.202NS	0.277*	0.177NS	0.202NS	1		
WUE	0.367*	0.182NS	-0.220NS	0.212NS	0.037NS	-0.108NS	0.346**	-0.014NS	0.090NS	0.100NS	0.020NS	0.143NS	-0.883**
(c) 1997/98													
Grain yield	1												
No of spike/m^2	0.443**	1											
No of grains/spike	0.305**	0.204NS	1										
1000 grain wt	0.652**	0.358**	-0.398**	1									
Grain wt/spike	0.905**	0.403**	0.402**	0.613**	0.442**	0.537**	0.673**	0.799**	0.871**	1			
Harvest Index	0.898**	0.408**	0.230NS	0.466**	0.463**	0.499**	0.444**	0.635**	0.630**	0.740**	1		
WUE	0.428*	0.074NS	-0.164NS	0.411**	0.154NS	0.063NS	0.387**	0.121NS	0.197NS	0.308**	0.352**	0.432**	-0.852**

NS $\hat{=}$ Not significant; ** and * $\hat{=}$ significant at 1% and 5% level respectively.

3.3 Water Use Efficiency

Water use efficiency (WUE) of Pavon 76 was consistently superior to that of Siete cerros (Table 7). Each increase in irrigation frequency from 60 to 90% ASM significantly depressed the WUE throughout the three seasons. WUE of each variety decreased with each increase in irrigation frequency in the three seasons. At all the irrigation levels, Pavon 76 had a higher WUE than Siete cerros in the three years (Table 5).

3.4 Correlation Analysis

In all the three seasons grain yield was found to have a positive relationships with number of spike/m^2, tiller number, plant height, duration of grain filling, length of spike and grain wt/spike (Tables 8a-c). Grain yield also had a strong association with parameters such as number of grain/spike and 1000-grain weight only 1997/98. The correlation between number of grains/spike and 1000 grain weight was however negative. Water use did not correlate with grain yield whereas WUE correlated with grain yield.

4 Discussion

4.1 Performance of Cultivars

The study revealed considerable similarities and some differences in the growth of the Siete cerros and Pavon 76. The trend of dry matter accumulation and leaf area indices (LAI) of the two cultivars was similar. This may be due to the fact that both cultivars have similar genetic background having been developed from Nario 10 (Hanson *et al.*, 1982). The response to agronomic treatments among cultivars with similar genotypes did not differ in the studies by Stapper and Fischer (1990), as in this current study.

Leaf Area Index increased progressively until 9 WAS and thereafter decreased at 12 WAS in both cultivars. Benbi (1994) and Abubakar (1999) also observed similar decrease of LAI among wheat cultivars after anthesis and is an indication cessation of growth.

The study revealed some consistency in grain yield superiority of Pavon 76 over Siete cerros in contrast to Abubakar (1999) findings that indicated sustained superiority of Siete cerros over Pavon 76. The factors responsible for the superiority of Pavon 76 over Siete cerros may include higher number of tillers and spikes/m^2, larger grain size, and higher harvest index. The present finding agrees with the reports by Hanson *et al.* (1982), Orakwe and Olugbemi (1990) that predicted superior yields from Pavon 76 over Siete cerros. The result indicates that high spike/m^2 and large grain size may compensate high number and weight of grain /spike in determination of grain yield.

4.2 Effect of Irrigation Regime

Increasing irrigation regime from 60% to 90% ASM only slightly enhanced growth attributes such as dry matter accumulation, LAI, tiller number/m^2 and plant height. The tend in the response to the irrigation treatment suggests that the crop was exposed to very light stress that only slightly impaired proper vegetative growth and development. Similar result of minor decreases in growth attributes following imposition of various

irrigation regimes were obtained by FALAKI (1994) and KUMAR and YAYOCK (1980) and is probably related to high level of adaptability of the cultivars used in the study.

The decrease in number of days to maturity with reduced level of irrigation was probably a hormone-induced response to lack of stress that delayed the development of the plant. ATMAN and JACOBS (1975) documented a similar hormonal response to temperature and light regimes that supports the present finding.

Increasing irrigation regime from 60% ASM to 90% increased grain yield marginally in two seasons (1995/96 and 1996/97) but remarkably in one season. The lack of significant increase of grain yield in the two seasons following increased moisture supply was probably due to the high water table of the experimental site used. HANKS *et al.* (1977) found insignificant influence of irrigation treatments on yield of corn and alfalfa and ascribed the lack of response to upward flow of water through capillary spaces from high water table into the root zone. ECKERT *et al.* (1978) also reported a similar lack of response to irrigation treatments in their experiment that was conducted under higher water table.

Yield components such as weight of spike, number of spike/m^2 number of sterile spikelets, 1000 grain weight, harvest index, grain weight and grain number per spike were not influenced by the irrigation treatments in the same manner as the grain yield. The lack of response of these yield attributes to the irrigation treatments may have accounted for the insignificant differences in grain yield.

The results indicate that irrigation at 60% ASM was sufficient for the cultivation of wheat at Kadawa. This moisture regime is less than 75% ASM reported by FALAKI (1994) and about 15% and 10% more than 50% ASM at which KUMAR (1992) and SINGH *et al.* (1980) respectively obtained the best water use efficiency. However, the 60% ASM falls within the range of 60-70% ASM recommended by ERIE (1962) for wheat cultivation at Arizona.

The total irrigation water use by maintaining irrigation at 60% ASM in the three-year study ranged from 595 mm to 604 mm. This range is less than the range of 650-850 mm obtained under a fixed irrigation interval by SIEWIERSKI (1979), and MAURYA and SACHAN (1985) at Ngala and Kadawa respectively. The range was also remarkably lower than 720 - 1080 mm obtained by KUZNIAR *et al.* (1989) at Bakura. The lower irrigation regime proposed might however have implications for salinity build up over time that may need to be monitored.

4.3 Interaction between Variety and Irrigation Regime

High irrigation regime of 90% ASM increased the number of days to maturity more in Siete cerros than Pavon 76, because of the genetic difference and difference in their length of maturity. Water use efficiency of Pavon 76 was consistently higher than that of Siete cerros at each of the irrigation levels evaluated because it used less water and gave superior yields. The fact that both varieties gave the highest WUE at 60% ASM suggests that their optimum irrigation requirement is about the same.

4.4 Correlation

A high level of correlation between grain yield and characters such as number of spike per m^2, grain weight per spike and harvest index total indicate that these characters are vital yield determinants. This is in line with findings of KINYERA and AYIECHO (1992), and ABUBAKAR (1999). The negative correlation between 1000 grain weight and attributes such as number of grain /spike and grain weight/spike indicate some compensatory tendencies among these yield attributes. Also the inconsistency in the level of significance in terms of the correlation between grain yield and number of grain/spike or 1000-grain weight suggests that the level of compensation among the attributes could vary between seasons. NEGEDU (1994) obtained similar result that supports this explanation.

A lack of significant correlation between grain yield and water use probably imply that moisture was not very limiting in the experiment and support the need to advocate the lower irrigation regime of 60% ASM for Kadawa.

5 Conclusion

The results of the study indicate that irrigation at 60% ASM is suitable for both varieties at Kadawa. Grain yield superiority of Parvon 76 predicted by ORAKWE and OLUGBEMI (1990) was only observed in one season. From the study, it was found that grain weight per spike rather than grain number per spike was more relevant to grain yield.

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Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 193–196

Buchbesprechungen

Michel Arbonnier; 2004

Trees, shrubs and lianas of West African dry zones.

CIRAD (Centre de coopération internationale en recherche agronomique pour le développement), Paris, ISBN 2-87614-579-0, Margraf Publishers, Weikersheim, ISBN 3-8236-1419-3 and MNHN (Muséum national d'histoire naturelle), Paris, ISBN 2-85653-571-2. 576 pages. Price: 76 €.

This book with French edititions of 2000 and 2002, now fortunately is published in an English version. It is a field handbook as a result of over fifteen years' experience of forestry operations under projects conducted by CIRAD. It sets out to fill a gap in the literature available on the flora of the dry zones of West Africa, between Dakar and Lake Chad, with the types of vegetation in the Saharan, Sahelian and Sudanian zones.

In the beginning useful determination keys, based on leaves, flowers, fruits and thorns and spines are given. On the following nearly 400 pages, 360 species of trees, shrubs and lianas of the dry climates are presented in alphabetical sequence of the families. Each species is described on one page, showing 1300 excellent colour photographs of flowers, fruits, leaves and bark. For each species, traditional as well as modern uses of the different parts of the plants for pharmaceutical and human and animal food purposes and their special importance for daily life are explained. To facilitate species identification, there are some keys relating to plant families, such as Loranthaceae, and comparative tables for certain genera, such as *Ficus , Lannea, Vernonia, Cordia, Capparis, Combretum, Jasminum, Protea, Ziziphus, Gardenia, Citrus, Grewia* or *Terminalia*.

This book is a very useful tool which will ensure a better understanding of West African ecosystems, in a time when conservation of biological diversity of drylands and the control of land degradation and desertification in these areas are rapidly growing in priority and importance. In view of the high value of the book and the enormeous amount of excellent photographs, the pecuniary price is reasonable. It is a very important book for specialists and also for non specialists in botany, be they technicians working in forestry, agriculture or animal production, teachers or students. It is a very good reference for anyone in need of information on the trees and shrubs of the region.

C. Richter, Witzenhausen

Verena Kremling; 2004

Zu kalt um aufzustehen. Einflüsse von Identität und Weltbild auf die Entwicklungszusammenarbeit mit Fulbe-Viehhaltern im Liptako (Burkina Faso).

344 Seiten, 29 Abbildungen (Karten, Graphiken, Photos). Sozioökonomische Prozesse in Asien und Afrika, Bd.9; Centaurus-Verlag, Herbolzheim, 2004. Zugl.: Freiburg (Breisgau), Univ.,Diss., ISSN 1423-6057, ISBN 3-8255-0518-9. Preis: 27,90 €.

Ausgangspunkt der vorgelegten Arbeit waren mehrjährige Erfahrungen der Verfasserin in Burkina Faso und die regelmäßige Konfrontation sowohl mit Gleichgültigkeit, als auch mit Begeisterung, Eigeninitiative und Identifikation der Zielgruppen mit den vorgeschlagenen Entwicklungsstrategien. Analysiert werden die Einflüsse von Identität und Weltbild der Fulbe im Liptako auf die Entwicklungszusammenarbeit. Überlieferte Normen dieses ehemaligen Herrschervolkes gebieten einerseits die Abgrenzung zu den Akkulturationsbestrebungen der Nachkommen ihrer früheren Untertanen. Auf der anderen Seite haben die politischen, sozioökonomischen und ökologischen Umwälzungen zu Anpassungsleistungen geführt, etwa die Übernahme des Ackerbaus und die Arbeitsmigration. Allerdings werden hier keine Lösungen für die kulturelle Krise der Fulbe gesehen. Ob eine Hypothese der Verfasserin, nämlich, dass eine staatlich geförderte Intensivierung der Viehhaltung im Sahel Akzeptanz finden würde, kann gegenwärtig nicht verifiziert werden.

Die Untersuchung soll Entwicklungsplanern erlauben, ihre Wahrnehmung zu erweitern und die Komplexität der Erfolg bzw. Misserfolg bestimmenden Faktoren zu erkennen. Aufgrund der detaillierten Informationen über Geschichte, Kultur, Wertesystem und traditionelles Wissen der untersuchten Fulbegruppe dürfte die Verfasserin dieses Ziel erreicht haben.

Eckhard Baum, Witzenhausen

R. Keller; 2004

Identification of tropical woody plant in the absence of flowers.
A field guide (2nd edition).

Birkhäuser Verlag, Basel, Boston, Berlin. 294 pp. ISBN 3-7643-6453-X, 62.06 €

Nach der ersten Auflage 1996, liegt nun bereits die zweite, gründlich überarbeitete Auflage vor; u.a. wurden die Schlüssel um etwa 20% erweitert. Ein allgemeiner Schlüssel (pp. 9 - 11) führt zu den Schlüsseln A bis V (pp. A 13 - V 97) und den Anhangsschlüsseln W (Euphorbiaceae s.l.), X (Malvaceae s.l.), Y (Sapindales) und Z (Leguminosae) - pp. 98 - 121.

Danach folgt der Abschnitt "glossary, notes and illustrations", wobei jeweils einer Tafel mit oft zahlreichen schwarz-weiß Zeichnungen zu den Merkmalen ausführliche Erklärungen gegenüberstehen.

Im zweiten Teil des Buches werden die wichtigsten Familien der Dicotyledoneae durch schwarz-weiß Abbildungen auf doppelseitigen Tafeln illustriert. Der prägnante Text bezieht sich auf die Abbildungen wichtiger Gattungen. Wegen ihrer besonderen Bedeutung werden hier die monocotylen Arecaceae in gleicher Weise behandelt.

Den Abschluss des Buches bilden eine Bibliographie und ein Index der Gattungen und Familien (pp. 245 - 288).

Die in den Anhang ohne Paginierung gestellten 32 Tafeln mit Farbfotos wichtiger Arten zeigen oft auch Blüten oder Früchte. Leider sind die hier behandelten Sippen nur teilweise im Index erschlossen - ein direkter Hinweis fehlt immer.

Eine Feldbestimmung von tropischen Gehölzen ist wegen der meist nicht erreichbaren Blüten und Früchte mit Problemen verbunden. Jetzt werden etwa 180 Familien im blütenlosen Zustand der Determination zugänglich gemacht. Eine weitere Bearbeitung, besonders die Vermehrung der hervorragenden Abbildungen (alle vom Verfasser) werden das Buch auf den besten Weg bringen. Vielleicht kann es sogar die sich weiter verschärfende Situation etwas mildern, die im Buch in humorvoller Weise wie folgt charakterisiert wird (p. xii): "... nowadays it is more and more difficult to find the right taxonomist in the right place at the right time!"

K. Hammer, Witzenhausen

Felicitas Becker und Jigal Beetz (Hrsg.); 2005

Der Maji-Maji-Krieg in Deutsch-Ostafrika.

240 Seiten, 66 Abb., 2 Karten. Ch. Links Verlag, Berlin, ISBN 3-86153-358-8.
Preis Broschur: 22,90 €

Ein internationales Team durchleuchtet Hintergründe von Entstehung, Verlauf und Folgen des Kolonialkrieges, der von 1905 bis 1907 im damaligen Deutsch-Ostafrika wütete und als Maji-Maji-Krieg in die Geschichte einging. Anliegen des Buches ist es, die Diskussion über dieses Ereignis, das im Vergleich zum Herero-Krieg, der etwa zur gleichen Zeit im heutigen Namibia tobte, heute weniger Beachtung findet, wachzurufen.

Vierzehn Autoren analysieren und kommentieren die zeitgenössische Berichterstattung durch die Presse in Deutschland und in der Kolonie, sowie die Berichte der Kolonialverwaltung und der Akteure der Schutztruppe. Die allgemein übliche Rechtfertigung des harten Durchgreifens und der Politik der verbrannten Erde wurde schon damals durch die Schriften des Marineoffiziers Hans Paasche, der an den Kämpfen teilgenommen hatte, sich aber später schuldig bekannte, konterkariert. Leider blieb diese Stimme damals weitgehend ungehört und bewirkte sogar heftige Gegenreaktionen. Aber auch Aufzeichnungen und Berichte der Einheimischen sind ambivalent. Da gab es diejenigen, die auf der Seite der Kolonialisten standen, ebenso wie die, welche unter dem Krieg zu leiden und unermessliche Verluste zu beklagen hatten. Hinzu kommen schließlich die Darstellungen der Regierung Tansanias und der tansanischen Historiker, die heute natürlicherweise zu

eigenen Interpretationen kommen. Die unterschiedlichen Sichtweisen der jeweils Betroffenen werden schon an den verwendeten Begriffen, Aufstand, Krieg und Freiheitskampf, deutlich.

Trotz der heute allgemein als gut anerkannten Beziehungen zwischen Deutschland und Tansania sind die Schatten der Vergangenheit noch gegenwärtig. Die historisch sachliche Betrachtung der Ereignisse ist daher dringend notwendig. Das vorliegende Buch leistet hierzu einen wichtigen Beitrag.

Eckhard Baum, Witzenhausen

Christian Richter; 2005

Agrikulturchemie und Pflanzenernährung.

425 Seiten mit zahlreichen Abbildungen und Tabellen. Margraf Publishers GmbH, Weikersheim. ISBN 3-8236-1440-1; Gebunden 35,00 €

Dieses neue Lehrbuch ist eine systematische Einführung in die Nährstoffdynamik in Boden und Pflanze und ihren Wechselwirkungen mit der Umwelt. Die Materie wird sowohl aus dem Blickwinkel der chemischen Prozesse als auch der landwirtschaftlichen Praxis dargestellt. Aufbauend auf eine sehr anschauliche Darstellung der grundlegenden chemischen Vorgänge im Boden werden die Pflanzennährstoffe und ihre Wirkungsweisen in der Pflanze detailliert beschrieben. Besonderer Wert wird in diesem Buch auf die chemischen Grundlagenkenntnisse und ihre Anwendung im Bereich Boden-Pflanze gelegt. So wird systematisch aufbauend das Verständnis der komplexen Wechselwirkungen zwischen Boden und Pflanze erleichtert.

Zahlreiche Beispiele aus verschiedenen Agrarräumen verdeutlichen die spezifischen Anforderungen an die Pflanzenernährung unter unterschiedlichen Klima- und Produktionsbedingungen. Hierbei wird die Bedeutung möglichst naturnaher Wirtschaftsweisen im Pflanzenbau verdeutlicht. Das Buch schließt mit einer kurzen Übersicht über die gängigen Methoden der Boden- und Pflanzenuntersuchung und der Nährstoffzustände.

Das Buch ist didaktisch und graphisch hervorragend gestaltet. Es zeichnet sich, im Gegensatz zu vielen anderen Lehrbüchern, besonders durch eine einfache, leicht verständliche Sprache und viele deutliche Schaubilder aus. Insbesondere für Studierende wird dadurch diese doch recht komplexe Materie leicht verständlich. Das Buch ist aber auch empfehlenswert als Nachschlagewerk und zur Auffrischung von Kenntnissen.

M. Zöbisch, Witzenhausen

Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 106, No. 2, 2005, pages 197–200

Kurznachrichten

Stiftungsprofessur besetzt: Ton Baars hat europaweit erste Professur für biologisch-dynamische Landwirtschaft an einer Universität inne

Kassel/Witzenhausen. Prof. Dr. Ton Baars wurde jetzt auf die europaweit erste Professur für biologisch-dynamische Landwirtschaft berufen. Die neu geschaffene Stiftungsprofessur ist am Fachbereich Ökologische Agrarwissenschaften der Universität Kassel in Witzenhausen angesiedelt. Stifter sind die Software AG-Stiftung, die Zukunftsstiftung Landwirtschaft, die Alnatura GmbH, die Rogau Stiftung sowie der Forschungsring für biologisch-dynamische Wirtschaftsweise. Diese Stiftungen finanzieren eine C 3-Professur in Höhe von rund 1,1 Mio. Euro für einen Zeitraum von sechs Jahren. Aufgabe der Stiftungsprofessur ist es, Lehre und Forschung für die biologisch-dynamische Landwirtschaft abzudecken. Zu den wissenschaftlichen Fragestellungen gehört es, Grundlagen und Methoden zur bio-dynamischen Lebensmittelqualität, insbesondere zur Tierhaltung und Tierzüchtung sowie zur Betriebsorganisation weiter zu entwickeln.

Der Niederländer Prof. Dr. Anthonie (Ton) Baars (48), hat an der Universität Utrecht im Fach Biologie mit Spezialisierung auf Ökologie seinen Master degree (MSc) erworben und an der Universität Wageningen promoviert. Seit 1986 war er am Louis Bolk Institut, Driebergen, einem renommierten Forschungsinstitut für biologische Landwirtschaft, Ernährung und Humanmedizin tätig. Er hat dort zu den Themen Grünland, Tiergesundheit und Tierzucht in der ökologischen Landwirtschaft wissenschaftlich gearbeitet.

Ton Baars wird in seiner Professur an seinen bisherigen Schwerpunkten anknüpfen. Dabei steht der Begriff einer positiven Tiergesundheit, die auf Ganzheitlichkeit basiert, im Mittelpunkt seiner Arbeit, die zum körperlichen und seelischen Gleichgewicht der Tiere beitragen soll. Seine Forschungsherde befindet sich auf der Domäne Frankenhausen, dem ökologischen Versuchshof der Universität Kassel. Mit Milchkühen wird er die Bedeutung der Jugendentwicklung und des Absetzalters des Kalbes für den Aufbau einer hofeigenen Immunität, die Rolle einer standortorientierten Tierzucht, Möglichkeiten der Selbstmedikation und einer phytotherapeutisch unterstützten Selbstheilung erforschen. Baars will zu einer Objektivierung der biologisch-dynamischen Qualität des System und der Produkte beitragen.

Als besondere Aufgaben in der Lehre sieht Baars neben der Vermittlung der Grundlagen des biologisch-dynamischen Landbaus an, die Studierenden zur interdisziplinären und transdisziplinären Problembearbeitung zu befähigen. „Ich beziehe mich dabei auf die Goetheanistische Wahrnehmung und Forschung, die ganzheitliche Betrachtung des Lebendigen und nutze die Erfahrungen und Lösungen von Landwirten, die als Pioniere mit ganzheitlichen Verfahren wirtschaften“, so Baars. Ihm liege besonders daran, auch

ein Bewusstsein für philosophische Fragestellungen anzuregen und zur Aussöhnung des Gegensatzes zwischen Reduktionismus und Holismus beizutragen.

Bedeutung für den Standort Witzenhausen

Bisher gab es in Europa noch keine Professur für die biologisch-dynamische Wirtschaftsweise an einer Universität, wie der Präsident der Universität Kassel, Prof. Dr. Rolf-Dieter Postlep, erläuterte. Er dankte den Stiftern für ihr ungewöhnliches Engagement. Postlep: „Die Integration der biologisch-dynamischen Wirtschaftsweise in Forschung und Lehre ist ein wichtiger Baustein zur Stärkung des Universitätsstandortes Witzenhausen". Dieser habe seit jeher eine Art Pionierfunktion inne: Die erste Professur für Ökologischen Landbau wurde hier bereits 1981 eingerichtet und der weltweit erste und einzige Universitätsstudiengang Ökologische Landwirtschaft wird angeboten. Der 1996 begonnene Prozess, den Fachbereich völlig auf Ökologische Agrarwissenschaften umzustellen, sei nun mit der Einrichtung der Stiftungsprofessur abgeschlossen. Zudem wurde im Februar 2005 in einem Kooperationsvertrag mit der Landwirtschafts-Fakultät der Universität Göttingen die Nutzung der jeweiligen Potentiale in Studium und Forschung vereinbart.

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(Presse, Universität Kassel, 2005)

Das Deutsche Institut für Tropische und Subtropische Landwirtschaft jetzt Innovations- und Dienstleistungszentrum der UNIK

Witzenhausen/Kassel. Das Deutsche Institut für Tropische und Subtropische Landwirtschaft (DITSL) in Witzenhausen erhält als An-Institut der Universität Kassel (UNIK) eine neue Ausrichtung. In Zukunft soll es das Innovations- und Dienstleistungszentrum für den internationalen Transfer der UNIK, insbesondere für nachhaltige ländliche Entwicklung, sein. Damit will es die Kompetenzen der Universität Kassel und weiterer wissenschaftlicher Kooperationspartner in die wissensbasierte Zusammenarbeit insbesondere mit Entwicklungs- und Schwellenländern einbringen. Das DITSL war und ist weiterhin eine gemeinnützige GmbH. Die wichtigsten Gesellschafter sind die Universität Kassel, die Bundesrepublik Deutschland und das Land Hessen sowie die Stadt Witzenhausen. Lag bislang der Schwerpunkt der Tätigkeiten in der Aus- und Fortbildung internationaler Führungs- und Fachkräfte, so treten in der neuen Aufgabenstruktur der Wissens- und Technologietransfer, die Koordination von Forschungsprojekten und Forschungsnetzwerken sowie entwicklungspolitische Bildungs- und Öffentlichkeitsarbeit dazu.

Für Universitätspräsident Prof. Dr. Rolf-Dieter Postlep ist das neue An-Institut eine weitere Maßnahme, um den Transfer des vielfältigen Wissens der Universität in Wirtschaft und Gesellschaft zu stärken. „Das DITSL an der UNIK rundet die bestehende Transferstruktur ab und konzentriert sich auf den internationalen Transfer, vor allem in Weltregionen wie die Tropen, Subtropen und Schwellenländer“, so Postlep anlässlich einer Pressekonferenz. In der neuen Konstruktion verbänden sich die wissenschaftlichen Kompetenzen und Forschungsmöglichkeiten der Universität Kassel, insbesondere in Witzenhausen, sowie anderer Kooperationspartner mit bestehenden Netzwerken des DITSL. Synergien sieht auch der Dekan des Fachbereichs Ökologische Agrarwissenschaften, Prof. Dr. Jürgen Heß: „Unsere bestehenden und geplanten Masterstudiengänge sowie vorhandene Studienmodule für fortgeschrittene Semester sind hervorragend geeignet, die Lehrkompetenzen des weltweit in den Ökologischen Agrarwissenschaften profilierten Fachbereichs für das internationale Klientel anzubieten.“

Einrichtung mit Tradition

Das DITSL, seit 1956 so benannt, hat über viele Entwicklungsstufen hinweg im Rahmen seiner Vorgängereinrichtungen letztlich seit 1898 in Witzenhausen Aufgaben im Bereich der Ausbildung und Entwicklung tropischer und subtropischer Landwirtschaft inne und bringt verschiedene inhaltliche Programme und eine materielle Infrastruktur in das neue An-Institut ein. Zahlreiche Liegenschaften, die entweder selbst genutzt oder an die Universität oder andere Bildungseinrichtungen vermietet werden, das Tropengewächshaus, eine umfangreiche Fachbibliothek zur tropischen und subtropischen Agrarwissenschaft und zur Kolonialgeschichte sowie die Völkerkundliche Sammlung gehören dazu.
Die inhaltlichen Programme, die zumeist aus Regierungsmitteln finanzierte Programme zur Qualifizierung ausländischer Fachkräfte durch Weiterbildung und Beratung sind, sollen weitergeführt werden. Daneben sollen in dem neuen An-Institut vier weitere Programmbereiche etabliert werden:

- ◇ In Zusammenarbeit mit den Fachgebieten Ökologische Lebensmittelqualität und Ernährungskultur und Agrar- und Lebensmittelmarketing ist unter der Leitung von Prof. Dr. Angelika Meier-Ploeger ein Weiterbildungsbereich mit internationalen Trainingsmaßnahmen zum Thema „Quality Management, Certification and Marketing of Organically Produced Agricultural Commodities“ etabliert worden.

- ◇ Im Zusammenwirken mit dem Fachgebiet Soziologie ländlicher Räume werden die seit langem durchgeführten Qualifizierungskurse für ausländisches Hochschulpersonal UNISTAFF und UNICAMBIO unter der Leitung von Prof. Fremerey und Dr. Wesseler im DITSL etabliert werden. Das UNISTAFF-Programm qualifiziert ausländisches Hochschulpersonal in Fragen der Hochschulentwicklung und Organisation in Lehre, Forschung und Administration und wird vom Deutschen Akademischen Austauschdienst DAAD gefördert. Das UNICAMBIO-Programm vermittelt Qualitätsmanagement-Programme an ausgewählte ausländische Hochschulbeschäftigte und wird vom DAAD/HRK und der Gesellschaft für Technische Zusammenarbeit GTZ und Gebühren der Teilnehmer/innen, die von den Heimathochschulen entsandt werden, finanziert. Das WZ I - Berufs- und Hochschulforschung der Universität Kassel, ist

mit inhaltlichen Beiträgen an der Durchführung beider Qualifizierungsmaßnahmen beteiligt.

- ◇ Unter der Leitung von Prof. Dr. Hensel, Fachgebiet Agrartechnik wird ein neuer Bereich Technologie-Transfer entwickelt, der sich auch mit Themen wie Standortgerechte Technologieentwicklung, Nachwachsende Rohstoffe sowie Wasser und Kulturtechnik in Weiterbildungs- und anderen Qualifizierungsmaßnahmen befasst.
- ◇ Absolventinnen und Absolventen bei Unternehmensgründungen, vorzugsweise in den Bereichen Qualitätssicherung/Zertifizierung, Consulting, Beratung, Verwaltung, Entwicklung ländlicher Räume und Umwelt-Ingenieurwesen zu unterstützen, ist ein weiterer Programmbereich.

Organisationsstruktur mit hochrangigem wissenschaftlichem Beirat
Das DITSL als An-Institut der Universität Kassel hat sich eine Struktur gegeben, die aus einer Gesellschafterversammlung, einem Aufsichtsrat und einem wissenschaftlichen Beirat besteht; ein Geschäftsführer ist für die Organisation und Abwicklung zuständig. Bislang und bis 31. Oktober 2005 ist dies Prof. Dr. Eckhard Baum, UNIK in Witzenhausen; ihm wird als hauptamtlicher Geschäftsführer Dr.-Ing. Christian Hülsebusch folgen, der zurzeit am Tropenzentrum der Universität Hohenheim tätig ist.
Mitglieder im Wissenschaftlichen Beirat, der sich am 11. Juli in Witzenhausen konstituierte, sind neben den Witzenhäuser Professoren Dres. Andreas Bürkert (Fachgebiet Ökologischer Pflanzenbau und Agrarökosystemforschung in den Tropen/Subtropen) und Oliver Hensel (Fachgebiet Agrartechnik) auch Dr. Uwe Muuß (Geschäftsführer des Tropenzentrums der Georg-August-Universität in Göttingen), Dr. Urs Niggli (Direktor des Forschungsinstituts für biologischen Landbau in Frick/Schweiz), Prof. Dr. Mathias Becker (Universität Bonn), Prof. Dr. Johann W. Gerlach (FU Berlin/ Mitglied des Vorstands des Deutschen Akademischen Austauschdienstes), Dr. Detlef Hanne (VolkswagenStiftung) sowie Dr. Oliver Fromm (Leiter des UniKasselTransfers), Horst Behnke (Hochschulverband Witzenhausen e.V.) und Michael Glameyer (Geschäftsführer des Internationalen Bildungszentrum Witzenhausen). In der Gesellschafterversammlung sind die Vertreter der Anteilseigner versammelt, darunter die Universität Kassel (23 Prozent), die Bundesrepublik Deutschland/Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung mit 16 Prozent, das Land Hessen mit 16 Prozent, die Gesellschaft zur Förderung der ländlichen Entwicklung (25 Prozent), die Stadt Witzenhausen mit 2,1 Prozent und weitere kleine Streubesitze. Der Aufsichtsrat wird von UNIK-Präsident Prof. Dr. Rolf-Dieter Postlep geleitet.

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(Presse, Universität Kassel, 2005)

Notes to authors

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The summary should concentrate on the main results and conclusions to highlight the author's contribution. It should be suitable for information storage and retrieval.

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April 2004